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Analysis of the effectiveness of indigenous knowledge in the coastal villages of Chabahar County in reducing flood risk

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ARTICLE INFO

Article History:
Received: 28 May 2024
Accepted: 15 July 2024

Keywords:
Indigenous knowledge
Coastal villages
Chabahar county
Reducing flood risk
Control and management

ABSTRACT

Recent studies show that the views towards flood risk reduction have undergone a turn of approach. Indigenous knowledge Coastal villages (IKCV) have used several indigenous flood control and management knowledge systems to minimize the risk of flood disasters. Therefore, there is a growing demand to empirically identify the effectiveness of indigenous knowledge in flood risk reduction. As a result, this article has experimentally investigated the effectiveness of local knowledge of coastal villages in Chabahar County in reducing the risk of flood disasters. A mixed research methodology has been designed along with a (qualitative-to-quantitative conversion strategy. Qualitative data collection was realized through interviews with focus groups (FGDs), categories and categories were extracted through the thematic analysis method, and a questionnaire was used to collect quantitative research data. To measure the effectiveness, a confirmatory factor analysis method with SmartPLS 4 software was used. The samples were selected non-probably, including 32 people who were knowledgeable about the research subject. The thematic analysis of the interviews of the participants in the coastal villages of Chabahar indicates five categories of native knowledge of the coastal villages, which are mainly based on the experiential knowledge and local creativity of the natives. Therefore, the five main structures of indigenous knowledge of the coastal villages of the Chabahar region were confirmed. Respectively, Meteorological with a factor load of 0.851, Human with 0.626, Riverine with 0.477, Ecological with 0.468, and Celestial with 0.431 had the greatest role in reducing flood effects. This means that knowledge of local flood control and management in coastal villages of Chabahar effectively reduces flood risk. This study proposes a sustainable approach to flood disaster risk reduction based on the integration of indigenous knowledge systems and modern flood management strategies.

1. Introduction

Flood is one of the main challenges facing humanity [1]. Heavy rain causes runoff to exceed the capacity of existing drainage facilities and floods occur on the land. The nature of flooding and the consequences of human activities have caused flooding to become an inherent environmental problem [2]; So that today, instead of eradicating it, they think about controlling and reducing its effects [3]. Studies of the last two decades of coastal villages show that the views towards flood risk reduction have experienced a turn of approach [4]. IKCV have used several indigenous flood control and management knowledge systems to minimize the risk of flood disasters. For example, Bariweni, et al. [5] showed that rural communities in Nigeria used indigenous initiatives such as diversions, dams, and spillways to prevent rivers from overflowing their banks; a subject that has its roots in the experiences of their ancestors [6]. In general, the strategies employed by coastal communities include a wide range of human and natural actions, including planting early crops, harvesting crops before the flood approaches, moving to higher areas and building water channels, building local bridges, concrete embankments [7]. And stone embankments and continuous investigation of climatic, plant and animal behavior were used to protect coastlines and villages. A report by the UN/ISDR [8], shows that the efforts made so far to integrate indigenous knowledge in flood risk reduction efforts have been very inadequate, even though there is convincing evidence that indigenous knowledge can provide practical solutions to minimize disasters at the levels offer different The role of indigenous knowledge in providing an effective strategy for mitigating flood disasters, which has apparently been neglected for decades, can be recognized [9]. The knowledge system of coastal communities is very suitable for the resilience of settlements against flood disasters [10, 11]. There is a growing demand to empirically identify the effectiveness of indigenous knowledge in flood risk reduction [12].

The province of Sistan and Baluchistan, located in the southeast of Iran, has such geographical and climatic diversity that it has turned it into a four-season province and at the same time has given it a dangerous face [13]. In the south of the province, in the Chabahar and Makar region, which is Iran's gateway to the world's oceans, floods have become one of the main dangers in the past periods, and the main disasters of these floods are damage to traffic routes and destruction of villages located on the banks of rivers. Is. The simultaneity of coastal storms with floods multiplies the depth of vulnerability of the conflict villages, which is considered one of the maritime hazards in that area, one of its examples is the Ashuba storm that hit the Chabahar coast not long ago [14]. With the arrival of the heavy rain system from the southwest of the country, on the 28th to the 30th of Farudin month, 1403 villages of Chabahar county have been involved in flooding. It has been unprecedented in the last half century. In the report announced by the Chabahar Marine Meteorological Station, for the first time in the last half century, 164 mm of rain fell within 24 hours and the recent system rains have caused at least 10 new rainfall records to be recorded in the climate of the southern regions of the country [15]. Despite the aforementioned conditions and features, due to environmental conditions and features such as unevenness, soil type and texture, and other factors such as the characteristics of the materials used in the construction of most residential houses, etc., it has created a complex situation in the coastal villages of Chabahar. According to the reports of Iran Red Crescent Organization, until April 29, 2024, the roads of a number of villages in the county were blocked and 2 villages faced a complete power outage. Also, with the continuation of torrential rains, the evacuation of some villages was put on the agenda [16].

Thus, it should be said that in Chabahar county, flood has become a dangerous event with destructive physical and socio-economic effects for coastal villages. To overcome the challenges caused by floods, the coastal communities of this region have potential capacities of indigenous knowledge that can be used in flood control and management. Indigenous knowledge systems, which are the understandings, talents, and philosophies developed in societies with a long history of interaction with their natural environment, inform decision-making about the essentials of everyday life. The long-term establishment of knowledge systems enables coastal communities to develop indigenous flood control and management practices that help minimize the risk of flood disasters. For coastal communities, perhaps due to the frequency and long history of flooding, patterns of collective action and cognitive patterns can be found that are adapted to the conditions of risk [17].

As a result, this article aims to empirically investigate the effectiveness of the indigenous knowledge system of coastal villages in reducing the risk of flooding, focusing on the coastal rural communities of Chabahar. This study will answer the following two research questions: First, to discover the implications and components of the indigenous knowledge system used by the coastal villagers of Chabahar to reduce floods? Second, how effective is the effectiveness of each of these indications of the local knowledge system in reducing the risk of flood disaster? The answers to the research questions provide the empirical basis for formulating appropriate strategies to increase flood risk reduction in the coastal villages of Chabahar.

2. Background

The term "native knowledge" has been mentioned under several topics such as traditional knowledge, local technical knowledge, rural knowledge, local knowledge, as well as ethnology or people's science in several existing researches. In defining indigenous knowledge, Mapara [18] says, *"Indigenous knowledge systems are the body of knowledge of the indigenous people of specific geographical areas that have survived there for a long time."* It is the experience gained over thousands of years due to human contact with the environment, which transcends all aspects of human endeavor including agriculture, medicine, security, botany, zoology, food technology, arts and crafts skills, linguistics, education, resource management. it is normal [19]. Risk management or crisis management and a host of other activities were passed down from generation to generation through proverbs, riddles, folk tales, songs, legends and myths, culture, religion, stories, informal teachings, communication, beliefs, traditions, apprenticeship. With the emergence of modernism currents and the dominance of common academic science, the local people think that indigenous knowledge lacks the necessary qualifications and does not have the opportunity to develop [20]. So that exactly this knowledge is designed to respond to people's needs and local conditions. Similarly, UN/ISDR [8] believes that knowledge is indigenous, creative and experimental, constantly combining external influences and internal innovations to meet new conditions. The study found that it is often a mistake to consider indigenous knowledge as 'old', 'backward', 'static' or 'unchanged' as it is necessary to reduce the effects of disasters and this gap can be bridged. Between the required disaster response and what is available.

In the literature of the last two decades, the importance of including indigenous knowledge in reducing the effects of floods has been especially emphasized [21]. As in the academic literature in general and specifically in the field of reducing the effects of floods, there is talk of integrating indigenous knowledge with academic knowledge. Several studies have investigated the effectiveness of indigenous knowledge on flood risk reduction. For example, Jha and Jha [22] examined the effectiveness of indigenous knowledge in providing adequate understanding of flood risks and vulnerabilities. They found that it enabled the Lepcha people of India to develop an adequate understanding of the nature and causes of disaster, as well as to increase their capacity to accurately predict natural disasters and ways and means to mitigate their effects. They suggested that indigenous knowledge deserves global recognition, conservation, documentation and integration into modern disaster management strategies. Similarly, Chen and Cheng [23] found that adequate understanding of flood risks and vulnerabilities through indigenous knowledge is effective in building resilient communities. They proposed the integration of indigenous flood forecasting and management techniques with scientific methods of flood control with the aim of achieving sustainable flood management and control systems. Obi, et al. [24] examined the effectiveness of indigenous knowledge from a gender perspective. He found that most rural women who are exposed to floods due to geographical location, gender role, poverty, gender inequality, lack of education and information, have used their knowledge about local coping strategies and mechanisms for flood management in Kailali region [25]. Nepal This study suggested strengthening indigenous flood control and management practices to minimize the vulnerability of rural women to floods. explored the potential of indigenous knowledge. He found that it had the potential to contribute much more than expected to disaster risk reduction. Choudhury, et al. [26] in aligned with Parsons, et al. [27] found that indigenous knowledge enables Char people in Bangladesh to reduce flood-related vulnerabilities. Hadlos, et al. [28] correlate with other studies on the ability to reduce flood risk with indigenous knowledge. This study showed that indigenous knowledge plays an important role in reducing flood disasters in different regions of the world. Also, this study found that the amount of indigenous knowledge increases communities' resilience to floods, which is derived from geophysical locations, flood exposure and socio-economic capabilities. Furthermore, the work of Membele, et al. [19] on the effectiveness of indigenous knowledge in flood forecasting was consistent withLeal Filho, et al. [29]. They found that indigenous knowledge is effective in predicting the nature of climate change, which enables Odisha's coastal fishing communities to manage and mitigate flood disasters [30]. This study opined that despite its findings, indigenous knowledge continues to be undervalued in global environmental change studies.

The study of Leal Filho, et al. [29] confirmed the previous studies in the field of indigenous knowledge and disaster risk reduction. This study showed that indigenous knowledge reduces the vulnerability of Zuzan rural communities in Khaf province to natural disasters. They proposed the integration of indigenous and modern knowledge to improve the efficiency of the risk reduction system. Similarly, Paulraj and Andharia [31] found that indigenous knowledge based on cultural beliefs, practices and environmental understanding enables Konyak communities in India to be resilient to floods and other natural disasters. They suggested that policy makers should recognize the importance of indigenous knowledge system and integrate it into the disaster management system. Kaya and Koitsiwe [32] agreed with the results of existing studies on the predictive capacity of indigenous knowledge. This study showed that the use of this knowledge base can effectively predict the occurrence of natural disasters in Botswana. They suggested the formulation of appropriate laws to protect the intellectual property rights of indigenous knowledge holders. In this regard, Sohail and Chen [33] found that indigenous knowledge was effective in predicting and interpreting weather patterns, increasing food security, facilitating flood coping mechanisms and healing flood victims in Bayira of the Rwenzori region. They suggested the integration of indigenous knowledge with scientific knowledge that is suitable for the local environment of the people.

In line with previous studies, Neeta [34] found that indigenous knowledge practices are an effective mechanism for flood management and disaster risk reduction among the Lozi people of Zambia. He proposed the integration of indigenous knowledge into development planning strategies to enable local communities to resist the phenomena of floods and climate change. Because they are very important for sustainable planning and future development [35, 36]. The work of Theodory [37] differed from previous studies in that he examined the factors that hinder the effectiveness of indigenous knowledge. He found that weak recognition of indigenous knowledge, lack of knowledge sharing culture, reduction of indigenous knowledge custodians and loss of culture and traditional practices are some of the obstacles to this. Successful application of indigenous knowledge in climate adaptation at the local level Inconsistent with previous studies, Macnight Ngwese, et al. [38] argued that indigenous knowledge has been effective in flood forecasting and management. They suggested integrating indigenous disaster mitigation techniques with modern scientific knowledge to minimize the vulnerability of coastal communities to floods. Therefore, the indigenous knowledge of the civil society about the nature of the risk and the mechanism to deal with it also shows inherent flexibility. In the face of a wide range of potential environmental stresses, including risks from climate change, the inherent flexibility of civil society and its capacity to adapt form the first line of defense [39]. In other words, when civil society and its organizations become sufficiently sensitive about their vulnerability to hazards and minimize their exposure and strengthen their capacity to cope with hazards, that means they are more resilient to environmental stressors. are [40]. From the review of the literature, it is clear that the existing studies lacked empirical evidence about the effectiveness level of indigenous knowledge of coastal villages in reducing the risk of flood disasters, especially in Chabahar region [41, 42]. As a result, this study fills the gap in the literature by empirically investigating the knowledge of local flood control and management and its effectiveness in reducing the risk of flood disasters in coastal communities of Chabahar. The result of this study provides a basis for strengthening the local approach to flood disaster risk reduction.

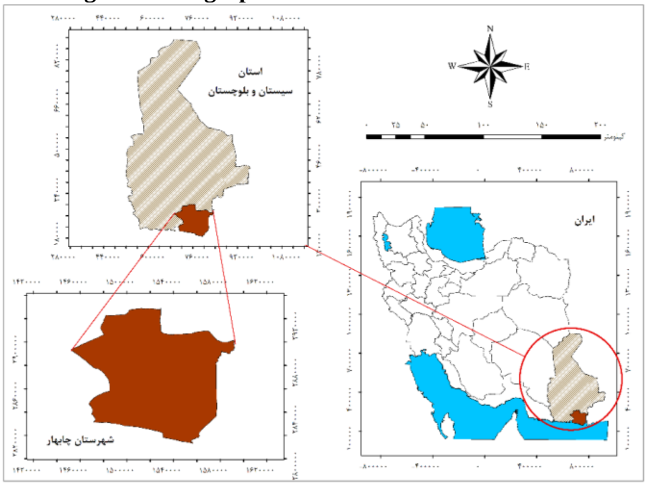
3. Methodology

This section explains the details of the study area and the reason for its selection. Chabahar was chosen as the study area. It also explains the sampling plan and data collection method. Finally, the indicators selected for the study and the technique adopted for data analysis are discussed in detail.

1.3. Case study

Chabahar county is one of the cities of Sistan and Baluchistan province, which is located seven meters above sea level. Chabahar is located in the southeast of Iran at 60 degrees and 37 minutes east longitude and 25 degrees and 17 minutes north latitude. This county is bordered by Iranshahr and Nikshahr cities from the north, Oman Sea from the south, Pakistan from the east, and Kerman and Hormozgan provinces from the west. The latest census indicates that Chabahar county includes three districts, six rural districts and 135 villages. The rural population of Chabahar has 40,918 households and 170,778 people. Chabahar has a temperate tropical climate with relatively humid humidity, the hottest part of the country in winter and the coldest southern port of Iran in summer. The weather of this county and its surroundings is always mild and springy. That is why it is called Chabahar (four seasons of spring).

Figure 1: Geographical location of the studied area



Source: Authors, 1403

The recent rains caused a lot of damage to the coastal villages of Chabahar. Flood damage has caused human casualties and waste, destruction of all kinds of buildings, damage to agricultural fields and gardens, destruction of infrastructure such as roads and communication arteries, energy transmission networks and lines, etc. According to the statement of the representative of the people of Chabahar in the parliament, more than 10 people have lost their lives and the transit and rural roads in some cities have been destroyed up to 70%. 400 villages have faced the issue of blocked roads and flooded houses. Many bridges have been destroyed and agricultural gardens have been destroyed, especially in Zarabad. The conditions of the recent flood show that since the flood of March 1402 in this region, there are still infrastructural and management weaknesses. The conditions of the people of those areas are also becoming more difficult day by day in terms of lack of access to roads, telecommunication and electricity. Damage to the communication ways, agricultural sector, out-of-season cultivation fields and tropical fruit gardens, electricity and water supply network are among the most extensive damages caused by the recent floods in Chabahar county. Disconnection of telecommunications in more than 30 villages of Chabahar due to problems with optical fiber, damage to three thousand hectares of dry land cultivated with sorghum and mung beans, five poultry units with 80 thousand chickens and chickens, more than 600 dams and 10 dams, more than It has caused 5 thousand billion rials in damage.

According to the statements made, the heavy rain has blocked the roads of 154 villages and 470 cases of low pressure blackouts, and important routes have also been blocked in the road area. Also, due to the intensification of the rains, the Khairabad Nikshahr dam overflowed for the second time in the last 2 months, and despite issuing warnings and recommending the transfer of pregnant mothers to the nearest medical centers, unfortunately, 6 pregnant mothers were caught in the flood, and with the efforts of the public and relief forces, they were taken to the centers. They were transferred for treatment.

The deputy of the crisis management headquarters of the governorate stated that the initial damage to the covered roads is 18 thousand billion rials, which is still increasing due to the volume of rains. It is worth mentioning that the loss of two billion cubic meters of water to the sea during the recent rains in southern Sistan and Baluchistan, including Chabahar, is the most pathetic part of repeating the story of the lack of proper flood management in a region that is facing a shortage of drinking water and agriculture.

2.3. Materials and Methods

This research is a hybrid study. The strategy used in the present research is of the type of conversion from qualitative to quantitative. Thus, in order to discover and document the components of early warning by the knowledge of natives of coastal villages to reduce the effects of floods and understand their early actions, this study has adopted a qualitative approach. Qualitative research method has been used due to its high flexibility to collect, lack of information and the ability to deeply interpret the topic of indigenous knowledge of coastal villages. In the second step, quantitative methodology has been used to measure the influence of the components and implications of local knowledge of coastal villages on reducing flood damage.

3.3. Data collection

For the qualitative data collection, focus group interviews (FGDs) and key informant interviews (KII) were used, allowing researchers to collect a large amount of high-quality primary data in a relatively short time frame, representing a significant number of participants. provides For this purpose, first the focus group discussion of local flood control and management knowledge used by coastal communities were identified. This group, consisting of 12 elders from each of the selected coastal communities, was determined based on age criteria. The criterion of age was used to create a focus group discussion because the elders are the custodians of indigenous knowledge of the coastal communities in the villages. Societies defined the elderly as any person over 70 years of age. The focus group discussion was held three times in the village square of each respective community and different types of local flood control and management knowledge used by their communities were discussed. The guide of the questions used for the focus groups is designed based on the review of the literature texts and the comprehensive coverage of the research topic: 1) an overview of the flood situation in coastal villages, 2) the main components of local early warning for flooding in coastal villages and 3) the reliability of each of the local knowledge. How much was it?

A questionnaire was used to collect quantitative research data. Empirical data was obtained from the participants in the interviews along with the introduction of other people. Respondents were asked to evaluate the effectiveness of indigenous knowledge of coastal villages in reducing flood effects based on a 5-point Likert scale, i.e. very effective (5), effective (4), moderate (3), low (2) and very low (1). . The responses led to principal component analysis.

4.3. Selection of sample units

Sample villages were introduced as flood-prone areas. In this research, five old coastal villages in Chabahar county named Kachu, Sham, Komb, Ramin, Osman Abad were selected. The reasons for choosing these villages are historical, coastal, and flood experience. The samples were selected in such a way that they have a low development status, are geographically connected and are located in the coastal area of Chabahar county. Research participants were selected using purposive sampling (i.e., study participants were selected based on a set of criteria), after consulting with village community leaders (e.g., village elders) who helped connect with individuals. FGD participants were selected based on the following criteria:

- living in the village for most of his life;
- Over 55 years old (for most participants), and no upper age limit;
- Maximum two participants from a different age group;
- Extensive experience with flooding (ie preferably living in flood prone areas);
- Be known in the community for having native knowledge related to disasters.

Overall, 32 interviews were obtained from the focus groups, of which 24 were male and 9 were female participants. Focused groups are conducted in social spaces (for example, in front of a mosque, in front of a shop, etc.). Due to travel restrictions, according to the initial planning, it was not possible to hold centralized centers of male and female villagers in each village at the same time. However, since the conducted focal point sample represents a relatively large sample for a qualitative study, the above-mentioned exclusion does not seriously affect the validity of the study and allows the achievement of data saturation. The duration of the focus groups was approximately two hours. Most of the participants in the sessions were subsistence farmers, fishermen and small business owners and were in the age group of 56 years or older.

5.3. Analysis method

According to the mixed research design, the analysis has been done in two consecutive stages. In the first stage, thematic analysis, which is one of the most common data analysis approaches in qualitative research, was used to implement the interviews taken from the participants. Thematic analysis is a process in which the collected data is thoroughly examined to identify recurring themes in the text. First, the data were coded by the authors of the report (i.e., assigning a code to a specific section of the text), followed by a process in which the codes were merged into themes of interest. After the iterative process of coding and subject identification, the final report and findings were written. In this process, general themes were developed based on themes covered in the interview guides, and a coding scheme was developed and applied to the data transcripts. Since the set of qualitative data sampled in this study was relatively large and there was no significant difference in the ecological, meteorological, river and cultural context of the participants, it was pointed out that data saturation (i.e. after a certain number of data) was achieved. During the writing phase of the report, quotes from the participants have been used in order to fully capture the in-depth information collected and provide textual results. Even though it would contribute to the overall validity of the results produced, due to logistical constraints, there was no opportunity for participants to provide feedback on the findings.

In the second step, confirmatory factor analysis using SmartPLS version 4 software was used for the quantitative part to measure the components and implications (resulting from the qualitative method) [43]. Researchers used this model for several reasons. First, this model assesses the quality of the measurement model; second, the reflexive nature of the model allows the consideration of multiple criteria that were needed by the researchers; covers [44]. Secondly, finally, the model leads to the consistency test between the theoretical structure and the experimental structure of the research, which provides the possibility of interpreting the results [45].

The maximum likelihood method was used to validate the model. In fitting the model, the closer the GFI, CFI, and AGFI indices are to one (0.10 to 1.00), the better the model fits and the better the data confirm the assumed relationship pattern. Also, the closer the RMSEA is to zero (0.10 to 0.00), the better the model fits. The fit index X2/df is also the lower the better and should not be more than 2. If the chi-square is not statistically significant, it is very appropriate to indicate it, but since this index is often obtained in samples larger than 100, it is not considered a suitable index to measure the fit of the model. In general, all the fit indices of the model presented in the present study had a good fit and confirmed the assumed model [46].

6.3. Screening and classification of categories

During data collection, FGD participants and interviewees provided a number of indicators that are seen in a community as indicators of local flood prediction of a future event. Following the findings of the literature review, it was revealed that the indicators are locally limited and case specific. However, it was observed that most of the indicators, even if they differ between the communities in question, are similar in the sense that they derive from the close relationship of the community with the surrounding environment and similar agricultural practices. Flood prediction signs are available through the specific behavior of local flora and fauna, changes in river behavior, monitoring of weather and temperature changes, and through the nature of the behavior of celestial bodies. Importantly, a large number of observed symptoms are related to villagers' anticipation of rainfall events (ie, not floods explicitly, but periods of rainfall leading to floods). Indigenous knowledge is embedded in people's daily life and livelihood and emerges from a close relationship with surrounding behaviors and environments. Considering that the majority of the population in the studied areas are subsistence farmers, in the absence of widespread access to irrigation agriculture, the amount and distribution of rainfall determines the performance of farms and, as a result, the availability of food for people.

With a set of existing indigenous flood forecasting indicators, it was necessary to create a meaningful classification, in order to present the results in a coherent manner and create a simple, yet comprehensive overview of the indigenous warning practices in the studied communities. As shown in the literature review section, previous studies have proposed different classifications of indigenous knowledge for EWS. In this study, the taxonomy developed by Acharya [47] was used, with documented indigenous flood prediction indicators grouped into four main categories:

Indigenous ecological knowledge: behaviors, phenomena and patterns that are not related to human behavior.

Indigenous Riverine knowledge: behavior of river waters;

Indigenous Meteorological knowledge: Wind movement, rain pattern, temperature and clouds and... .

Indigenous Celestial knowledge: This knowledge deals with celestial elements such as the moon and its role in tides, rainbows.

Indigenous human knowledge: canalization, building architecture, construction of decks for food storage, planting of early crops, road access.

۴. Result

The findings of the research are reported in the first stage of a report of the content analysis of round-trip interviews. Qualitative findings including 4 classes of native flood forecasting of native villages along with 23 indications were identified. The second part of the findings is presented to the output of the confirmatory factor analysis, which describes the implementation of the measurement model and its output. Then, in order to measure the validity of the obtained model, all the indicators and components of the model will be tested by the Fornell-Larker divergence validity matrix. Finally, the T-test was used to determine the significance of the path of the factor loading of the model.

Summary of focus group discussions on indigenous flood control and management knowledge used by coastal communities Table 1 shows a summary of focus group discussions of 35 types of indigenous flood control and management knowledge used by coastal communities in flood risk reduction.

1.4. Themes of indigenous knowledge of coastal villages

The main themes and classification were prepared during the interviews. In Table 3, the core class, the flood prediction class and the implications of the local knowledge of the coastal villages along with the explanations in the studied area are presented. An attempt has been made to document a general picture of what was available. A detailed explanation of the specific categories is provided later in this section (Table-3).

Table 3: Summary of focus group discussions on indigenous knowledge of coastal villages used by participants

Axial categori	Selective category	The implications of indigenous knowledge	Explanation
Indigenous knowledge of coastal villages in	Indigenous ecological knowledge	Fisherman observe increased number of fish in the rivers (E1)	Observing the increase in the number of fish in rivers by fishermen during floods is a phenomenon that they use in the field of flood forecasting. This phenomenon is often referred to as the "tributary sanctuary hypothesis". This suggests that fish take refuge in tributaries during floods, which can be a safer and more favorable environment for them compared to the main river stem.
		Migration of shorebirds (E2)	Coastal communities also use the migration patterns of some birds, especially seagulls and swallows, to predict floods. Their disappearance in the sky indicates that the flood is approaching, while their appearance indicates that the flood is receding. The focus group discussion revealed that when birds migrate from the islands, flooding is just around the corner. On the other hand, the migration of birds to coastal communities is a sign that the flood has stopped. Additionally, flooding is indicated when birds begin to perch only on tall trees. The focus group discussion also revealed that immediately after observing the pattern of bird migration, residents of coastal communities move their pets and other valuables to safety because floodwaters often come at night.
		Increase fruit trees (E3)	Flooding is an abiotic stress that can affect plant growth, yield and fruit quality of many fruit tree species. In full of rain years, indigenous communities use the increase in the amount of fruiting trees to predict floods. When this phenomenon occurs clearly, it acts as a long-term warning mechanism for the residents of coastal areas.
		animal behavior (E4)	This is another flood forecasting measure used by coastal communities. They study animal behavior and use it to predict floods. The focus group discussion revealed that the croaking of frogs and toads indicates that a flood is around.
		The presence of beach flies and the increase of mosquitoes (E5)	This is an early warning sign that is accepted by coastal communities. They revealed that a high presence of greenish beach flies and an increase in mosquito infestations are signs to the community that flooding is around the corner. As soon as this happens, farmers quickly harvest their crops.
	Indigenous Meteorological knowledge	Extremely hot temperatures (M1)	Understanding temperature patterns, especially warm temperatures, is critical to flood forecasting. Extreme heat can lead to increased evaporation rates, which can contribute to the accumulation of moisture in the atmosphere and subsequently affect precipitation patterns, potentially leading to heavy rainfall and flooding events. By incorporating temperature data into flood forecasting models, researchers and decision makers can increase the accuracy and effectiveness of flood forecasting systems and ultimately improve preparedness and response strategies for flood events.
		Rainfall intensity (M2)	People also use the amount, distribution, and duration of rainfall to predict the onset, magnitude, and type of flooding. They revealed that when there is rainfall in December and then stops and starts again from January to March, and also when it starts raining continuously every 3 days, it indicates severe flooding.
		Occurrence of dark clouds (M3)	The occurrence of dark clouds can be a significant indicator for flood forecasting, especially when flood modeling and forecasting using Earth observation data is considered. In different communities, including in coastal areas, the presence of dark clouds is considered as a key indicator of heavy rains and the possibility of floods. Indigenous knowledge practices, as highlighted in the resources provided, include observing weather patterns, studying cloud formation, and interpreting natural signs such as animal behavior and tree changes to predict flood events.
		Heavy winds (M4)	Nature and direction of winds: People in the past have successfully used the nature and direction of winds to predict floods. The focus group discussion revealed that when the

			wind from the river is strong and blows south, there will be flooding that year. Similarly, when strong winds start approaching in May, major flooding occurs in that season. This situation was very evident in the recent flood.
	Indigenous Riverine knowledge	Increased sounds from the waters moving in the river (R1)	It is a predictive measure used by societies. They revealed that a river overflow or increased eddies in the river is a sign of an approaching flood.
		Colours of water (darker, muddier, increased debris) (R2)	The presence of large amounts of debris such as dead leaves, grass, polythene bags, and sand and silt particles indicates an impending flood. Also, the watercolor changes from yellowish brown to dark brown.
		Creation of foam in the waters (R3)	This technique is used by communities to predict floods. They revealed that the high foam and howling sound from the river was a sign of a fast approaching flood.
		Flood cycle (R4)	Coastal communities study the flood cycle to predict high magnitude floods. They revealed that high-magnitude floods occur on a two- to three-year cycle. In other words, when a big flood occurs this year, the previous year's flood will not be as big.
	Indigenous Celestial knowledge	Full moon (C1)	Coastal communities study the moon and use it to predict flood years. They revealed that the approach of a full moon at the time of peak rainfall indicates that a flood is imminent.
		Nature of water currents and tides (C2)	When the water currents move faster, especially in May, it signals to people that a flood is near. Also, the focus group discussion revealed that to recognize that a flood is imminent, it is when the water becomes very turbulent and the tide rises to a height of about 1 meter.
		Use the rainbow (C3)	Coastal communities have stated that they use rainbows to predict the magnitude of floods, even though this rarely happens. They revealed that the repeated appearance of rainbows infers that the flood of that year will be very large. They also revealed that three conditions are necessary for a rainbow to be accepted as a prediction. First, it must be raining. Second, there must be sunshine, and finally, the forecaster must come outside between the sun and the rain to see the rainbow.
	Indigenous human knowledge	Channelization (H1)	Canalization: These are local drains built by residents to divert floodwater from their communities to the river. The purpose of canalization is to drain floods in communities. The discussion of the focus group showed that in times of big floods, there are mudslides and drainage blockages.
		Parallel architecture of buildings (H2)	Buildings are tilted towards the direction of water flow to ensure that water does not get trapped in the building but flows downwards. The focus group discussion showed that the foundations of the buildings are high in such a way that one part of the foundation is higher than the other part, and as a result, the building leans to a level. They also noted that the buildings were stretched and lined up with the flow of the waterways (rather than across) to create a natural passageway for the water to flow through instead of standing still.
		Using the flooded surface of trees and docks (H3)	Local people have used the inundation level of trees and docks to predict the severity of flooding in their communities. The focus group discussion showed that when the water level only covers the pier in a year, it means that the flood intensity will not be high. On the other hand, if the water level reaches about three feet (90 cm) of a tree or building on higher ground near the pier, it indicates that there will be a flood that year.
		Building a deck to store food in times of crisis (H4)	It is a flood coping strategy used by local communities to store boat products and fish catches. This deck is high enough to prevent flood water from reaching the farm crops.
		Construction of temporary and low-cost houses (H5)	Most of the coastal communities' houses are made of mud, wood, and bamboo, and some live in tents. The focus group discussion revealed that this is a strategy adopted by people to minimize flood damage if their communities are completely submerged.
		Planting early crops (H6)	This is another emergency preparedness measure adopted by coastal communities to deal with flooding. They plant early crops that can be harvested within 3 to 6 months of planting before the flood approaches. Examples of these products include potatoes, vegetables, watermelons, etc.
		Bringing boats closer to home (H7)	It is a preliminary flood emergency measure adopted by coastal communities. The focus group discussion revealed that almost every family has a canoe that they keep very close to home to evacuate family members and property in case of flash floods.
		Road access (H8)	This is an early warning sign of impending flooding. They revealed that the inundation of access roads to communities indicated that flooding was imminent. On the other hand, the retreat of water from the access roads shows the reduction of floods.

1.4.1. Indigenous Ecological knowledge

In the studied communities, many ecological indicators were documented. In this category, it seeks to predict the occurrence of floods based on the specific behavior of animals. For the ecology class, 5 main categories were identified. The most common category was observing the increase in the number of fish in rivers by fishermen during floods. Among rural communities, observing the increase in the number of fish in the tributaries of rivers is used by fishermen as a phenomenon to predict floods. Mainly, this behavior of the fish shows that they take refuge in the tributaries to protect themselves, which can provide them with a safer and more favorable environment compared to the main river. By monitoring fish movements during floods, fishermen and researchers can gain valuable insights into fish behavior in response to changing environmental conditions. This behavior can be critical to the survival of fish populations during flood events, as it allows them to escape strong currents, debris, and other flood-related hazards. By studying fish movement patterns during floods, scientists can improve their understanding of fish behavior and use this information to improve flood prediction models and conservation efforts aimed at protecting fish populations and their habitats. Also, among rural communities, the migration of coastal birds such as seagulls is considered one of the other signs of flooding, and their disappearance is a sign of an accident. In addition to birds, the excessive sound of frogs and toads can be observed.

"When there's a flood, the birds move away from the area. They go several kilometers further. These animals give us a good understanding of how to deal with the flood. Wherever the birds migrate from, that's exactly where the flood wants to go. "

Most of the above categories occur in the short time period before the rainfall event. In the focus groups, it was noted that most of the floods occurred from December to May. Examples of animal behavior that indicate heavy rainfall or flooding in the future were discussed. For example, ducks raise their wings and want to be in the water, fishermen see and catch more "trout" than usual, and cows show signs of excitement.

Different species of trees were recorded as another important ecological indicator found in the communities visited and serve as an indication of the heavy rainfall expected in the coming season. Communities see trees as long-term information, as changes in trees can be seen from July to the flood season. Two main patterns were shown, i.e. the increase in the number of fruits and their abundant flowering are signs of the rainy season and warning. The abundance of weed growth in the area is effectively used to predict the occurrence of floods in coastal communities. The focus group discussion showed that when weeds started to grow in large quantities in the river and its course indicated an approaching flood. Finally, the focus group discussion also showed that immediately after observing the bird migration pattern, residents of coastal communities domesticated animals. And other valuables they take to a safe place because the floodwaters often come at night.

2.4.1. Indigenous Meteorological knowledge

Understanding the meteorological indicators that cause floods plays a vital role in predicting this destructive event. Weather indicators are considered as a main class in flood forecasting, which were extracted from the focus groups of four main categories. These indicators include "very hot temperature", "precipitation intensity", "occurrence of dark clouds" and "heavy winds", which provide valuable insight into weather conditions and help predict flooding. Indigenous communities try to make accurate predictions about possible flood events by analyzing various and complex criteria that are the result of the experience of their ancestors.

The participants stated in their interviews that the rain intensity pattern is the most important indicator of meteorological flood forecasting. Monitoring local rainfall patterns and intensity emerged as a major indicator of meteorological flood forecasting. As interviewee 5 quoted*: "We focus more on the intensity of the rain than on the clouds or the wind to understand that a flood is coming."* Study participants noted that the intensity of rainfall is indicative of future flooding, as it rains for several days in a row before a flood. It should be mentioned that the villagers pointed out that floods in their localities sometimes occur when there is no local rainfall, and the reason for that is the rainfall in the upper parts. Rainfall changes are closely monitored by communities to increase overall preparedness and secure early action. For example, they pointed out that in the olden days, when there was heavy rain, there were people responsible for monitoring the changes, who had the duty to warn other members of the community. If they notice heavy rain that starts in the morning and continues throughout the day in the evening, they stay awake and monitor the situation.

Meteorological indicators show both seasonality (i.e. forecast of heavy rainfall in the season) and more immediate feature (i.e. future flooding). Extremely hot temperatures starting in October and leading to the flood season are cited as one of the dominant indicators. Some of the villagers pointed out that during this period, the movements of the villagers are much less than before. Research participants directly associated higher temperatures in the coastal region with higher amounts of rainfall. Strong monsoon winds causing damage to houses (eg damage to roofs) during the flood season have also been documented. In addition, wind direction (both southerly and northwesterly winds) was also an indicator of impending heavy rains and floods. In addition, the meteorological indicators of the appearance of dark clouds and the increase of tornadoes have been reported. From the interviews obtained in this section, it can be concluded that meteorological indicators are defined in relation to ecological indicators in the short-term time domain for flood detection.

3.4.1. Indigenous Riverine knowledge

The study of Acharya [47] showed that river-based flood forecasting indicators are the most reliable indicators. Similar results can be obtained for the present study. Taking advantage of the availability of residual moisture, a large percentage of people farm along the river banks. Since flooding affects crops and perpetuates the cycle of disaster-poverty downstream, people have developed several strategies to monitor water and predict future flooding during their close relationship with flowing water. For example, one of the participants explained in this regard:

"The river water immediately before the flood is very dirty and they (the waters) come with garbage and wooden

planks and the moment they appear we know it's only a few hours before the river floods."

Villagers said that as the flood rises, the sound of the water in the river bed becomes louder and they realize that the water level is rising rapidly and the banks of the rivers are filled to their maximum capacity. The speed of the water has increased and challenges people to cross the rivers. The presence of rubbish and debris, muddy colours, the bottom of the waters and the foul smell emanating from the river have all been recorded as signs of the coming flood.

The nature of the water in the river is a predictive measure used by coastal communities to predict approaching floods through the smell of their rivers. Participant 12 stated that *"the closer it gets to the time of the flood, the river starts to smell like rotten eggs and is unfit to drink."*

Also, the contributors went on to state *that "a sudden change in water color from clear to deep brown indicates that a flood is about to occur."* Similarly, when the water starts to clear, it indicates that the floods have started to recede. This action was very useful for the beaches. The communities' response to the flood event has been useful.

4.4.1. Indigenous Celestial knowledge

Celestial indicators class compared to other indicator groups, celestial indicators were a smaller group. This class includes three main categories. In a number of societies, the full moon is considered a sign of heavy rain. A full moon between October and December indicates rain, and participants explained that the full moon is surrounded by stars that "fall over each other" in an east-west direction. In parallel, the tidal cycles created by the moon are important in interpretations. Strong tides create the possibility of waves of sea water and its entry into the land. The formation of rainbows along with the appearance of other signs can help predict floods. Despite the fact that this atmospheric phenomenon rarely occurs, its participants have expressed a high correlation between the presence of rainbows and the occurrence of floods in villages.

5.4.1. Indigenous Human knowledge

The class of human indicators with eight indications was identified as one of the most important classes to reduce the effects of floods in the villages of Chabahar city. Predicting the impact of flooding on livestock and smaller animals (such as goats, pigs and chickens) poses an additional challenge to communities, as animal replacement is often beyond the financial means of individuals. Hence, the participants explained the various mechanisms they developed to minimize the loss. For example, villagers built their poultry on high platforms and kept it from local materials to ensure safety during floods. As heavy rainfall and rising water levels are observed, larger animals, such as cattle, may move to higher elevations for grazing, and community members advise each other not to feed cattle near beaches or rivers. The results show that livestock management measures are mainly based on river flood forecasting indicators and meteorological conditions closer to the flood event.

By default, the existence of customary construction rules compatible with nature determines the unwritten rules of construction in the areas by prohibiting the construction of houses in accident-prone areas. However, observations show that in cases where such construction is unavoidable, before starting the structure, the area should be filled with sand and the foundation raised up to six blocks (1.2 m), which is less considered. The focus group discussion showed that the communities People are not allowed to build on low-lying land that is not part of the land designated for residential purposes. Another important and noteworthy point regarding the effects of flood risk in Chabahar county is that due to the smoothness of the land surface and the fineness of the soil texture and low permeability, it is faced with the spread and persistence of water on the surface of the land and the flooding of residential units in the settlements, especially the settlements, and many times in The reports of ABFA organization of Sistan and Baluchistan province and the published news have mentioned the extent and intensity of flooding in this province. For example, it is mentioned in the ABFA report of Sistan and Baluchistan province that:

"It should be noted that the type of soil is effective on the stability of the structures and preventing possible risks due to the loosening of the building, and the size and shape of the soil grains creates unique and special characteristics, which in this region, high absorption of moisture in fine-grained soils, the possibility It increases the settlement of the building... On the other hand, according to the report of the head of the earthquake and hazard department of the Road, Housing and Urban Development Research Center and based on the statistics of the Statistics Center in 2015, of all the residential units located in the settlements affected by the recent floods in Sistan and Baluchistan province, such as In Dashtiari area, around Chabahar and Konarak port, 18% of them are rural skeleton buildings and more than 80% of the rest are made of clay, stone, mud, and even mud Therefore, when they are exposed to water, they will absorb moisture and completely lose their previous strength, and under the influence of factors such as the occurrence of an earthquake, even if it is weak, the possibility of complete destruction increases Housing and Urban Development has recommended that in addition to the renovation of destroyed and flood-damaged units, standing buildings with the above conditions also need renovation and cannot be trusted to rebuild."

Other construction measures such as canalization, drainage by local farmers to direct water to fields around villages have been one of the common activities. Also, the comparison of the water level to the pier (water structures) helps to better understand the high probability of flooding. On the other hand, these docks are used for multipurpose activities. In addition to the measuring criteria, aspects of life and food security were used to store food in times of crisis. People revealed that they harvest their crops ahead of time and sell them as soon as they see any sign of approaching flood. This enables them to recoup part of the investment in planting crops.

Looking at the above components, it can be said that the local human knowledge that prevailed in the coastal villages of Chabahar has mainly provided solutions based on compatibility with nature. Hotak is one of the most comprehensive structures for collecting floods caused by seasonal rains in Chabahar villages. As the participants acknowledged; Hotak is a pit-shaped device that is built with the purpose of collecting floods caused by seasonal rainfall for various purposes, including providing drinking water for cattle and helping to irrigate seasonal crops. Contributors 1, 2, 3, 4, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29 and 30, 31 and 32 jointly mentioned this. For example, participant 23 stated that:

“Hotak or hotag in Balochi language means a big pit where water collects. Many times these hotags are formed naturally; whenever it rains, they are filled with water; now, due to the drought, many hotags are dry. .. Yes, these hotags help to control the flood, but the amount of water that is taken from the flood also depends on the size of the pit even use it for agriculture."

According to the report published by the water management of Sistan and Baluchistan province (2023), it shows that the construction of hotak is considered a conventional method of water extraction in the region. The report states that:

"Around Chabahar and Dashtiari region, the people of 548 villages use hotak for irrigation and cattle drinking purposes. Sometimes hotak are the unique water resources of Chabahar and Dashtiari region. Therefore, in most cases, next to Degar, Godtri area is called hotak. They create water for the village's consumption. After successive droughts, water extraction from Hotak is given a higher priority than Degar."

Coastal villages of Chabahar are among the areas that have the most prominent local methods in relation to flood exploitation. Hotek and Degar systems have been thriving in these areas in the villages of Kachu, Sham, Komb, Ramin, and Osman Abad since the distant past. Therefore, in this region, despite the development of modern irrigation, local methods are still the most efficient in these regions. Participant 3 says:

"In our village, the flood caused damage every time it came; this has been experienced for us; our ancestors came and made these "degars" to be able to store drinking water. From that time until now [this knowledge] has reached us and we also taught our children."

Relocation and evacuation have been identified as one of the oldest human strategies to reduce the effects of floods. Although it was challenging to determine the level of adherence to the warning message delivered through local channels, study participants explained that when advice is given to move from flood hotspots (eg, lowlands), some people will move to the area. Highlands In the highlands, there are several options where people will stay. Or with relatives, in evacuation centers (eg schools), tents or temporary shelters, or rented houses. In addition, some people may have houses in both low and high areas. Villagers explained that in most cases, women and children move to the highlands with livestock, while men may stay in the lowlands and monitor the situation. Near an impending flood event, based on weather and river indicators, some people look for a safe place in the mountains or on top of ant hills. It is evident that despite a large number of long-term local indicators (eg ecological), and a recommendation to move to higher ground, people in the studied communities prefer to wait closer to the flood event or even when the flood waters are approaching.

The interviews showed that the preparation of houses and temporary shelters have been recognized as an adaptation strategy. By showing an understanding and self-awareness of living in flood-prone areas, the studied communities emphasized several ways in which they strengthen houses before heavy rains, strong winds, and floods. Foundations are improved by adding an extra layer of mud around the houses. In addition, the roofs are reinforced by a process of thatching (i.e. adding extra layers of palm fronds) and covering the roof with plastic sheeting, thus preventing water leakage while making the roofs more resistant to strong winds. Those who live in mud houses may also add additional layers of mud. In addition to the retrofitting of houses, the construction of temporary shelters was also recorded. Traditional pavilions are built in flood-prone areas and families will stay in these temporary shelters during the rainy season.

The waters are rising. Based on these observations, a decision will be made regarding possible evacuation. In other cases, the participants mentioned that the water level was only observed without the use of sticks. We note that these are primary measures that do not directly reduce risk, but are more quantifiable and actionable indirectly through observing the river index (i.e. water level). In addition, there are several primary actions related to religion that lead to e.g. Increasing social cohesion or mental resilience was mentioned as an initial measure to reduce the effects of floods, which can have a long-term effect.

2.4. Measuring the effectiveness of local knowledge components of coastal villages in reducing the effects of floods

Examining the measurement model

Figure 1 shows the measurement model in the form of an output with path coefficients, R2 values and factor loadings. Because the values of factor loadings of items (observable variables) should not be less than 0.4. Therefore, as can be seen, the values of factor loadings are acceptable for all routes and R2 values greater than 0.4 have been obtained.

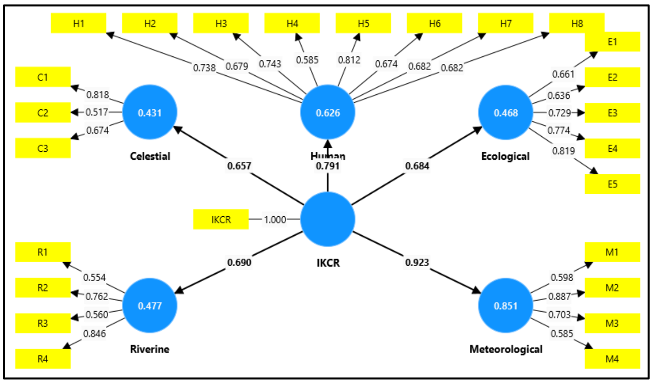


Figure 1- Implementation of the measurement model and its output

Therefore, the five main indigenous knowledge structures of the coastal villages of Chabahar region were confirmed. Respectively, Meteorological with a factor load of 0.851, Human with 0.626, Riverine with 0.477, and Ecological with 0.468 and Celestial with 0.431 had the greatest role in reducing flood effects. In Meteorological structure, Rainfall intensity (M2) with 0.887 and Occurrence of dark clouds (M3) with 0.703 have the highest factor loading and Heavy winds (M4) with 0.585 show the lowest factor loading. In the Human structure, two items Using the flooded Construction of temporary and low-cost houses (H5) with 0.812 and surface of trees and docks (H3) with 0.743 have the highest factor loadings and the item Building a deck to store food in times of crisis (H4) With 0.585, it shows the lowest factor loading. In the Riverine structure, two items Flood cycle (R4) with 0.846 and Colors of water (darker, muddier, increased debris (H2) with 0.762 have the highest factor loading and the item Increased sounds from the waters moving in the river (R1) with 0.556 have the lowest factor loading The two items The presence of beach flies and the increase of mosquitoes (E5) with 0.819 and animal behavior (E4) with 0.774 had the highest factor load and the item Migration of shorebirds (E2) had the lowest factor load with 0.636. In the Celestial structure, the two items Full moon (C1) with a score of 0.818 and Use the rainbow (C3) with 0.674 have the highest factor loading and the item Nature of water currents and tide (C2) has the lowest factor load (Figure-1)

Table 2: Fornell-Larcker criterion

	Celestial	Ecological	Human	IKCR	Meteorological	Riverine
Celestial	0.68					
Ecological	0.45	0.72				
Human	0.63	0.60	0.70			
IKCR	0.65	0.68	0.79	1		
Meteorological	0.62	0.56	0.71	0.92	0.70	
Riverine	0.61	0.45	0.70	0.69	0.60	0.69

In Table 2, the output of divergent validity (diagnostic validity) of the measurement model is presented. According to common views, the root is taken from the AVE values of hidden variables. If the root value of each latent variable is greater than the correlation of that variable with other reflective latent variables, the model has divergent validity. Based on this, the divergent or diagnostic validity of the measurement model is also acceptable.

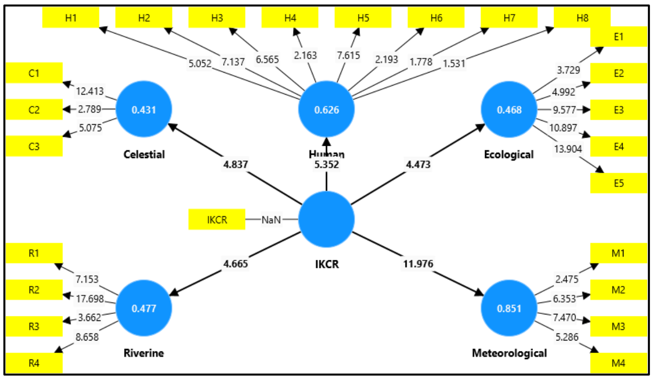


Figure 2: T values of the measurement model

Table 3: Test of research hypotheses (path and significance coefficients)

	Original sample (O)	R-square	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
IKCR -> Celestial	0.657	0.431	0.617	0.136	4.837	0
IKCR -> Ecological	0.684	0.468	0.64	0.153	4.473	0
IKCR -> Human	0.791	0.626	0.743	0.148	5.352	0
IKCR -> Meteorological	0.923	0.851	0.898	0.077	11.976	0
IKCR -> Riverine	0.69	0.477	0.647	0.148	4.665	0

Table 3 shows the significance of the model and its related indicators. Figure 2 also shows the T values of the measurement model. According to the measurement model, five routes have been examined and tested, the results of which are as follows:

Path of IKCR structure to Celestial: path coefficient value and T value are obtained as 0.657 and 4.837 respectively. This path is significant at the alpha level of one percent ($P \leq 0.01$) and the value of R2 is 0.431, which shows; 43.1% of the Celestial element is explained by the IKCR structure.

Path from IKCR structure to Ecological structure: path coefficient and T values in this path are 0.684

and 4.473, respectively. The mentioned path, which is significant at the alpha level of one percent ($P \leq 0.01$), shows the R2 value of 0.468; therefore, 46.8% of the changes in the Ecological element are explained by the IKCR structure.

Path of IKCR structure to Human structure: In this case, the path coefficient and T value were obtained as 0.791 and 5.352, respectively, which is significant at the alpha level of one percent ($P \leq 0.01$). Also, the value of R2 is equal to 0.626. In this way, 62.6% of the changes in the Human element can be explained by the IKCR structure.

The path of the IKCR structure to the Meteorological structure: the path coefficient and T value of this path are 0.923 and 11.976, respectively. The above path is significant at the alpha level of one hundredth ($P \leq 0.01$). The R2 value of 0.851 shows that 85.1% of the changes in the control element are explained by the structure of the organization, which is a significant amount.

IKCR structure path to Riverine structure: the path coefficient and T value of this path are obtained as 0.69 and 4.665, respectively. The above path is significant at the alpha level of one hundredth ($P \leq 0.01$). The R2 value of 0.477 shows that 47.7% of the changes in the Riverine element are explained by the IKCR structure.

5. Discuss

Considering a mixed approach, the present study tried to investigate the effectiveness of local knowledge components of coastal villages in reducing the effects of floods, focusing on the villages of Chabahar county. The researchers tried to bring out the hidden components of indigenous knowledge of coastal villages from the heart of the local community. The findings reveal a number of components of indigenous knowledge of coastal villages that are used by local people to predict future flood risks. The indicators that emerged through discussions with the study participants can be categorized into five different categories of ecological, meteorological, river, celestial and human indicators. It is obvious that the vast majority of indicators are directly related to people's observation and observation of changes in the natural environment around them and are highly context and case specific. The indigenous knowledge indicators of coastal villagers for floods are generally placed in one category. Indigenous early warning indicators that were obtained to deal with and predict floods, in many cases, have been derived from adaptation to the behaviors of their living environment. This suggests that communities have a high level of experience with flood risks in their area and have developed integrated warning systems. Also, the indicators that go from one society to another show a high similarity, which is most likely due to the geographical, social, cultural and economic conditions of the studied societies. This serves as a valuable lesson for governmental and non-governmental organizations living in the coastal villages of Chabahar county to deal with floods. However, there is a need to fully understand that efforts should be extended to understand this community-specific knowledge system and its context. However, there is no doubt that in case of establishing a Community-based Early Warning System, as one of the priority areas of the disaster risk management policy in the villages of Chabahar county, considering the local views about this system should be the starting point.

From the interpretation of the findings, it is inferred that the studied villages in Chabahar county have devised a wide range of coping and reduction strategies to minimize the effects of flood risks on their lives and livelihoods. This research provided a detailed description of these actions. However, the assessment of the effectiveness of the components showed that despite a large number of measures, a limited number of them are known to be efficient and some are only proposed as auxiliary and complementary components for predicting the flood of impact reduction. However, local communities state that these methods of flood detection and warning have been neglected, which is rooted in an overemphasis on academic knowledge. The combination of this situation with the ineffectiveness of institutions in charge of crisis management in the studied area makes local communities vulnerable to natural hazards such as floods. Possible explanations include insufficient dissemination and communication, lack of understanding, lack of timely action, and weak trust in the indigenous knowledge components of coastal villages by the custodian institutions.

The researchers' findings regarding the reduced reliability of IK warning signs are consistent with previous research. For example, Cagonio et al. (2016), while investigating the use of indigenous weather forecasting methods by pastoralists in northern Kenya, found that the increased frequency and severity of droughts in the past decade had negatively affected the reliability of indigenous forecasting. The findings of this issue should also be examined through the lens of methodological choices. Sampling for this, as well as our study, was designed for older people in communities, assuming that these people are more knowledgeable about the subject and are accustomed to using these signs. As IK communities have established themselves over decades and typically across a full range of climate variability, the question now arises as to how climate change (and related globalization processes) has and will affect these IK systems. In general, climate change and globalization are considered a threat to IK [48], although there is much research that explains the value of IK in climate change adaptation design [25]. It is likely that the inclusion of younger subjects in our study would have led to different findings, as they are likely to adapt to these changes differently than older subjects. At the same time, our findings show that - according to the elderly - young people rely less on IK. To confirm this point, a follow-up study with young people as the target group should be conducted. Despite the uncertainty surrounding the reliability of IK for EWS, the results of this study show that, in general, an indigenous EWS is considered more reliable than official warning information. This may be due to the previously discussed gaps in the existing formal system.

There are several limitations to the present study. First, the data collection process in each community was relatively short, with one half-day visit by one research team. However, due to a long-term relationship between MRCS and the communities under study, there was an existing connection and the research team members were able to extract as much information as possible. Second, even though the composition of FGD participants was communicated to community leaders in advance, FGDs sometimes included more than two individuals under the age of 55. The concept of IK for Disaster Risk Reduction from the perspective of not only the older community members (as is usually done in IK studies) but also of society as a whole, thus creating a more realistic picture. Third, it was challenging to attach a specific timeline to the observed indicators and to identify a trigger level for a specific indicator (eg, understanding the severity of future floods and heavy rains based on the number of ants occurring in the area). A possible solution for this could be the use of other tools from the rural participatory assessment spectrum (except for focus group discussions and semi-structured interviews) or innovative tools such as memory threads (Climate Center, 2013). In addition, in many cases, it was not possible to obtain photographic evidence of common predictive indicators due to the remote location of the interviews and FGDs and the timing of the study. Also, since communities provided examples of indicators in the local language (such as specific tree or animal species), it was not always possible to obtain an English or scientific name for the species. Finally, since the FGDs and KII were conducted in the local language, some information was lost in the translation to English. Every effort was made to minimize this effect on the validity of our findings.

Kamarudin, et al. [49] In order to more easily use IK to improve community-based and national EWS, our study suggests the integration of IK with scientific knowledge. categorize IK into a dimension of whether it can be scientifically explained (or not) and whether it is relevant for DRR or CCA, emphasizing that IKs that cannot be scientifically explained should continue to be used by communities. Apart from the scientific explanation, they also had communities that confirmed the IK that had been captured. Similarly, we propose to integrate the IK of this study with scientific knowledge, as a sequence of further identification and documentation as described in R1. This process should be carried out in a participatory and inclusive manner, including local communities, scientists and professionals, ensuring that documented IK is widely held and implemented in areas prone to floods and droughts (and not just in the study area). There is actually an IK connection for the initial action.

The analysis showed that Meteorological (with an influence coefficient of 0.923) was the most effective in reducing the risk of flood disasters among the five classes of indigenous flood control and management knowledge practices employed by coastal villages. Other classes such as Human, Riverine, Ecological and Celestial knowledge are followed in descending order. This empirical evidence supports the findings of the focus group discussion, which shows that indigenous knowledge systems have great potential in reducing flood risk in coastal communities. In general, five categories of indigenous flood control and management knowledge applied by coastal communities are included in the framework of global structural and non-structural flood risk management (FRM) measures. This indicates the presence of indigenous structural and non-structural practices of FRM in coastal communities. This suggests that coastal communities rely on indigenous structural and non-structural measures to reduce flood risk. Also, indigenous knowledge of coastal communities is compatible with modern flood risk management techniques in Chabahar county. It also shows that indigenous and modern flood control and management systems are in the same direction and related.

In addition, indigenous technical knowledge, which is an indigenous structural action, was the most effective indigenous flood control and management knowledge system employed by coastal communities. This means that indigenous technical knowledge is very effective in flood risk management. It also shows that the use of local technology in flood risk management can invent new ways to reduce flood risks. Such methods can be a link between local and specialized knowledge that minimizes the contribution of coastal villages' excessive dependence on imported expertise and technologies in the implementation of flood defense structures such as canals, embankments, and dikes. Understanding this issue can explain the reason for the failure of many measures to reduce flood risks in Chabahar and even other regions of the country, which are mostly foreign to local knowledge. The results of the research in line with the study of Trogrlić, et al. [50] indicate that the identification of the constituent components of indigenous knowledge, in addition to the greater efficiency of modern project macro-cost measures, moderates the elitism of projects towards the local community and leads to the use of modern technologies compatible with local characteristics.

The indigenous Meteorological knowledge method consists of four components of high heat, rainfall intensity, occurrence of dark clouds and heavy winds, which acts as a local warning system for flood control and management. Because high heat causes evaporation and increases the humidity of the air, and after that the masses of black and watery clouds start to rain heavily. Such components mainly occur in combination and local people acknowledge that the identification of one of these components alone cannot be considered a serious warning; but the collection of evidence can be used effectively. These results are consistent with the study of Bucherie, et al. [51]. Their results show that the interviewed Lake Malawi communities have detailed knowledge of flood early warning signs (changing clouds, wind direction and rainfall patterns) and distinct meteorological processes that lead to flash floods. In general, indigenous meteorological knowledge has a stronger warning power for flash floods than other categories.

In the context of indigenous human knowledge, it can help create a shared sense of confrontation and ownership of the project, which includes structured actions. This result is consistent with the focus group discussion; In a way that shows that indigenous human knowledge has contributed to eight major methods in reducing flood damage in coastal communities. First, the construction of canalization enables the collection of floodwaters and directs them to the river. Second, building buildings lined up along the river helps create a natural passageway for the water to flow instead of stagnant. Fourth, the use of human structures such as piers have been used to predict the intensity of floods. Fifth, they consider the use of low-cost materials for construction in order to minimize the damage caused by floods. Sixth, using natural warning systems to harvest agricultural products, which is considered a deterrent. Seventh, the construction of light boats for emergency preparedness and eighth, access to the road is considered as a warning mechanism. These results are consistent with the study of Macnight Ngwese, et al. [38], which show that indigenous human knowledge is an effective strategy for flood management in rural Ghana.

Three categories of indigenous knowledge practices, i.e. Riverine, Ecological and Celestial knowledge, include non-structural indigenous flood risk management practices employed by coastal communities. This is an indication that indigenous non-structural practices constitute a major part of FRM in coastal communities. The implication is that indigenous non-structural FRM measures developed and implemented by coastal communities are effective in reducing the risk of flood disasters. Also, it shows that the adoption of indigenous non-structural measures tends to minimize the flood risk disaster in the coastal villages of Chabahar county. Consequently, indigenous non-structural measures are very important and reliable FRM practices in coastal communities. Studies by Kelman, et al. [52] and Echendu [53] support the argument that there is a need to localize non-structural FRM practices in coastal villages. It is essential that indigenous non-structural measures are relevant in modern FRM practices. This result is consistent with the findings of the focus group discussion, which show that indigenous non-structural measures enable coastal communities to receive early warnings of impending flooding using the local knowledge system. Communities respond to the warning by harvesting their crops and taking their pets and other valuables to a safe place. This has been very effective in predicting flood events for decades, most notably a recent one that was one of the worst in 40 years. Also, signs of early rainfall, inundation of the access road, and high water flow and tide, which indicate the occurrence of a large flood, enable coastal communities to prepare preventive, safety and response measures to reduce the risk of flood disasters. In addition, the focus group discussion revealed that communities use indigenous safety knowledge practices to keep children and property safe from flood water. Coastal communities also built local silos to store farm produce and also hid during early warning of impending flooding to ensure that floodwaters did not destroy their farm produce based on indigenous food security practices. This ensures the availability of food in coastal communities during floods. Focus group discussion also revealed that indigenous flood control practices (such as construction of defense and water channels, sand dumping and tilting of buildings along the direction of water flow) enable coastal communities to minimize the effects of flooding and increase local capacity to overcome create a flood

5. Conclusion

The results of this study showed that the indigenous knowledge of the coastal village was divided into five categories. These are local ecological knowledge, local meteorological knowledge, local riverine knowledge, local celestial knowledge and local human knowledge, each of which can be of particular importance in controlling and managing floods in coastal villages according to the characteristics and environmental and human conditions of rural areas. This is compelling evidence that indigenous knowledge can provide pragmatic solutions for disaster minimization at many levels of governance. This study proposes a sustainable approach to flood disaster risk reduction based on the integration of indigenous knowledge and flood management strategies in a more adaptive and modern way. In addition, there is a need to formulate a policy instrument that promotes and publicizes indigenous knowledge and improves the capacity of indigenous technical knowledge of coastal communities to respond more to flood challenges.

The recurrence of floods in the country and in the province of Sistan and Baluchistan highlights the need to predict and prepare for risks, and especially emphasizes the need to improve infrastructure and apply effective flood control strategies that are compatible with the natural environment in the coastal villages of Chabahar county due to their high vulnerability. It is undeniable in different physical, social, economic and environmental aspects. Examining the situation of the studied areas shows that the coastal villages were more affected than other areas due to the intensity of sudden rainfall. In these areas, the weakness in infrastructure and communication network, structures, sewage network and surface water disposal is highly evident; in the situation that the experience of recent periods and even the review of past records show the pattern of recurring floods and flooding in the villages of Chabahar county.

Since ancient times, one of the most common ways to provide water in dry areas is to use rainwater, and in this province, people have co-existed with nature since the past, and in order to provide water for their consumption, based on local knowledge and knowledge of the region, rainwater is used. And they controlled the floods and directed them to certain places. Still, despite many advances in the field of science and technology, structures such as Hotak, Degar, Darband and Khoshab are used in different regions of Iran, especially in the studied area, to provide water and support people's lives. These methods and where should the structures be built? What is the type of soil used? Is it suitable for water extraction or not? The degree of permeability or impermeability of the soil, etc., is the result of the experience and years of coexistence of the natives with the region. It should be mentioned that in the past, people created these structures with the least facilities and using materials that are generally soil and stone, and they did not have powerful tools and machines for this work. But despite this, generations have been engaged in life and livelihood with these "nature-based solutions". Hotek is one of the most comprehensive structures for collecting floods caused by seasonal rains in Sistan and Baluchistan province. The creation of "Bandsar" in order to control floods, supply and adjust underground water and sustainable agricultural process has also been customary in different parts of Chabahar county. This method is also a "mechanism based on the knowledge and wisdom of Baloch natives and affected by the climatic conditions of the region" and can be considered a suitable strategic model for managing water resources and watershed management as well as sustainable agriculture. In particular, the natives of Chabahar and Konarak cities have been able to protect the sustainable resources of their climate for a long time by creating and constructing earthen dams (dams) to control floods, watersheds and increase and adjust the level of underground water (aquifers), create a bed of rich flood-prone soils, and stabilize the soil. Blocking the advance of the desert, especially the sand-blasted sediments, and in order to exploit sustainable agricultural products in a rainfed manner.

One of the most important points that is important in the floods of coastal rural areas of Chabahar county is the understanding of "taking advantage of the golden opportunity of flood storage" in order to use rainwater in the time periods when these areas are not only providing water in economic sectors but also in providing water. Drinking is also facing a dead end. Meanwhile, according to the statement of the chairman of the Agriculture, Water and Natural Resources Commission of the Islamic Council, nearly 2 cubic millimeters of water has flowed into the sea during the recent rains. In this way, it seems that despite the fact that the local knowledge of coastal villages can help watershed management and flood control in these areas; but it is still not taken into account and the coastal villages of Chabahar are highly vulnerable to these dangers.

These points are compelling evidence that indigenous knowledge can provide pragmatic solutions to minimize disasters at many levels of governance. In general, as the findings of this study show, any primary action at the local level is not solely informed by a single knowledge system, in this case, the indigenous knowledge system of coastal villages. Surveyed communities reported that some receive official warning information about imminent danger. Therefore, based on a complex process of triangulation between different sources of warning information, the decision to take initial actions is made. This shows that, like any other knowledge system, the indigenous knowledge system for the early warning system is constantly evolving and adapting to changing conditions. In any case, fully understanding local ways of coping and mitigation, auditing them, integrating them into planned interventions and strengthening them if possible can improve existing approaches by NGOs and government and provide more cost-effective interventions for DRR and actions. Provide humanitarian aid in the region.

7. Suggestions and applications of research results

Indigenous flood control and management knowledge is effective in reducing the risk of flood disasters in local coastal communities. Therefore, there is still a need to improve its level of effectiveness by inculcating modern flood control and management techniques in indigenous practices. This makes it more responsive to the challenges caused by floods in coastal communities. As a result, a sustainable approach to reduce the risk of flood disasters should include the integration of indigenous and modern disaster management strategies such that, first, the necessity of comprehensive watershed management as a conscious process to integrate different aspects of natural resource exploitation (biophysical, socio-political and economic) in A local sustainable management system should be designed in order to achieve the goals of the users (food security, profitability, risk reduction) considering the goals of the society (poverty reduction, welfare of future generations and environmental protection). Secondly, meteorological stations should be built in strategic locations of coastal communities. This allows coastal residents to learn about a set of weather parameters, especially precipitation parameters and wind speed and location. This will help them to improve their skill in flood forecasting instead of relying on the inundation level of trees, buildings and docks in studying flood cycle and flood forecasting. Second, the services of construction industry professionals, including architects, engineers, and urban planners, should be engaged in educating local people on the construction of affordable, sustainable houses of good aesthetic value, whose building materials are locally sourced and processed. This allows people to build houses that are more flood resistant. Also, the government should employ the services of engineers to train coastal communities in the construction of local bridges, dykes, and earthen ponds. This not only improves the indigenous technology base but also serves as a source of livelihood for the local people. Fourth, in an effort to reduce the impact of flooding, coastal communities harvest their crops as soon as they receive signals of impending flooding and sell the leftovers cheaply. To prevent this, the government should provide high-yielding, early-ripening seedlings and modern crop storage facilities in coastal communities. Camps should be established in flood-prone rural areas so that people are safe from the danger of floods. Insurance companies should be encouraged to operate in coastal communities. It allows people to insure their products and property. Coping strategies and other ways to reduce the flood risk of coastal communities should be harnessed by relevant organizations and integrated into the flood control and management system of coastal villages of Chabahar. This strengthens the capacity base of managers and residents of coastal rural areas in managing the challenges caused by floods in the coastal villages of Chabahar. The government, in cooperation with the coastal communities, should establish a more effective communication system by installing observation centers in the village squares of the coastal communities. This ensures easy and quick dissemination of information about impending flooding and quick response of coastal communities. Policy makers should develop mechanisms that promote and popularize indigenous knowledge. It should focus on public awareness, educational activities, and inculcation of indigenous knowledge in policies and programs at macro and micro levels. In addition, identification, validation and adaptation of indigenous knowledge will be key to their preservation as well as increased flood risk reduction in Chabahar coastal communities.

5. References

[1] D. Perera, J. Agnihotri, O. Seidou, and R. Djalante, "Identifying societal challenges in flood early warning systems," *International Journal of Disaster Risk Reduction*, vol. 51, p. 101794, 2020.

[2] A. J. Echendu, "The impact of flooding on Nigeria's sustainable development goals (SDGs)," *Ecosystem Health and Sustainability,* vol. 6, no. 1, p. 1791735, 2020.

[3] M. I. Brunner, L. Slater, L. M. Tallaksen, and M. Clark, "Challenges in modeling and predicting floods and droughts: A review," *Wiley Interdisciplinary Reviews: Water,* vol. 8, no. 3, p. e1520, 2021.

[4] G. Martinez, S. Costas, and Ó. Ferreira, "The role of culture for coastal disaster risk reduction measures: Empirical evidence from northern and southern Europe," *Advances in Climate Change Research,* vol. 11, no. 4, pp. 297-309, 2020.

[5] P. Bariweni, C. Tawari, and J. Abowei, "Some environmental effects of flooding in the Niger Delta Region of Nigeria," *International Journal of Fisheries and Aquatic Sciences,* vol. 1, no. 1, pp. 35-46, 2012.

[6] R. H. Bark and M. C. Acreman, "Investigating social processes that underpin local flood risk management action," *Environmental Science & Policy,* vol. 109, pp. 95-102, 2020.

[7] S. Arifin, S. S. Wicaksono, S. Sumarto, M. Martitah, and D. Sulistianingsih, "Disaster resilient village-based approach to disaster risk reduction policy in Indonesia: A regulatory analysis," *Jàmbá: Journal of Disaster Risk Studies,* vol. 13, no. 1, pp. 1-9, 2021.

[8] UN/ISDR, "Guidelines for Reducing Flood Losses: A Contribution to the International Strategy for Disaster Reduction," Retrieved online on the 19th of July, 2014 2014.

[9] E. Mudefi, "Disaster management 'deeds' in the context of April 2022 KwaZulu-Natal floods: A scoping review," *International Journal of Disaster Risk Reduction,* p. 104122, 2023.

[10] M. Tavakoli and A. Mokhtari Karchegani, "Analysis of factors affecting the structure of rural settlements in Makran coastal region in the face of climate change," (in eng), *Journal of Oceanography,* Research/ Original/ Regular Article vol. 13, no. 52, pp. 131-144, 2023, doi: 10.52547/joc.13.52.10.

[11] A. Mokhtari Karchgani, M. Tavakoli, G. Barzo, and K. Yar Ahmadi, "Prospects for smart villages and sustainable territorial development: a bibliometric analysis and systematic review," 2024, doi: 10.22034/JPD.2024.2023834.1051.

[12] R. A. Atanga, "The role of local community leaders in flood disaster risk management strategy making in Accra," *International journal of disaster risk reduction,* vol. 43, p. 101358, 2020.

[13] M. Biranvandzadeh, J. M. HESHMATI, and K. Sorkhkamal, "Assessment of development level of Sistan and Baluchistan province compared to other Iran's provinces," 2015.

[14] M. Mirzabeygi *et al.*, "Heavy metal contamination and health risk assessment in drinking water of Sistan and Baluchistan, Southeastern Iran," *Human and Ecological Risk Assessment: An International Journal,* vol. 23, no. 8, pp. 1893-1905, 2017.

[15] R. I. o. N. Disasters, "Flood report of April 1403 in Sistan and Baluchistan province," Research Institute of Natural Disasters, 2024, vol. 1.

[16] M. Banan-Dallalian, M. Shokatian-Beiragh, A. Golshani, and A. Abdi, "Use of a Bayesian Network for storm-induced flood risk assessment and effectiveness of ecosystem-based risk reduction measures in coastal areas (Port of Sur, Sultanate of Oman)," *Ocean Engineering,* vol. 270, p. 113662, 2023.

[17] D. Mafi-Gholami, A. Jaafari, E. K. Zenner, A. N. Kamari, and D. T. Bui, "Vulnerability of coastal communities to climate change: Thirty-year trend analysis and prospective prediction for the coastal regions of the Persian Gulf and Gulf of Oman," *Science of the Total Environment,* vol. 741, p. 140305, 2020.

[18] J. Mapara, "Indigenous knowledge systems in Zimbabwe: Juxtaposing postcolonial theory," 2009.

[19] G. M. Membele, M. Naidu, and O. Mutanga, "Using local and indigenous knowledge in selecting indicators for mapping flood vulnerability in informal settlement contexts," *International journal of disaster risk reduction,* vol. 71, p. 102836, 2022.

[20] M. Mbah, S. Ajaps, and P. Molthan-Hill, "A systematic review of the deployment of indigenous knowledge systems towards climate change adaptation in developing world contexts: implications for climate change education," *Sustainability,* vol. 13, no. 9, p. 4811, 2021.

[21] G. P. Cuaton and Y. Su, "Local-indigenous knowledge on disaster risk reduction: Insights from the Mamanwa indigenous peoples in Basey, Samar after Typhoon Haiyan in the Philippines," *International Journal of Disaster Risk Reduction,* vol. 48, p. 101596, 2020.

[22] V. Jha and A. Jha, "Traditional knowledge on disaster management: A preliminary study of the Lepcha community of Sikkim, India," 2011.

[23] T.-L. Chen and H.-W. Cheng, "Applying traditional knowledge to resilience in coastal rural villages," *International Journal of Disaster Risk Reduction,* vol. 47, p. 101564, 2020.

[24] R. Obi, M. U. Nwachukwu, D. C. Okeke, and U. Jiburum, "Indigenous flood control and management knowledge and flood disaster risk reduction in Nigeria's coastal communities: an empirical analysis," *International journal of disaster risk reduction,* vol. 55, p. 102079, 2021.

[25] J. Petzold, N. Andrews, J. D. Ford, C. Hedemann, and J. C. Postigo, "Indigenous knowledge on climate change adaptation: A global evidence map of academic literature," *Environmental Research Letters,* vol. 15, no. 11, p. 113007, 2020.

[26] M.-U.-I. Choudhury, C. E. Haque, A. Nishat, and S. Byrne, "Social learning for building community resilience to cyclones: role of indigenous and local knowledge, power, and institutions in coastal Bangladesh," *Ecology & Society,* vol. 26, no. 1, 2021.

[27] M. Parsons, J. Nalau, K. Fisher, and C. Brown, "Disrupting path dependency: Making room for Indigenous knowledge in river management," *Global Environmental Change,* vol. 56, pp. 95-113, 2019.

[28] A. Hadlos, A. Opdyke, and S. A. Hadigheh, "Where does local and indigenous knowledge in disaster risk reduction go from here? A systematic literature review," *International journal of disaster risk reduction,* vol. 79, p. 103160, 2022.

[29] W. Leal Filho *et al.*, "The role of indigenous knowledge in climate change adaptation in Africa," *Environmental Science & Policy,* vol. 136, pp. 250-260, 2022.

[30] A. Mokhtari Karchegani and A. God bless you, Morteza, "The pattern of livelihood adaptation of rural communities in Iran in the face of climate change," *Geography and environmental hazards*, pp. -, 2023, doi: 10.22067/geoeh.2023.83326.1392.

[31] J. Paulraj and J. Andharia, "Resilience of indigenous peoples to disasters: An exploration of practices of Konyak community, Nagaland," *European Scientific Journal,* 2015.

[32] H. O. Kaya and M. Koitsiwe, "African indigenous knowledge systems and natural disaster management in North West Province, South Africa," *Journal of Human Ecology,* vol. 53, no. 2, pp. 101-105, 2016.

[33] M. T. Sohail and S. Chen, "A systematic PLS-SEM approach on assessment of indigenous knowledge in adapting to floods; A way forward to sustainable agriculture," *Frontiers in Plant Science,* vol. 13, p. 990785, 2022.

[34] N. Neeta, "Indigenous knowledge practices as mechanism for flood management and disaster risk reduction: the case of the Lozi people of Zambia," *Indilinga African Journal of Indigenous Knowledge Systems,* vol. 15, no. 2, pp. 140-150, 2016.

[35] J. Udie, S. Bhattacharyya, and L. Ozawa-Meida, "A conceptual framework for vulnerability assessment of climate change impact on critical oil and gas infrastructure in the niger delta," *Climate,* vol. 6, no. 1, p. 11, 2018.

[36] H. He, R. Li, J. Pei, J.-P. Bilodeau, and G. Huang, "Current overview of impact analysis and risk assessment of urban pluvial flood on road traffic," *Sustainable Cities and Society,* p. 104993, 2023.

[37] T. F. Theodory, "Dealing with Change: Indigenous Knowledge and Adaptation to Climate Change in the Ngono River Basin, Tanzania," Ph.D dissertation., Rheinische Friedrich Wilhelms University Of Bonn, Germany, 2016.

[38] N. Macnight Ngwese, O. Saito, A. Sato, Y. Agyeman Boafo, and G. Jasaw, "Traditional and local knowledge practices for disaster risk reduction in Northern Ghana," *Sustainability,* vol. 10, no. 3, p. 825, 2018.

[39] P. A. Williams, N. P. Simpson, E. Totin, M. A. North, and C. H. Trisos, "Feasibility assessment of climate change adaptation options across Africa: an evidence-based review," *Environmental Research Letters,* vol. 16, no. 7, p. 073004, 2021.

[40] A. Gori *et al.*, "Accessibility and recovery assessment of Houston's roadway network due to fluvial flooding during Hurricane Harvey," *Natural hazards review,* vol. 21, no. 2, p. 04020005, 2020.

[41] P. Salah and J. Sasaki, "Knowledge, awareness, and attitudes toward tsunamis: A local survey in the southern coast of Iran," *Sustainability,* vol. 13, no. 2, p. 449, 2021.

[42] S. Islam, F. Goerlandt, X. Feng, M. J. Uddin, Y. Shi, and C. Hilliard, "Improving disasters preparedness and response for coastal communities using AIS ship tracking data," *International Journal of Disaster Risk Reduction,* vol. 51, p. 101863, 2020.

[43] J.-M. Becker, J.-H. Cheah, R. Gholamzade, C. M. Ringle, and M. Sarstedt, "PLS-SEM's most wanted guidance," *International Journal of Contemporary Hospitality Management,* vol. 35, no. 1, pp. 321-346, 2023.

[44] A. Kamis, R. A. Saibon, F. Yunus, M. B. Rahim, L. M. Herrera, and P. Montenegro, "The SmartPLS analyzes approach in validity and reliability of graduate marketability instrument," *Social Psychology of Education,* vol. 57, no. 8, pp. 987-1001, 2020.

[45] C. M. Ringle, M. Sarstedt, N. Sinkovics, and R. R. Sinkovics, "A perspective on using partial least squares structural equation modelling in data articles," *Data in Brief,* vol. 48, p. 109074, 2023.

[46] M. Sarstedt and J.-H. Cheah, "Partial least squares structural equation modeling using SmartPLS: a software review," ed: Springer, 2019.

[47] I. Acharya, "Indigenous flood management techniques from gender perspective: A case of Kailali district," *Administration and Management Review,* vol. 24, no. 1, pp. 103-119, 2012.

[48] J. Mercer, "Knowledge and disaster risk reduction," in *Handbook of hazards and disaster risk reduction*: Routledge, 2012, pp. 97-108.

[49] K. H. Kamarudin, M. F. Rashid, and N. O. Chong, "Local community knowledge for flood resilience: A case study from East Coast Malaysia," *International journal of built environment and sustainability,* vol. 9, no. 2, pp. 21-34, 2022.

[50] R. Trogrlić, M. van den Homberg, and N. R. Cross, "Indigenous knowledge and early warning systems in the Lower Shire Valley in Malawi," ed: Technical Report, 2018.

[51] A. Bucherie, M. Werner, M. van den Homberg, and S. Tembo, "Flash flood warnings in context: combining local knowledge and large-scale hydro-meteorological patterns," *Natural Hazards and Earth System Sciences,* vol. 22, no. 2, pp. 461-480, 2022.

[52] I. Kelman, J. Mercer, and J. Gaillard, "Indigenous knowledge and disaster risk reduction," *Geography,* vol. 97, no. 1, pp. 12-21, 2012.

[53] A. J. Echendu, "Applicability of Indigenous knowledge and methods in flood risk management in a nigerian city," *Natural Hazards Research,* 2023.