

Traditional Weather Forecasting in the Age of Climate Change: Folk Meteorology, Indigenous Knowledge, Disaster Preparedness, and Coastal Resilience in the Philippines

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Abstract: Despite increasing attention to disaster risk reduction and climate adaptation in the Philippines, limited research has examined folk meteorology as a culturally embedded system of local ecological intelligence among coastal communities. Existing studies often prioritize scientific forecasting technologies while overlooking how Indigenous environmental interpretation continues to shape preparedness and resilience in everyday life. Addressing this gap, the study explored how coastal Bicolano communities interpret environmental warning signs, transmit traditional forecasting knowledge, and integrate folk meteorology with modern disaster forecasting systems. Using a qualitative research design grounded in hermeneutic phenomenology and narrative inquiry, in-depth interviews, narrative conversations, participant observation, and field immersion were conducted among coastal residents, fisherfolk, and disaster survivors from typhoon-prone communities in Camarines Sur, Albay, and Catanduanes, Philippines. Reflexive thematic analysis revealed that folk meteorology remains deeply embedded within community life and disaster anticipation practices. Participants identified sea behavior, atmospheric conditions, celestial formations, animal movements, and embodied environmental sensations as important ecological indicators associated with approaching typhoons, floods, and storm surges. The findings further revealed that coastal communities do not perceive traditional ecological knowledge and scientific forecasting systems as competing forms of knowledge. Instead, respondents actively combine Indigenous ecological observations with official advisories, television forecasts, Facebook weather updates, and mobile weather applications to strengthen preparedness and adaptive decision-making. Beyond forecasting, folk meteorology also functions as a form of environmental hermeneutics shaping emotional resilience, cultural identity, and environmental awareness. The study emphasizes the importance of integrating local ecological intelligence into culturally grounded disaster risk reduction, climate adaptation, and community-based resilience planning in increasingly hazard-prone coastal environments.

Keywords: folk meteorology; local ecological intelligence; disaster preparedness; indigenous knowledge systems; coastal resilience; hybrid forecasting; climate adaptation

1. Introduction

Communities exposed to recurrent environmental hazards often develop localized systems of interpreting nature, weather, and ecological change as part of their survival and adaptation strategies. Across many coastal and rural societies, generations of repeated exposure to storms, floods, droughts, and changing climatic conditions have produced culturally embedded forms of environmental knowledge that shape risk perception, preparedness behavior, and community resilience [1,2]. These systems of knowledge, commonly referred to as folk meteorology or local ecological knowledge, are derived not from formal scientific instruments but from lived experiences, long-term observation of environmental patterns, and intergenerational transmission of ecological interpretation [3–8]. In disaster-prone regions, such knowledge systems continue to influence how communities anticipate hazards, interpret warning signs, and prepare for impending calamities.

The Philippines is among the most disaster-prone countries in the world due to its geographic exposure to tropical cyclones, floods, landslides, volcanic eruptions, and other natural hazards [9,10]. Situated along the western Pacific typhoon belt, the country experiences an average of approximately twenty tropical cyclones annually, many of which result in destructive flooding, storm surges, and widespread socio-economic disruption [11]. Within the Philippines, the Bicol Region occupies a particularly vulnerable position because of its direct exposure to the Pacific Ocean. Historical records indicate that the region has experienced more than two hundred tropical cyclones since the mid-twentieth century, including some of the strongest landfalling typhoons in Philippine history [12,13]. Consequently, Bicolanos have developed deep familiarity with typhoons and other climate-related hazards through centuries of repeated exposure and survival.

Despite advances in meteorological science, disaster forecasting technologies, and artificial intelligence-based weather prediction systems, local communities in hazard-prone areas continue to rely partly on traditional environmental indicators when anticipating storms and extreme weather events [2,7]. Fisherfolk, farmers, and coastal households often interpret changes in sea conditions, cloud formations, animal behavior, wind direction, humidity, tides, and other ecological signals as warning signs of an approaching typhoon. Such practices are especially common in rural and coastal communities where environmental observation forms part of everyday life and livelihood activities. These systems of folk meteorology are not merely collections of superstitious beliefs or informal stories but represent accumulated environmental experiences shaped by long-term interactions between humans and nature [6].

Recent disaster studies increasingly recognize the importance of integrating Indigenous knowledge systems and local ecological intelligence into disaster risk reduction and climate adaptation frameworks [7,14]. Local knowledge contributes to community resilience by strengthening environmental awareness, improving preparedness behavior, and fostering collective memory regarding past disasters [2]. Studies have shown that communities possessing strong local ecological knowledge are often better able to interpret environmental risks and mobilize adaptive responses during hazards [15]. However, much of the existing literature remains dominated by quantitative hazard modeling, technological forecasting systems, and macro-level vulnerability analysis, while localized systems of environmental interpretation remain understudied, particularly in the Philippine context.

In the Bicol Region, folk understandings of typhoons and environmental hazards remain deeply embedded in everyday narratives and disaster experiences. Coastal residents frequently associate unusual sea behavior, sudden silence of birds, changes in wave intensity, darkening horizons, and atmospheric conditions with the arrival of strong typhoons. Among some communities, expressions such as “the sea fights the typhoon” reflect localized interpretations of coastal processes during storms and symbolize the relationship between nature, survival, and resilience. These interpretations demonstrate that environmental hazards are understood not only through scientific forecasting but also through culturally mediated systems of ecological meaning and observation.

Previous studies conducted in the Bicol Region have revealed the increasing integration of disaster science, machine learning, and community-based disaster preparedness approaches. Onsay and Rabajante demonstrated the potential of combining machine learning and participatory rural appraisal for predicting disaster risk preparedness in vulnerable communities [16]. Similarly, recent studies on Bagyong Kristine (TS Trami) and Super Typhoon Pepito emphasized the importance of combining econometric forecasting, artificial intelligence, and lived experiences to understand flood risks, storm surge vulnerability, and disaster resilience among coastal households [12,17]. These works further revealed that many households continue to interpret natural signs and ecological cues alongside scientific advisories and digital weather forecasts. Moreover, behavioral studies on non-landfalling tropical cyclones suggest that local perceptions of hazards are strongly shaped by prior experiences, environmental familiarity, and culturally embedded interpretations of storm risks as reported in the preprint study by Onsay [18,19].

While previous research has significantly contributed to understanding disaster preparedness, machine learning prediction, and risk perception in typhoon-prone communities, limited attention has been devoted

specifically to folk meteorology as a localized knowledge system in the Philippines. Existing studies often mention Indigenous or traditional knowledge only as secondary findings rather than examining them as central frameworks of environmental intelligence and preparedness. Consequently, there remains insufficient understanding of how coastal communities interpret ecological signs before typhoons, how these interpretations are transmitted across generations, and how traditional forecasting systems continue to shape preparedness behavior in contemporary disaster contexts increasingly influenced by scientific forecasting technologies and climate change.

This study addresses this gap by examining folk meteorology as a form of local ecological intelligence within a coastal Philippine community in the Bicol Region. Specifically, the study explores how residents interpret environmental signs associated with approaching typhoons, how traditional forecasting knowledge is learned and transmitted, and how these practices influence disaster preparedness and community resilience. By situating folk meteorology within broader discussions of disaster risk reduction, environmental hermeneutics, and local ecological knowledge, this study argues that traditional forecasting practices function not merely as cultural artifacts but as adaptive systems of environmental interpretation developed through repeated exposure to climatic hazards.

Furthermore, this study contributes to emerging interdisciplinary disaster scholarship that seeks to bridge scientific forecasting and culturally grounded environmental knowledge systems. Rather than positioning folk knowledge in opposition to meteorological science, the study examines how local communities hybridize traditional ecological interpretation with modern disaster advisories, social media information, and artificial intelligence-based weather forecasting. Such hybrid systems of preparedness are increasingly important in climate-vulnerable regions where communities navigate uncertainty through both scientific and experiential forms of knowledge.

As climate change intensifies the unpredictability and severity of tropical cyclones globally, understanding localized forms of ecological intelligence becomes increasingly relevant for inclusive and culturally sensitive disaster risk reduction strategies [20]. This research therefore contributes not only to disaster studies and environmental sociology but also to broader discussions concerning resilience, climate adaptation, Indigenous knowledge systems, and community-centered disaster governance. Ultimately, the study presents the importance of preserving and understanding folk meteorology as part of the lived environmental heritage and adaptive resilience of coastal communities in the Philippines.

To provide an analytical structure for interpreting participants' narratives, the study organizes the findings around four interrelated dimensions: recognition, participation, mediation, and impact. Recognition refers to how coastal residents identify and interpret environmental signs associated with approaching hazards. Participation captures the ways local ecological knowledge is learned, shared, and transmitted through observation, storytelling, and community interaction. Mediation refers to the processes through which traditional ecological knowledge is combined with scientific forecasting systems and contemporary information sources. Finally, impact examines how these interpretations influence preparedness behaviors, adaptive responses, and community resilience. These dimensions provide the analytical lens through which the relationships illustrated in Figure 1 are examined throughout the study.

This work is guided by a conceptual framework that positions folk meteorology as a form of local ecological intelligence developed through continuous interaction with coastal environments and recurrent exposure to climatic hazards. Drawing from the concepts of local ecological knowledge [6], environmental hermeneutics, and community resilience, the framework proposes that coastal residents engage in systematic observation of environmental indicators such as sea behavior, atmospheric conditions, celestial signs, and animal behavior. These observations are accumulated through intergenerational learning and collective ecological memory, forming a culturally embedded system of folk meteorology. The framework further suggests that environmental observations are interpreted through local meanings and experiences, which influence preparedness behaviors such as securing livelihoods, protecting property, storing supplies, and making evacuation decisions. These preparedness actions contribute to community resilience by enhancing adaptive capacity, collective learning, and social cohesion. In the context of increasing climate uncertainty, folk meteorology does not operate independently from scientific forecasting. Rather, local communities integrate traditional ecological knowledge with official weather advisories, social media updates, and digital forecasting technologies, creating a hybrid forecasting system that supports disaster risk reduction and climate adaptation. Figure 1 illustrates the proposed relationships among environmental observation, folk meteorology, environmental interpretation, preparedness behavior, community resilience, and hybrid forecasting within the context of climate uncertainty.

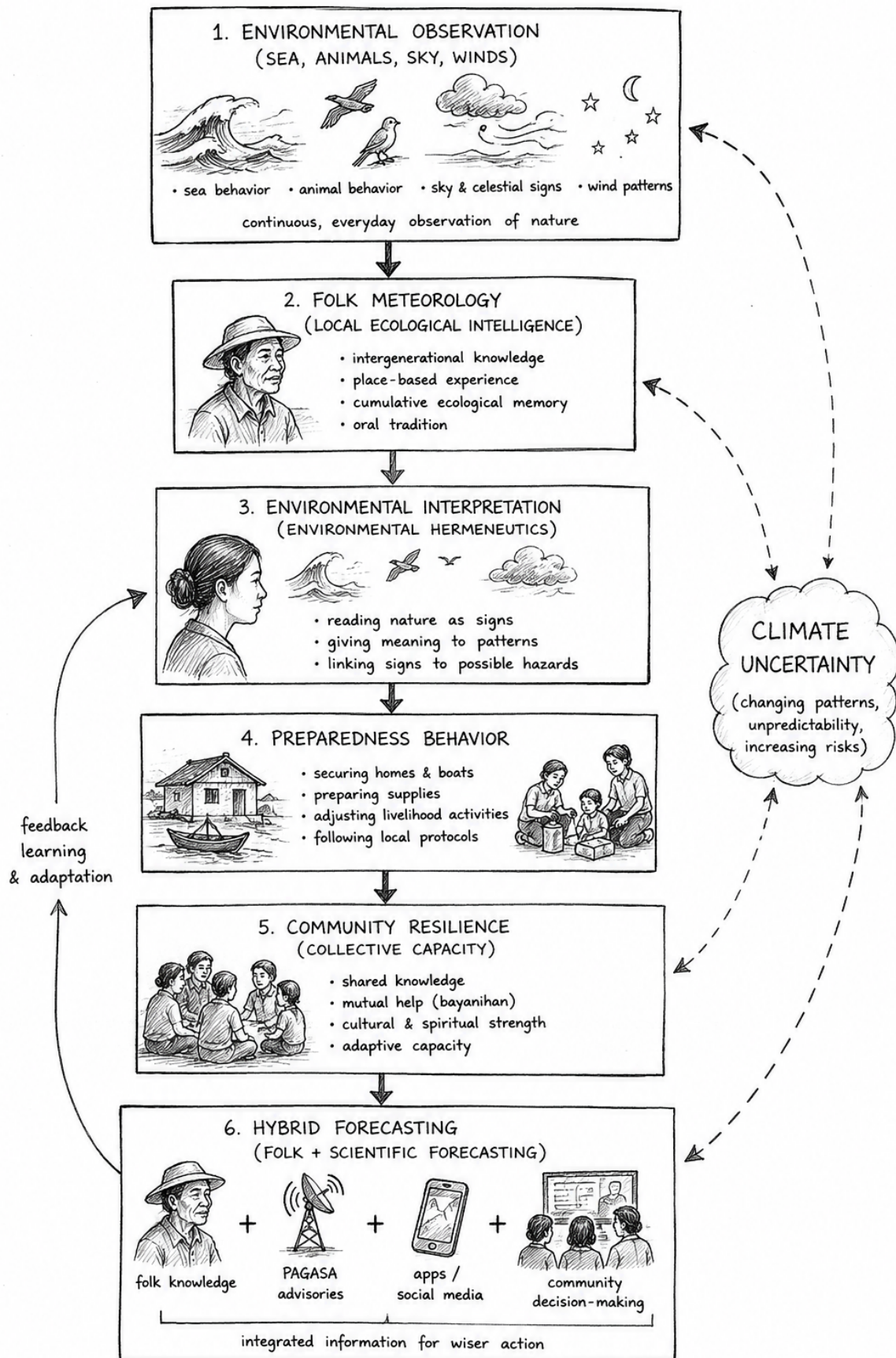


Figure 1. Conceptual framework of folk meteorology as local ecological intelligence and hybrid disaster preparedness.

2. Materials and Methods

2.1. Research Design

This study employed a qualitative research design grounded in hermeneutic phenomenology and narrative inquiry to explore folk meteorology as a form of local ecological intelligence in a coastal Philippine community. Hermeneutic phenomenology was utilized to interpret the meanings, lived experiences, and cultural understandings attached to traditional typhoon prediction practices, while narrative inquiry enabled the collection of community stories, memories, and intergenerational environmental knowledge related to storms and disaster preparedness [21]. The study also incorporated elements of anthropology-at-home, recognizing the researcher's cultural familiarity and immersion within the disaster-prone coastal context of the Bicol Region [22].

2.2. Study Area

The study was conducted in selected coastal communities in the Partido District, Camarines Sur, Bicol Region, Philippines (Figure 2). The Bicol Region is among the most hazard-prone areas in the country due to its direct exposure to the Pacific Ocean and frequent typhoon landfalls. Historically referred to as the “land of howling winds” and the “super typhoon capital” of the Philippines, the region has experienced repeated exposure to destructive tropical cyclones, storm surges, floods, and extreme rainfall events over several decades [12,23]. The selected coastal communities are characterized by strong dependence on fishing, farming, and marine-related livelihoods, making environmental observation highly embedded in everyday life. Repeated exposure to typhoons has contributed to the development of localized forecasting practices and ecological interpretations passed down through generations. These communities were purposively selected because of their extensive disaster experiences and the persistence of traditional weather prediction practices alongside modern forecasting systems, consistent with studies emphasizing the importance of local ecological knowledge in disaster-prone coastal societies [6, 16].



Figure 2. Map of the Bicol Region.

2.3. Participants and Sampling Procedure

The study involved two sets of respondents drawn from selected coastal and disaster-prone communities in the Bicol Region, Philippines. The respondents were purposively selected based on their lived experiences with typhoons, flooding, storm surges, and traditional environmental forecasting practices. Participants were chosen specifically because of their familiarity with coastal hazards, local ecological conditions, and community-based disaster preparedness practices, consistent with purposive sampling approaches commonly employed in qualitative and phenomenological research [21,24].

The first set of respondents consisted of 12 household participants from various flood-prone communities in Camarines Sur who previously experienced severe flooding during Bagyong Kristine (TS Trami). These respondents came from the municipalities and communities of Calalahan, Talisay, Sabang, Kinalansan, Dolo, Telegrafo, Minor, Tagas, Tambangan, Milaor, Naga City, and Bula. The participants included mothers, fathers, fisherfolk, students, elderly residents, professionals, entrepreneurs, teachers, and blue-collar workers belonging to varying socio-economic backgrounds. Many respondents lived in low-lying coastal or river-adjacent communities highly vulnerable to flooding and typhoon-related hazards.

The second set of respondents consisted of 13 coastal residents and fisherfolk from typhoon-prone communities in Camarines Sur, Albay, and Catanduanes who shared narratives regarding folk meteorology, storm surge experiences, and traditional typhoon prediction practices during Super Typhoon Pepito. These respondents included retired fisherfolk, fish vendors, clam harvesters, dried fish producers, boat makers, homemakers, and coastal residents from Telegrafo, Sabang, Tagas, Calalahan, Manzana, Dolo, Lagonoy, Presentacion, Caramoan, Garchitorena, Sagñay, Tiwi, and Pandan, Catanduanes. Most participants belonged to low-income and climate-vulnerable households whose livelihoods were highly dependent on fishing and marine-related economic activities, reflecting the vulnerability of coastal populations repeatedly exposed to climate-related hazards [12,17,23].

Several elderly respondents from both groups were recognized within their communities as knowledgeable regarding traditional weather interpretation, environmental signs, sea behavior, wind direction, animal behavior, and local forecasting practices. Their lived experiences provided important insights into the intergenerational transmission of folk meteorology and local ecological intelligence among coastal Bicolano communities. Similar studies have emphasized the role of elders and fisherfolk as key custodians of Indigenous ecological knowledge and environmental memory in disaster-prone coastal societies [6,7].

Collectively, the two groups of respondents provided rich qualitative narratives regarding:

- (a) folk meteorological beliefs and practices;
- (b) traditional disaster preparedness;
- (c) coastal environmental interpretation;
- (d) typhoon and flooding experiences;
- (e) resilience and adaptation strategies; and
- (f) the integration of local ecological knowledge with modern forecasting systems.

2.4. Data Collection Procedures

The study employed qualitative data gathering methods grounded in hermeneutic phenomenology and narrative inquiry. Before fieldwork, preliminary community coordination and informal consultations were conducted to identify potential participants possessing extensive experiences and knowledge regarding typhoons, flooding, coastal hazards, and traditional forecasting practices. Such community immersion and relational engagement are essential in qualitative fieldwork to establish trust, contextual understanding, and cultural sensitivity during data collection [25].

Purposive and snowball sampling techniques were utilized in selecting respondents. Initial participants were identified through local contacts and community referrals, while succeeding participants were recommended by earlier respondents recognized as knowledgeable regarding folk meteorology and disaster experiences. Snowball sampling is particularly useful in locating participants possessing specialized experiential and community-based knowledge that may not be easily accessible through conventional sampling procedures [26].

Data gathering was conducted through in-depth semi-structured interviews, narrative conversations, and informal sharing sessions. The first set of respondents focused primarily on lived experiences during Bagyong Kristine, flood experiences, preparedness practices, resilience, and environmental perceptions. Meanwhile, the second set of respondents focused more extensively on folk meteorology, local ecological intelligence, traditional typhoon prediction practices, storm surge interpretation, and community preparedness during Super Typhoon Pepito. Narrative interviewing allowed participants to freely articulate meanings, memories, and environmental interpretations rooted in lived disaster experiences [27].

Participants were asked open-ended questions regarding:

- (a) their past experiences with typhoons and disasters;
- (b) local environmental indicators associated with approaching storms;
- (c) interpretations of sea conditions, waves, winds, clouds, and animal behavior;
- (d) local beliefs, intuitions, and superstitions regarding typhoons;
- (e) traditional preparedness and evacuation practices;
- (f) perceptions regarding climate change and environmental degradation;
- (g) and their views regarding disaster risk reduction and management.

The interviews were conducted primarily in Bikol languages and Filipino to preserve the contextual meanings, local expressions, and authenticity of participants' narratives. Several respondents spoke in Bikol Partido, Bikol Central, Rinconada Bikol, and other local dialects commonly used in their respective communities. Interviews were audio-recorded with participants' consent and supplemented with field notes documenting environmental settings, participant emotions, non-verbal responses, and contextual observations. Using participants' native languages in qualitative inquiry enhances cultural authenticity and preserves locally embedded meanings often lost in direct translation [28].

The researcher also conducted participant observation in selected coastal communities to observe:

- (a) sea conditions and coastal landscapes;
- (b) fishing and marine-related activities;
- (c) housing conditions and disaster exposure;
- (d) local preparedness practices; and
- (e) community interactions related to environmental interpretation and disaster anticipation.

Participant observation enabled deeper understanding of the everyday environmental practices and social realities shaping local ecological interpretation and disaster preparedness within coastal communities [29].

After data collection, interview recordings were transcribed, translated into English when necessary, and subjected to hermeneutic and reflexive thematic analysis. Particular attention was given to recurring narratives, metaphors, local expressions, ecological interpretations, and culturally embedded meanings associated with typhoons, flooding, and coastal hazards.

Ethical considerations were strictly observed throughout the study. Participants were informed regarding the objectives of the research, confidentiality measures, voluntary participation, and their right to withdraw at any stage of the study. To ensure anonymity and privacy, respondents were identified only through generalized demographic descriptions and community affiliations. Ethical reflexivity and protection of participant identity remain central principles in qualitative disaster research involving vulnerable communities [30].

2.5. Research Instrument

A semi-structured interview guide was developed based on the objectives of the study and relevant literature on local ecological knowledge, Indigenous forecasting systems, disaster preparedness, and environmental interpretation. The guide was flexible to allow participants to narrate experiences freely while ensuring alignment with the central themes of the research.

The interview guide consisted of open-ended questions focusing on:

- (a) folk meteorological practices;
- (b) ecological signs before typhoons;
- (c) disaster memories and experiences;
- (d) local meanings attached to storms;
- (e) preparedness behavior;
- (f) and perceptions toward climate variability and modern forecasting technologies.

The instrument underwent informal review by qualitative researchers and local experts familiar with disaster studies and Bicolano culture to ensure contextual appropriateness and clarity.

Data Analysis. The study employed reflexive thematic analysis [31]. Audio-recorded interviews were transcribed, translated when necessary, and repeatedly reviewed to familiarize the researcher with the narratives. Initial codes were generated inductively from the data, focusing on recurring environmental signs, interpretations, preparedness behaviors, emotional meanings, and cultural narratives associated with typhoon prediction.

Codes were subsequently organized into broader themes reflecting the dimensions of folk meteorology and local ecological intelligence. Themes were continuously refined through interpretive and hermeneutic analysis to uncover deeper meanings embedded in participants' narratives and cultural expressions.

Particular attention was given to:

- (1) metaphors and local expressions regarding storms;
- (2) culturally embedded interpretations of nature;
- (3) relationships between environmental observation and preparedness;
- (4) and hybridization between traditional and scientific forecasting systems.

The analysis also integrated environmental hermeneutics by interpreting how participants “read” nature as a meaningful environmental text. Reflexivity was maintained throughout the analytical process to acknowledge the researcher’s positionality as someone culturally familiar with the coastal Bicolano context.

2.6. Trustworthiness and Rigor

To ensure trustworthiness, the study employed credibility, transferability, dependability, and confirmability procedures following established qualitative research standards [32]. Credibility was strengthened through prolonged community engagement, repeated interviews when necessary, triangulation of narratives across participants, and member validation of selected interpretations. These approaches enhanced the authenticity and contextual accuracy of participants’ lived experiences and environmental narratives [33].

Transferability was addressed by providing thick descriptions of the study setting, participants, and local cultural contexts to allow readers to assess the applicability of findings to similar disaster-prone communities. Dependability was supported through systematic documentation of coding procedures, analytical decisions, and field reflections, while confirmability was enhanced through reflexive journaling and careful grounding of interpretations in participants’ narratives and verbatim statements. Reflexivity was continuously maintained throughout the research process to acknowledge the researcher’s positionality and cultural immersion within the Bicolano coastal context [34].

2.7. Researcher Positionality and Reflexivity

The researcher is a native Bicolano and possesses cultural familiarity with local languages, environmental practices, disaster experiences, and community narratives. This insider perspective facilitated rapport-building, contextual understanding, and interpretation of locally embedded meanings associated with folk meteorology and disaster preparedness. At the same time, the researcher recognized the potential influence of prior assumptions and cultural familiarity on data interpretation. To mitigate potential bias, reflective field notes and analytic memos were maintained throughout the study. Interpretations were continuously compared with participants’ narratives through member validation and follow-up discussions. In addition, peer debriefing with colleagues familiar with qualitative research and disaster studies, together with the maintenance of an audit trail documenting methodological and analytical decisions, enhanced the transparency, credibility, and trustworthiness of the findings [32–35].

2.8. Ethical Considerations

The study observed ethical principles throughout the research process. Participants were informed regarding the objectives of the study, voluntary nature of participation, confidentiality measures, and their right to withdraw at any point without consequence. Informed consent was secured prior to data collection in accordance with recognized ethical standards for qualitative social research [36].

Pseudonyms and generalized community identifiers were used to protect participants’ identities and maintain confidentiality. Audio recordings, transcripts, and field notes were securely stored and used solely for academic and research purposes.

Special consideration was given to the cultural sensitivity of Indigenous and local knowledge shared by participants. The researcher ensured that local narratives, beliefs, and ecological interpretations were represented respectfully and contextually without misappropriation or distortion. Ethical sensitivity in representing Indigenous and community-based knowledge systems is essential in culturally grounded qualitative research [37].

3. Results

Results reveal that folk meteorology among coastal Bicolano communities’ functions as a culturally embedded system of environmental interpretation, disaster preparedness, and adaptive resilience. Through thematic analysis, several major dimensions of folk meteorological knowledge emerged from participants’ narratives, observations, and lived experiences [2,6]. Figure 3 presents the thematic framework developed from the study.

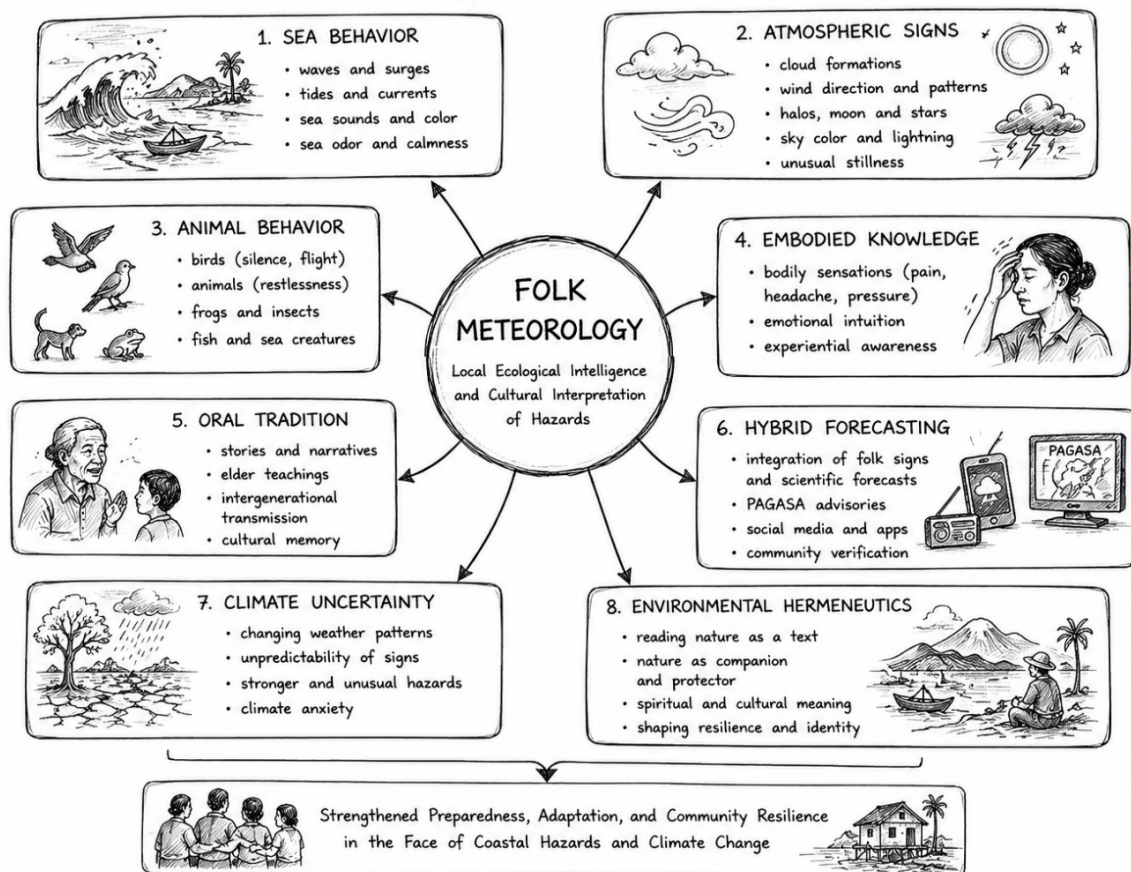


Figure 3. Thematic framework of folk meteorology in coastal Bicolano communities.

3.1. Community Memory, Typhoon Narratives, and Indigenous Disaster Resilience

The findings reveal that disaster memory and Indigenous environmental knowledge remain deeply embedded within the collective consciousness of coastal Bicolano communities. Through participatory narratives and lived experiences, respondents described the Bicol Region as a place historically shaped by recurring typhoons, floods, storm surges, and other climate-related hazards. Participants frequently recalled destructive historical typhoons such as Super Typhoons Sening, Rosing, Loleng, Reming, and Rolly, which remain strongly embedded in community memory and local storytelling traditions. These recollections demonstrate how repeated exposure to disasters has contributed to the development of culturally grounded preparedness practices and adaptive resilience among Bicolanos [16,23].

One important finding is that local residents continue to rely heavily on folk meteorology and Indigenous forecasting systems despite the increasing availability of scientific weather advisories. Participants explained that coastal Bicolanos and Catandunganons predict storms through the observation of stars, cloud formations, sea conditions, wind direction, animal behavior, and even the behavior of plants such as the *calachuchi* tree. These findings reinforce previous studies emphasizing the importance of local ecological knowledge in disaster preparedness and community resilience [2,17].

To visually illustrate the dominant concepts and recurring themes emerging from participant narratives, Figure 4 presents a word cloud showing commonly expressed terms associated with folk meteorology, environmental interpretation, disaster preparedness, and resilience among coastal Bicolano communities.

The narratives also revealed unique cultural interpretations associated with typhoon behavior. Participants described the phenomenon locally called *ballos*, referring to the second and often more destructive half of the typhoon after the temporary calm produced by the eye of the storm. Respondents explained that communities anticipate the arrival of *ballos* with both fear and preparedness because it often brings the strongest winds and heaviest rainfall. Traditional adaptation practices such as opening windows opposite the wind direction, reinforcing roofs with ropes and sandbags, storing food and water, and performing collective prayers were also commonly observed. These practices illustrate how Indigenous knowledge, spirituality, and lived environmental experiences collectively shape disaster preparedness behavior in the region [13]. Bicolano resilience is not solely derived from formal disaster education and government intervention but is also rooted in generations of

accumulated environmental knowledge, cultural memory, and adaptive survival practices developed through continuous interaction with hazardous coastal environments.



Figure 4. Word cloud of key themes and environmental concepts in coastal Bicolano folk meteorology.

3.2. Folk Meteorology as Everyday Environmental Intelligence

Folk meteorology remains deeply embedded within the everyday lives of coastal Bicolano communities and continues to shape local disaster anticipation, preparedness, and environmental interpretation. Participants consistently described traditional forecasting practices not as superstition, but as accumulated ecological intelligence developed through repeated exposure to typhoons, floods, storm surges, and changing coastal conditions. Many respondents emphasized that nature itself “gives warnings” before destructive weather events occur and that these environmental signals are learned through observation, lived experiences, and intergenerational teaching [7,15].

Participants explained that coastal residents, particularly fisherfolk and elderly community members, continuously observe the sea, skies, winds, tides, animals, and surrounding environmental conditions as part of their ordinary daily routines. Through time, these repeated observations become localized systems of environmental interpretation guiding preparedness behavior and survival decisions. Similar findings have been documented in studies emphasizing the importance of Indigenous ecological knowledge and community-based environmental observation in disaster preparedness and resilience [2,6,7].

One elderly fisherfolk participant explained:

“The sea changes its behavior before the typhoon. The waves become different, the wind feels heavier, and even the air smells unusual. We already know something is coming.”

Folk meteorology functions as a form of local ecological intelligence rooted in continuous interaction between humans and hazardous coastal environments. Rather than relying solely on isolated signs, respondents described interpreting combinations of ecological indicators such as wave behavior, wind patterns, cloud formations, sea odor, atmospheric conditions, animal behavior, and celestial formations. Such findings reinforce arguments that environmental knowledge in disaster-prone communities is accumulated through long-term ecological observation, experiential learning, and adaptation to recurring hazards [3–5,8].

Importantly, the findings further reveal that folk meteorology operates not in opposition to scientific forecasting systems but alongside them. Many participants described combining traditional ecological observations with Philippine Atmospheric, Geophysical and Astronomical Services Administration, (PAGASA) advisories, social media updates, television forecasts, and mobile weather applications. This hybridization reflects

the coexistence of Indigenous knowledge systems and modern disaster forecasting technologies within contemporary community preparedness practices. Previous studies similarly emphasize that communities increasingly integrate traditional ecological knowledge with scientific and technological forecasting systems to strengthen adaptive capacity and disaster resilience [38,39].

The succeeding subsections discuss the major dimensions of folk meteorology identified in the study, including sea behavior, atmospheric and celestial signs, animal behavior, embodied environmental knowledge, and their implications for disaster preparedness and resilience.

3.2.1. Sea Behavior as Environmental Warning System

Among all environmental indicators identified by participants, sea behavior emerged as the most significant and widely trusted forecasting mechanism among coastal communities. Respondents consistently associated unusual wave intensity, roaring sea sounds, darkened seawater, abnormal tides, and sudden coastal turbulence with approaching typhoons and severe weather disturbances [40,41].

Fisherfolk participants emphasized that the sea “behaves differently” before major storms. Many described observing stronger wave collisions, rapidly changing currents, unusual sea color, and intensified coastal sounds prior to typhoon landfall. Some respondents explained that they sometimes cancel fishing activities even before official weather advisories are released because the sea itself already “communicates danger.”

A recurring local expression repeatedly mentioned by respondents was:

“Inagaw kan dagat an bagyo.”
(“The sea fights the typhoon.”)

Within the community context, this expression does not literally imply that the sea physically attacks the typhoon. Rather, it reflects a culturally grounded interpretation that the sea absorbs, weakens, or resists the force of incoming storms before they fully reach land. Participants described large storm surges and violent waves as signs that nature itself is reacting against the approaching typhoon.

One participant explained:

“Pag darakula na an mga hukol, pig-agaw na kan dagat an bagyo.”
(“When the waves become huge, the sea is already fighting the typhoon.”)

This interpretation demonstrates how environmental hazards are culturally understood not merely as destructive events but also as dynamic interactions between humans, nature, and coastal ecosystems. The findings further suggest that the sea functions simultaneously as livelihood source, warning system, environmental companion, and symbol of resilience within coastal Bicolano communities [42].

3.2.2. Ecological Indicators beyond Sea Behavior

Beyond sea conditions, participants identified a range of atmospheric, celestial, and biological indicators associated with approaching typhoons and severe weather disturbances. Common atmospheric signs included unusual cloud formations, reddish sunsets, dark horizons, ring-shaped halos around the moon, rapidly moving clouds, heavy humidity, sudden heat, and the disappearance of stars. Elderly respondents frequently emphasized observing changes in wind direction, atmospheric stillness, and nighttime temperature as indicators of impending weather disturbances.

Several participants also described traditional astronomical observations that continue to persist within local forecasting practices. In some communities, residents referred to a constellation known locally as *Arko ni Noe* (“Noah’s Ark”), believing that the alignment of its brightest star with Mt. Isarog signals the possible arrival of a strong typhoon. Respondents likewise identified localized wind systems such as *amihan*, *habagat*, *dumagsa*, *kanaway*, and *salatan*, each associated with distinct weather patterns and typhoon behavior. These observations demonstrate the persistence of celestial and atmospheric forecasting systems despite increasing dependence on digital weather technologies.

Animal behavior likewise emerged as an important forecasting mechanism. Participants associated unusual movements and sounds among birds, dogs, frogs, ducks, insects, chickens, and marine organisms with approaching storms and environmental disturbances. Common observations included birds flying inland, restless dogs, increased frog activity, ants transferring eggs to higher locations, and changes in fish behavior before severe weather events. One respondent explained:

“When the birds become silent and the dogs cannot stay calm, older people already become alert because those signs usually happen before bad weather.”

These findings suggest that ecological interpretation extends beyond atmospheric observation into multispecies environmental awareness shaped by everyday interaction with nature. Similar studies have emphasized that local ecological knowledge systems frequently incorporate animal behavior, environmental relationships, and experiential observation as part of community-based disaster anticipation and adaptation strategies [6,7,43]. Collectively, the findings demonstrate that folk meteorology relies on the interpretation of interconnected environmental cues rather than isolated warning signs, reflecting a broader system of local ecological intelligence developed through long-term interaction with hazardous coastal environments [2,15].

3.2.3. Embodied Environmental Knowledge

Another important finding emerging from the study involves embodied environmental knowledge or the interpretation of physical sensations and bodily experiences as indicators of environmental change. Several elderly participants described experiencing headaches, body pain, dizziness, breathing discomfort, and unusual physical heaviness before severe weather disturbances occur.

Respondents associated these bodily sensations with changes in atmospheric pressure, humidity, temperature, and incoming storms. Some fisherfolk explained that they “feel” environmental changes physically even before visible weather signs become apparent.

One elderly respondent remarked:

“Before strong storms, my joints become painful and the air feels heavier. That is when I know the weather is changing.”

These findings suggest that folk meteorology is not limited to external environmental observation but also includes embodied ecological experience developed through prolonged exposure to hazardous coastal conditions. Such interpretations reflect phenomenological relationships between human bodies, environmental memory, and disaster anticipation.

Embodied forecasting practices further demonstrate the depth of environmental familiarity among coastal residents whose livelihoods and survival are continuously shaped by the rhythms and uncertainties of the sea.

To synthesize the diverse ecological indicators, environmental interpretations, and preparedness responses identified by participants, Table 1 presents the major folk meteorological signs commonly interpreted by coastal Bicolano communities during approaching typhoons and severe weather disturbances.

Table 1. Folk meteorological indicators, environmental interpretations, and associated disaster preparedness practices among coastal Bicolano communities.

Category	Folk Meteorological Indicator	Local Interpretation/Meaning	Associated Preparedness Practice
Sea Behavior and Coastal Conditions	Roaring sea sounds	Approaching strong typhoon or rough weather	Avoid fishing; prepare emergency supplies
	Sudden large storm surges	“The sea fights the typhoon” and weakens incoming storm winds	Secure boats and evacuate coastal areas
	Darkened seawater	Severe weather disturbance is approaching	Monitor tides and prepare for flooding
	Unusually calm sea before storms	Impending atmospheric disturbance	Heightened alertness among fisherfolk
	Strong waves reaching roads or seawalls	Incoming storm surge or typhoon intensification	Move boats inland; reinforce houses
	Rising tides beyond normal levels	Storm surge risk	Evacuate low-lying coastal areas
	Sea waves splashing onto roads	Severe coastal hazard approaching	Relocate boats and livestock
	Sea color becoming gray or black	Dangerous sea condition	Avoid fishing and sea travel
	Continuous lightning over the sea	Severe weather disturbance	Suspend marine transportation
	Loud crashing waves at night	Typhoon nearing land	Prepare for evacuation
	Storm surges accompanied by weak winds	“The sea absorbs the typhoon”	Reduced fear of direct landfall winds
	Sudden sea retreat before wave surges	Incoming large coastal waves	Immediate evacuation
	Large waves during otherwise weak rainfall	Typhoon diverted offshore	Continue monitoring coastal conditions
	Persistent sea odor inland	Storm surge or strong winds approaching	Increase household preparedness
	Violent sea despite weak wind	Offshore typhoon interaction	Prepare for storm surge impacts
	Sea “swallowing” storm energy	Typhoon weakening offshore	Reduced fear of direct wind damage

Table 1. Cont.

Category	Folk Meteorological Indicator	Local Interpretation/Meaning	Associated Preparedness Practice
Atmospheric and Weather Conditions	Sudden changes in wind direction	Typhoon path or weather shift	Secure roofs and lightweight materials
	Heavy and humid air	Incoming rainfall or storm	Store food and drinking water
	Strange smell coming from the sea	Bad weather approaching	Suspend fishing activities
	Fast-moving dark clouds	Typhoon intensification	Prepare for evacuation
	Reddish sky during sunset	Incoming storm or heavy rainfall	Increase household preparedness
	Ring around the moon	Rainfall or weather disturbance	Monitor weather conditions carefully
	Disappearance of stars	Typhoon or heavy rainfall approaching	Stay indoors and monitor advisories
	Thunder despite clear skies	Atmospheric instability	Stay alert for sudden weather changes
	Extreme heat before rainfall	Typhoon-associated atmospheric disturbance	Monitor weather advisories
	Unusual stillness before storms	Typhoon intensification	Immediate household preparation
	Bright stars followed by rapid clouding	Rapid weather change	Monitor official forecasts
	Strong winds from unusual directions	Typhoon path shift	Secure houses and boats
	Ecological signs occurring simultaneously	Confirmation of major incoming disaster	Immediate preparedness and coordination
Animal and Ecological Behavior	Sudden silence of birds	Environmental disturbance before storms	Increase disaster alertness
	Birds flying inland	Strong winds or coastal danger approaching	Fisherfolk avoid going to sea
	Restless dogs and animals	Atmospheric pressure changes before disasters	Prepare for evacuation
	Frogs croaking loudly	Heavy rainfall approaching	Monitor flood-prone areas
	Ants transferring eggs upward	Possible flooding	Elevate belongings and appliances
	Ducks flying unusually high	Incoming typhoon	Reinforce homes and secure fishing equipment
	Fish moving deeper into the sea	Rough seas and dangerous waters	Suspend marine livelihood activities
	Jellyfish near shorelines	Strong currents and rough seas	Avoid coastal activities
	Sudden disappearance of insects	Environmental imbalance before storms	Heightened preparedness awareness
	Animal migration toward uplands	Impending flood or severe storm	Relocate livestock
	Low-flying birds	Atmospheric pressure disturbance	Avoid travel and fishing
Vegetation and Landscape Indicators	Abnormal fish scarcity before storms	Dangerous sea conditions	Suspend fishing operations
	Coconut trees bending abnormally	Strong incoming winds	Reinforce roofs and housing materials
	Banana leaves folding tightly	Heavy rainfall expected	Store food and protect crops
	Mountain fog becoming thicker	Continuous rainfall approaching	Prepare for possible flooding
	Strong river currents before rainfall	Upstream flooding risk	Move to safer areas
Embodied Environmental Sensations	Sudden erosion along riverbanks	Flood intensification	Relocate vulnerable belongings
	Frequent body pain among elders	Weather pressure changes	Prepare for changing weather
	Sudden headaches or dizziness among fisherfolk	Signs of atmospheric disturbance	Heightened environmental awareness
	Sudden silence in coastal communities	Environmental warning before disasters	Heightened community alertness
Community-Level Hazard Recognition	Simultaneous flooding and storm surges	Compound disaster risk	Community-wide evacuation and preparation

3.2.4. Folk Meteorology and Hybrid Disaster Preparedness

The findings further reveal that folk meteorology directly influences local preparedness behavior and disaster response practices. Environmental warning signs often trigger preparedness actions such as:

- securing fishing boats,
- storing rice and drinking water,
- charging mobile phones,
- reinforcing houses,
- preparing emergency supplies,
- elevating appliances,
- and avoiding sea travel.

Many respondents explained that ecological signs sometimes motivate earlier preparedness than official advisories because local observations are considered immediate, personal, and experience-based [44,45].

Importantly, participants did not reject scientific forecasting systems. Instead, most respondents described using hybrid preparedness approaches combining:

- (1) traditional ecological observations,
- (2) PAGASA advisories,
- (3) Facebook weather updates,
- (4) television forecasts,
- (5) and mobile weather applications.

One participant explained:

“We still listen to PAGASA, but we also observe the sea because sometimes nature already tells us before the announcements.”

This hybridization demonstrates that Indigenous forecasting systems and scientific forecasting technologies are not necessarily competing knowledge systems. Rather, communities negotiate and integrate both forms of knowledge to strengthen preparedness, reduce uncertainty, and improve adaptive decision-making during disasters [46,47].

To further synthesize the ecological domains and environmental interpretations emerging from participant narratives, Table 2 presents the classification matrix of folk meteorological indicators identified among coastal Bicolano communities.

Table 2. Folk meteorological classification matrix among coastal Bicolano communities.

Ecological Domain	Examples of Folk Meteorological Indicators	Local Interpretation/Meaning
Sea-Based Indicators	Roaring waves, storm surges, dark seawater, rising tides, crashing waves at night, sea odor	Approaching typhoon, rough seas, storm surge risk, coastal danger
Atmospheric Indicators	Dark clouds, ring around the moon, reddish sunsets, unusual heat, strong winds, disappearing stars	Rainfall, typhoon intensification, atmospheric instability, weather disturbance
Biological Indicators	Birds flying inland, restless dogs, frogs croaking loudly, ants transferring eggs, fish moving deeper	Environmental disturbance, flooding risk, approaching storm
Vegetation and Landscape Indicators	Coconut trees bending, banana leaves folding, mountain fog thickening, riverbank erosion	Strong winds, heavy rainfall, flood intensification
Embodied Environmental Indicators	Headaches, body pain, dizziness, heavy air sensation, physical discomfort among elders	Atmospheric pressure changes and incoming severe weather
Community-Level Indicators	Simultaneous ecological signs, unusual silence in coastal areas, collective environmental observation	Confirmation of major incoming disaster and heightened preparedness awareness
Spiritual and Cultural Indicators	Religious interpretations, “the sea fights the typhoon”, environmental myths and narratives	Cultural reading of hazards, emotional resilience, environmental meaning-making

3.3. Intergenerational Transmission of Folk Meteorological Knowledge

The findings reveal that folk meteorological knowledge among coastal Bicolano communities is primarily transmitted through oral tradition, observation-based learning, and lived disaster experiences. Participants consistently explained that environmental forecasting practices are learned informally within households and communities rather than through formal education or written instruction. Elderly respondents recalled learning how to “read” the sea, skies, winds, animals, and environmental conditions from parents, grandparents, fisherfolk elders, and older community members during childhood [6,48].

Knowledge transmission commonly occurred through:

- (1) fishing activities,
- (2) farming experiences,
- (3) storm survival narratives,
- (4) and everyday interaction with the coastal environment.

Several participants explained that children growing up near the sea gradually develop environmental sensitivity through repeated exposure to typhoons and continuous observation of nature. Elderly fisherfolk emphasized that younger generations previously learned forecasting signs by accompanying adults during fishing activities and observing environmental changes directly.

One elderly respondent explained:

“Before, children learned by listening to stories and observing the sea with their parents. We were taught how to understand the wind, the waves, and the skies.”

Participants also described storytelling as an important mechanism for preserving disaster memory and ecological knowledge. Narratives about destructive typhoons, storm surges, floods, and survival experiences were repeatedly shared within families and communities, reinforcing preparedness consciousness among younger generations.

However, respondents expressed concern regarding the gradual decline of traditional forecasting practices due to modernization, digital technologies, and changing lifestyles. Several elderly participants observed that younger people increasingly rely on smartphones, Facebook updates, television forecasts, and mobile weather applications rather than direct environmental observation.

One participant remarked:

“Young people now depend more on Facebook and cellphones. Before, we looked at the sea and the sky.”

Despite this perceived decline, many younger respondents acknowledged that folk meteorology still influences preparedness decisions, particularly in households strongly connected to fishing and coastal livelihoods. These findings suggest that traditional ecological knowledge is not disappearing entirely but is instead undergoing transformation within increasingly digital and technologically mediated disaster environments [49,50]. Folk meteorological knowledge remains socially embedded within family relationships, community memory, and coastal cultural identity, even amidst rapid technological and generational change.

3.4. Folk Meteorology and Hybrid Disaster Preparedness

Folk meteorology continues to play an important role in contemporary disaster preparedness among coastal Bicolano communities. Participants consistently linked ecological warning signs with concrete preparedness actions such as:

- (a) securing fishing boats,
- (b) storing food and drinking water,
- (c) charging mobile phones,
- (d) reinforcing houses,
- (e) elevating appliances,
- (f) preparing emergency kits,
- (g) and avoiding sea travel.

Many respondents explained that traditional ecological observations often trigger preparedness actions earlier than official weather advisories because environmental signs are personally experienced and continuously observed within the community [51,52].

The findings reveal that coastal communities do not rely solely on either traditional ecological knowledge or scientific forecasting systems. Instead, respondents continuously integrate environmental observation, community interpretation, official weather advisories, and digital information sources in shaping disaster preparedness decisions. Figure 5 illustrates the hybrid Indigenous forecasting process identified in the study.

Importantly, participants did not reject scientific forecasting systems. Instead, respondents demonstrated highly adaptive hybrid preparedness practices integrating traditional ecological interpretation with modern forecasting technologies. Most participants reported simultaneously relying on:

- (a) PAGASA advisories,
- (b) television news reports,
- (c) Facebook weather updates,
- (d) mobile weather applications,
- (e) radio announcements,
- (f) and Indigenous environmental observations.

One fisherfolk participant explained:

“We still listen to PAGASA, but we also observe the sea because sometimes nature already tells us before the announcements.”

Another respondent stated:

“Even if there is already Facebook and weather apps, older people still look at the waves and winds because nature gives early warnings.”

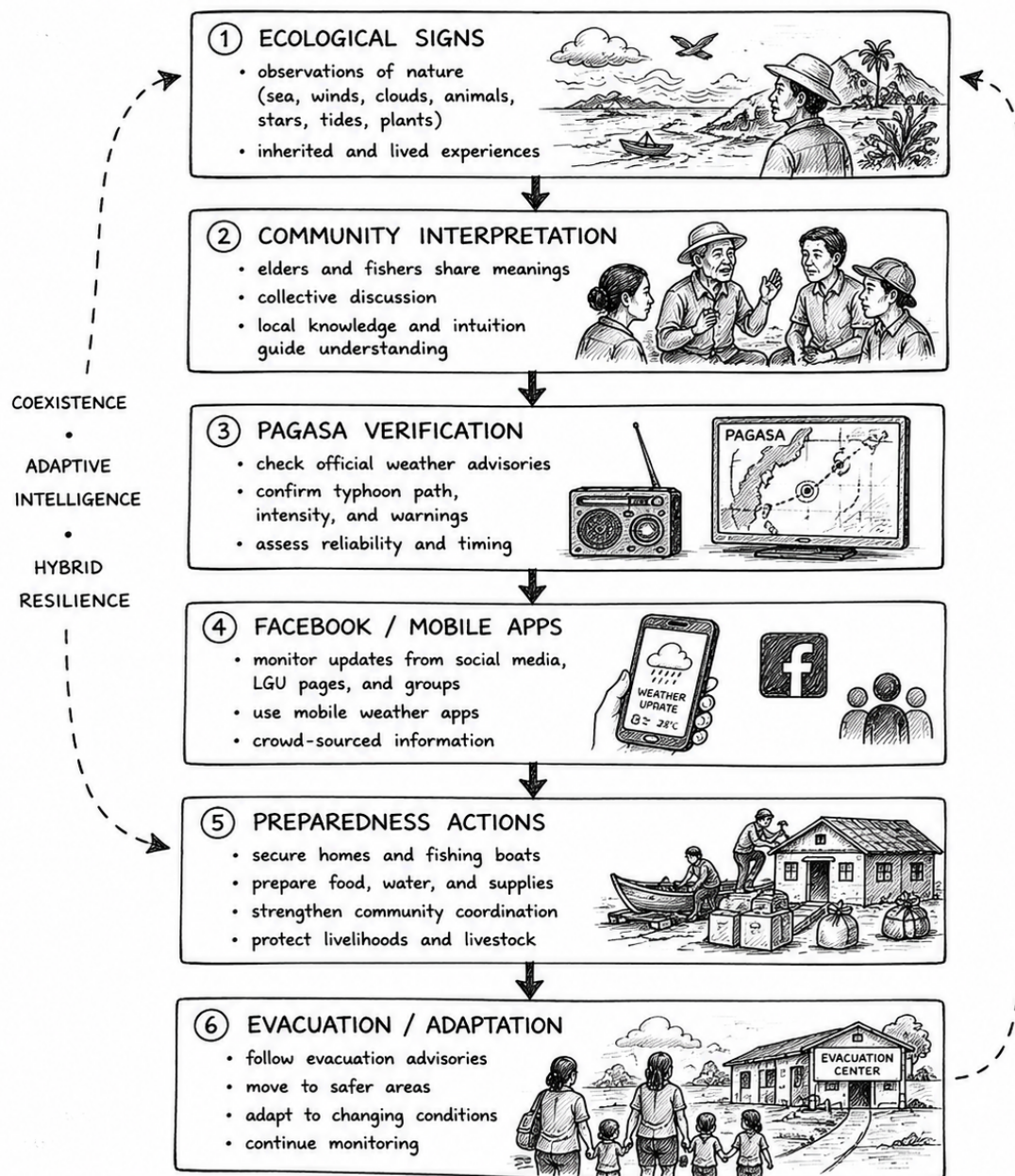


Figure 5. Indigenous forecasting process as a hybrid system of knowledge and disaster preparedness.

These findings suggest that coastal communities do not perceive folk meteorology and scientific forecasting as competing knowledge systems. Rather, respondents continuously negotiate and combine both forms of knowledge to reduce uncertainty and improve disaster preparedness. This hybridization reflects adaptive intelligence wherein communities integrate scientific information with localized environmental familiarity and experiential knowledge [53,54].

The coexistence of traditional and scientific forecasting systems also strengthens preparedness flexibility. While modern forecasting technologies provide broader regional information and official warnings, folk meteorology offers localized environmental interpretation rooted in everyday interaction with the coastal environment. Together, these systems contribute to more context-sensitive and culturally grounded disaster preparedness practices.

Ultimately, the findings challenge simplistic assumptions that traditional forecasting practices are obsolete or incompatible with modern science. Instead, the study demonstrates that coastal communities actively hybridize Indigenous ecological intelligence and scientific forecasting technologies as complementary tools for survival and resilience in increasingly hazard-prone environments as shown in Table 3.

Table 3. Hybrid forecasting and preparedness practices among coastal Bicolano communities.

Traditional Ecological Observation	Scientific/Modern Forecasting Source	Associated Preparedness Practice
Observation of waves, tides, and sea behavior	PAGASA typhoon advisories	Securing boats and avoiding sea travel
Monitoring wind direction and cloud formations	Television weather forecasts	Reinforcing roofs and lightweight structures
Observation of animal behavior	Facebook weather updates	Preparing emergency supplies
Interpreting unusual sea odor and atmospheric changes	Mobile weather applications	Early household preparedness
Celestial observations and environmental intuition	Radio announcements	Monitoring typhoon movement
Simultaneous ecological warning signs	LGU disaster advisories	Community-level evacuation
Observation of rising tides and storm surges	Online typhoon trackers	Coastal evacuation readiness
Embodied environmental sensations (body pain, heavy air)	Scientific rainfall and wind forecasts	Increased household vigilance
Oral forecasting traditions from elders	Social media disaster information	Intergenerational preparedness awareness
Community interpretation of ecological signs	Combined official and digital advisories	Hybrid disaster decision-making

3.5. Climate Change and the Disruption of Ecological Predictability

A major emerging theme in the study involves participants' perceptions that climate change has disrupted traditional environmental rhythms and reduced the predictability of ecological forecasting signs. Many respondents explained that weather patterns have become increasingly erratic, typhoons have intensified, and seasonal cycles no longer behave according to familiar environmental patterns observed in previous decades [20,55].

Participants frequently described contemporary weather conditions as “unpredictable,” “confusing,” and “no longer normal.” Several elderly respondents expressed concern that ecological indicators previously considered reliable no longer consistently correspond to actual weather outcomes. Respondents explained that storms sometimes intensify unexpectedly, rainfall patterns abruptly change, and typhoons arrive outside traditional seasonal expectations.

One participant explained:

“Before, the signs of nature were easier to understand. Now the weather suddenly changes. Sometimes the signs appear, but the typhoon behaves differently.”

Participants provided several examples of ecological signs that they perceived as becoming less predictable. Elderly fisherfolk noted that traditional wind indicators such as *amihan*, *habagat*, and *salatan* no longer consistently correspond to expected rainfall patterns, typhoon movements, or sea conditions. Some respondents observed that winds occasionally shift direction abruptly or occur outside their usual seasonal periods, making traditional interpretations more difficult.

Others reported changes in animal behavior that were previously used as forecasting cues. Participants explained that birds no longer consistently migrate inland before storms, while unusual insect activity and frog vocalizations sometimes occur without the expected rainfall or flooding that traditionally followed. Fisherfolk also observed changes in fish movement and feeding patterns, which they associated with warming seas, altered ocean conditions, and increasingly erratic weather systems.

Several coastal residents further described changes in marine environmental indicators. Respondents noted that sea conditions occasionally remain calm despite the approach of severe weather systems, while rough seas sometimes occur without subsequent typhoon landfall. A number of participants also reported that marine bioluminescence and other coastal phenomena previously associated with seasonal environmental changes now appear less predictable than in earlier decades.

Participants frequently linked these disruptions to climate change, environmental degradation, coastal ecosystem decline, and changing ocean conditions. Recent extreme weather events such as Bagyong Kristine and Super Typhoon Pepito were often cited as examples of storms whose behavior exceeded traditional expectations regarding intensity, rainfall accumulation, flooding extent, and duration. These experiences contributed to growing uncertainty regarding the future reliability of long-established forecasting signs.

Several respondents also expressed forms of climate anxiety and concern that younger generations may inherit environmental conditions fundamentally different from those experienced by earlier generations. Nevertheless, participants emphasized that folk meteorology remains valuable because it strengthens environmental awareness, preparedness consciousness, and community vigilance even amidst climatic uncertainty [56,57].

While climate change may reduce the predictability of specific ecological indicators, participants emphasized that their relationship with nature extends beyond forecasting alone. The sea, winds, mountains, and other environmental features continue to serve as sources of meaning, guidance, and resilience as shown in Figure 6, shaping how communities interpret and respond to environmental hazards.

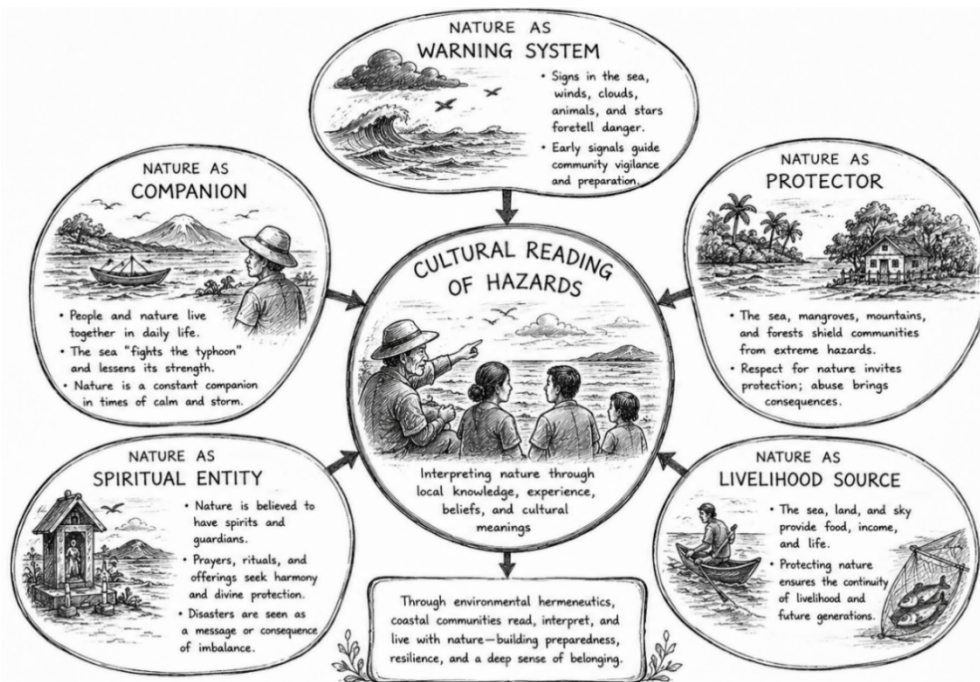


Figure 6. Environmental hermeneutics and the cultural reading of hazards among coastal Bicolano communities.

3.6. Nature as Companion: Environmental Hermeneutics and the Cultural Reading of Hazards

One of the most important conceptual contributions emerging from this study is the finding that coastal Bicolano communities interpret nature not merely as a source of danger but also as a meaningful environmental companion in times of disaster. Participants consistently demonstrated that typhoons, waves, winds, tides, and environmental disturbances are culturally interpreted through systems of meaning deeply embedded in local memory, spirituality, survival experiences, and ecological familiarity. These interpretations reveal that folk meteorology in the Bicol Region functions not only as a forecasting practice but also as a form of environmental hermeneutics in which nature itself is continuously “read,” interpreted, and emotionally negotiated by coastal communities [2,23].

A recurring cultural expression repeatedly mentioned by respondents was:

“Inagaw kan dagat an bagyo.”
 (“The sea fights the typhoon.”)

At a literal level, the expression refers to unusually large waves and violent storm surges occurring before or during typhoons. However, at a deeper interpretive level, the phrase reflects a culturally mediated understanding that the sea absorbs, weakens, or resists the force of incoming storms before they fully strike coastal communities. Rather than perceiving the sea solely as destructive, participants often described it as simultaneously dangerous and protective.

One participant explained:

“Pag darakula na an mga hukol, pig-agaw na kan dagat an bagyo.”
 (“When the waves become huge, the sea is already fighting the typhoon.”)

This interpretation demonstrates how hazards are emotionally and culturally processed through localized environmental narratives. The sea is not understood merely as a physical body of water but as:

- livelihood,
- warning system,
- protector,
- spiritual presence,
- and ecological companion.

Such findings reveal that environmental interpretation among coastal Bicolanos extends beyond scientific forecasting into symbolic, emotional, and relational understandings of nature.

Importantly, these interpretations also contribute to emotional resilience during disasters. Several respondents explained that interpreting the sea as “fighting” or “weakening” the typhoon reduces panic and helps communities psychologically endure severe weather events. Rather than producing fatalism, these narratives foster calmness, preparedness, and collective vigilance. Participants repeatedly emphasized the importance of remaining emotionally composed during typhoons because panic is believed to worsen disaster outcomes [6,15,58].

The findings further suggest that environmental hermeneutics among coastal communities are shaped through repeated interaction with hazardous environments across generations. Through continuous exposure to typhoons, residents gradually develop interpretive frameworks allowing them to understand environmental signals not simply as random natural events but as meaningful ecological communications. In this sense, folk meteorology operates as both:

- (a) practical environmental intelligence,
- (b) and cultural meaning-making system.

This culturally grounded interpretation of hazards also explains why participants continue valuing traditional ecological observations despite the increasing availability of scientific forecasting technologies. Respondents do not merely seek predictive accuracy; they also seek emotional familiarity, cultural continuity, and experiential understanding rooted in local environmental relationships.

The findings therefore challenge purely technocratic approaches to disaster risk reduction that treat hazards only as physical phenomena measurable through scientific instruments. While scientific forecasting remains essential, the study demonstrates that communities also interpret disasters through:

- (1) memory,
- (2) emotion,
- (3) spirituality,
- (4) environmental identity,
- (5) and cultural narratives.

Ultimately, the study argues that folk meteorology in the Bicol Region represents a sophisticated form of local ecological intelligence and environmental hermeneutics developed through centuries of coexistence with hazardous coastal environments. Table 4 presents Bicolano expressions and cultural meanings related to typhoons and coastal hazards. These culturally embedded interpretations remain important not only for forecasting and preparedness but also for sustaining emotional resilience, environmental awareness, and community cohesion amidst increasingly uncertain climatic futures.

Table 4. Selected Bicolano expressions and cultural meanings related to typhoons and coastal hazards.

Bicolano Expression	English Translation	Cultural Meaning
<i>“Inagaw kan dagat an bagyo.”</i>	“The sea fights the typhoon.”	The sea is believed to absorb or weaken the incoming storm before landfall.
<i>“Pag darakula na an mga hukol, pig-agaw na kan dagat an bagyo.”</i>	“When the waves become huge, the sea is already fighting the typhoon.”	Large waves are interpreted as protective environmental reactions.
<i>“An dagat nagtatabang sa pagluya kan bagyo.”</i>	“The sea helps weaken the typhoon.”	Nature is viewed as an environmental companion during disasters.
<i>“Kan naglupad an pato, aram ko na may papaabot na bagyo.”</i>	“When the duck flew upward, I already knew a typhoon was coming.”	Animal behavior functions as a folk meteorological indicator.
<i>“Pigbabasa mi an panahon.”</i>	“We read the weather.”	Environmental interpretation is considered an important survival skill.
<i>“Mina-observer kami sa kalikasan, bituon, paros, saka huni kan hayop.”</i>	“We observe nature, stars, winds, and animal sounds.”	Ecological observation guides forecasting and preparedness.
<i>“An dagat mayo man kaaway.”</i>	“The sea is not an enemy.”	The sea remains central to livelihood, identity, and survival.
<i>“Pirme kami handa basta may bagyo.”</i>	“We are always prepared whenever there is a typhoon.”	Preparedness is normalized within coastal communities.
<i>“Tuod naman kami sa bagyo.”</i>	“We are already used to typhoons.”	Repeated exposure has shaped adaptive resilience.
<i>“Pinapamahawan sa Bicol an bagyo.”</i>	“In Bicol, typhoons are treated like breakfast.”	Symbolizes toughness and familiarity with disasters.
<i>“Dawa makusog an bagyo, makaogma pag nagtatarabangan.”</i>	“No matter how strong the typhoon is, we can survive if we help each other.”	Emphasizes bayanihan and collective resilience.
<i>“An kalikasan nungka nagpapatawad.”</i>	“Nature never forgives.”	Environmental abuse is believed to contribute to disasters.
<i>“Pigsingil na siguro kita kan kalikasan.”</i>	“Perhaps nature is making us pay.”	Typhoons and floods are interpreted as ecological consequences.

Table 4. Cont.

Bicolano Expression	English Translation	Cultural Meaning
<i>“Pag magulo an prosesyon ni Ina, may makusog na Bagyong maagi.”</i>	“When the Peñafrancia procession becomes chaotic, destructive typhoons follow.”	Spiritual-cultural interpretation linking religion and disasters.
<i>“May mga taga-bantay an kalikasan.”</i>	“Nature has guardians.”	Reflects belief in unseen environmental protectors.
<i>“An caskong bulawan minasabay sa bagyo.”</i>	“The golden ship appears together with storms.”	Local myth associated with severe flooding and typhoons.
<i>“An baha hali sa ibang banwaan.”</i>	“The floodwaters come from upstream towns.”	Demonstrates local understanding of watershed and flood dynamics.
<i>“Dai kami nagbuburikat pag may anunsyong bagyo.”</i>	“We never become complacent when there is a typhoon warning.”	Communities take weather advisories seriously.
<i>“Padagos sana an buhay.”</i>	“Life simply continues.”	Expression of endurance and post-disaster recovery.
<i>“Pag may bagyo, dai sana magamo, matakot tanganing makaisip patanos.”</i>	“During a typhoon, people should stay calm and not panic so they can think wisely.”	Emphasizes emotional control and rational disaster response.
<i>“An bagyo parte na kan pagbuhay.”</i>	“Typhoons are already part of life.”	Hazards are normalized through lived experience.
<i>“Mayo kitang laban sa anggot na kalikasan.”</i>	“We cannot fight the power of nature.”	Recognition of human vulnerability against environmental forces.
<i>“An dagat nagsisinyal nin maraot na panahon.”</i>	“The sea signals bad weather.”	Strange sea odor and wave behavior serve as ecological warning signs.
<i>“Mas makatakot an bukid pag nagrasyay.”</i>	“The mountain is more frightening when it collapses.”	Landslides are perceived as deadlier than storm surges in upland-coastal communities.
<i>“Daga kan mga Bagyo”</i>	“Land of Howling Winds.”	Cultural identity of Catanduanes as a highly typhoon-prone island.
<i>“An mata kan bagyo may kahilom, pero an ballos mas makusog.”</i>	“The eye of the typhoon is calm, but the ballos is stronger.”	Local understanding of the second and more destructive eyewall of the typhoon.
<i>“An ballos an pinaka makusog na parte kan bagyo.”</i>	“The ballos is the strongest part of the typhoon.”	Demonstrates Indigenous knowledge of typhoon structure and behavior.
<i>“An dagat mayo nin pagluwas, mayo man nin kabuhi.”</i>	“Without the sea, there is no livelihood and no life.”	Reveals the deep dependence of coastal communities on marine ecosystems.
<i>“An habagat asin amihaan igwa nin kahulugan.”</i>	“The habagat and amihaan winds have meanings.”	Wind systems are interpreted as forecasting tools for weather changes.
<i>“Maski makusog an bagyo, padagos an buhay.”</i>	“Even if the typhoon is strong, life continues.”	Reflects persistence, hope, and emotional resilience after disasters.

3.7. Policy Recommendations

Figure 7 presents the proposed policy framework emphasizing the integration of Indigenous ecological knowledge, community-based early warning systems, hybrid forecasting approaches, climate education, and culturally grounded disaster governance to strengthen resilience and adaptive preparedness in hazard-prone coastal communities.

- (1) *Integrate Indigenous and local ecological knowledge into disaster risk reduction programs.* Governments, disaster management agencies, educational institutions, and humanitarian organizations should recognize folk meteorology and local ecological knowledge as valuable complements to scientific forecasting systems. Community-based preparedness programs may integrate localized environmental indicators, oral disaster histories, and traditional forecasting practices alongside official meteorological advisories and modern early warning technologies. This recommendation is supported by findings that participants consistently identified sea behavior, atmospheric conditions, celestial observations, animal behavior, and embodied environmental sensations as meaningful indicators of approaching hazards, demonstrating the continued relevance of local ecological intelligence in disaster preparedness (Sections 3.2.1–3.2.4).
- (2) *Strengthen community-based early warning systems.* Disaster preparedness institutions should collaborate with fishers, farmers, Indigenous communities, elderly residents, and local knowledge holders in identifying community-specific environmental warning signs associated with storms, floods, droughts, wildfires, and other climate-related hazards. Incorporating localized observations may improve public trust, preparedness participation, and early response behavior. This recommendation reflects findings that elderly residents, fisherfolk, and long-term coastal inhabitants were widely recognized as key custodians of forecasting knowledge and environmental memory, providing locally specific hazard interpretations unavailable through standardized forecasting systems alone (Sections 3.2 and 3.3).



Figure 7. Policy framework for integrating folk meteorology into disaster risk reduction and climate adaptation.

- (3) *Document and preserve traditional environmental knowledge.* Governments, researchers, universities, museums, and cultural organizations should support the documentation and preservation of traditional forecasting systems through oral history projects, community archives, digital storytelling, participatory mapping, and climate education programs to prevent the erosion of intergenerational ecological knowledge.

- This recommendation is supported by participants' concerns regarding the gradual decline of traditional forecasting practices as younger generations increasingly rely on smartphones, social media, and digital weather applications, raising concerns about the loss of intergenerational ecological knowledge (Section 3.3).
- (4) *Promote hybrid forecasting and knowledge integration approaches.* Disaster communication strategies should encourage the coexistence of scientific forecasting technologies and local ecological observations rather than framing them as competing systems. Integrating satellite forecasting, meteorological advisories, and culturally familiar environmental interpretations may strengthen risk communication, preparedness understanding, and adaptive decision-making. This recommendation directly reflects findings that respondents routinely combined traditional ecological observations with PAGASA advisories, television forecasts, Facebook weather updates, radio announcements, and mobile weather applications, demonstrating strong community receptiveness to hybrid forecasting systems (Sections 3.2.5 and 3.4).
 - (5) *Enhance climate change education and environmental literacy.* Climate adaptation programs should include discussions on how climate change disrupts ecological predictability, seasonal rhythms, biodiversity, and traditional forecasting systems. Community-centered climate education may help vulnerable populations adapt to increasing environmental uncertainty while preserving locally grounded resilience practices and environmental stewardship. This recommendation is informed by participants' observations that weather patterns have become increasingly unpredictable and that ecological indicators previously considered reliable no longer consistently correspond to actual weather outcomes, which many respondents attributed to climate change and environmental degradation (Section 3.5).
 - (6) *Support participatory and culturally grounded disaster governance.* National and international disaster risk reduction frameworks should move beyond purely technocratic approaches by recognizing the cultural, emotional, experiential, and relational dimensions of disaster preparedness. Integrating local ecological intelligence into adaptation planning and resilience policies may contribute to more inclusive, socially responsive, and culturally sensitive disaster governance in hazard-prone regions worldwide. This recommendation is supported by findings that participants interpreted environmental hazards not only as physical threats but also through cultural narratives, emotional meanings, spiritual beliefs, and environmental relationships, highlighting the importance of culturally grounded approaches to resilience and disaster governance (Section 3.6).

4. Discussions and Recommendations

Folk meteorology among coastal Bicolano communities is not merely a collection of superstitious beliefs but a culturally embedded system of environmental intelligence shaped by generations of lived experience with typhoons, floods, storm surges, and coastal uncertainty. In one of the most disaster-prone regions in the Philippines, repeated exposure to extreme weather events has enabled communities to develop localized systems of environmental interpretation rooted in observation, memory, and survival [1,23]. Participants' reliance on sea behavior, atmospheric conditions, animal movements, celestial signs, and bodily sensations demonstrates how ecological familiarity becomes an adaptive mechanism for disaster preparedness and resilience. These findings strongly support previous arguments that Indigenous ecological knowledge emerges from continuous interaction with hazardous environments and remains valuable in contemporary disaster risk reduction [2,6,59]. Similar studies further emphasize that local ecological knowledge is socially transmitted through lived environmental interaction and experiential adaptation within climate-vulnerable communities [8,15].

One major implication of the study is the recognition that disaster preparedness in vulnerable coastal communities extends beyond formal scientific forecasting systems. Although official advisories from PAGASA remain important, participants consistently described how ecological signs often trigger earlier preparedness actions than government warnings. The observation of roaring waves, darkened seawater, sudden wind shifts, and unusual animal behavior commonly resulted in immediate responses such as securing boats, reinforcing houses, storing food, elevating appliances, and avoiding sea travel. Similar patterns were documented in previous Bicol disaster studies where lived environmental familiarity significantly shaped preparedness behavior and adaptive decision-making among hazard-prone households [12,16,17]. Comparable findings from Indigenous and coastal communities globally also show that traditional ecological observations often strengthen anticipatory action and localized disaster preparedness [44,51]. These findings suggest that local ecological intelligence should not be dismissed as outdated knowledge but recognized as a complementary preparedness mechanism capable of strengthening localized early warning systems.

Moreover, folk meteorology functions as a form of environmental hermeneutics in which nature is continuously interpreted through cultural meanings, emotions, and social memory. Expressions such as "*Inagaw*

kan dagat an bagyo” (“*The sea fights the typhoon*”) illustrate how coastal communities do not simply observe environmental changes but actively assign symbolic interpretations to hazards and ecological processes. Within community narratives, the sea is simultaneously perceived as livelihood source, warning system, protector, spiritual presence, and environmental companion. Similar interpretations emerged in previous hermeneutic analyses conducted in Bicol where disasters were understood not only as physical events but also as emotionally and culturally mediated experiences shaped by spirituality, collective suffering, and environmental attachment [16,17]. These findings are likewise consistent with studies emphasizing that Indigenous ecological knowledge systems often integrate symbolic, emotional, and relational understandings of nature alongside practical survival functions. This shows the importance of integrating environmental humanities and disaster anthropology perspectives into disaster studies, particularly in communities where nature remains deeply intertwined with identity, livelihood, and survival [6,60–62].

Another important implication involves the coexistence of Indigenous ecological knowledge and scientific forecasting technologies. Contrary to assumptions that modernization completely replaces traditional knowledge systems, the findings demonstrate the emergence of hybrid forecasting practices combining folk meteorology, PAGASA advisories, Facebook updates, television forecasts, radio announcements, and mobile weather applications. Participants continuously negotiated between ecological observation and digital information in shaping preparedness decisions. Similar hybrid patterns were documented in studies emphasizing the integration of machine learning, scientific forecasting, and culturally grounded preparedness systems in Bicol communities [16,17]. Comparable international studies likewise note that Indigenous and scientific knowledge systems increasingly coexist as complementary adaptation tools in climate-vulnerable regions [46,47,53]. Rather than representing epistemological conflict, this coexistence reflects adaptive intelligence wherein communities strategically combine experiential knowledge with modern forecasting technologies to reduce uncertainty and improve resilience.

The findings additionally underscore the sociological significance of intergenerational knowledge transmission. Participants described learning folk meteorological practices through storytelling, fishing activities, disaster narratives, and observation-based learning within households and communities. Disaster memory therefore becomes socially reproduced through oral tradition and everyday environmental interaction. Bankoff and Sarmiento argued that communities repeatedly exposed to hazards eventually develop “cultures of disaster,” wherein resilience becomes embedded in social memory and collective identity [1,13]. In the Bicol context, recurring typhoons such as Sening, Rosing, Reming, Rolly, Kristine, and Pepito remain deeply etched in local consciousness and continue shaping preparedness attitudes and survival practices [16,17]. Similar studies also emphasize that Indigenous ecological knowledge is commonly preserved through storytelling, experiential learning, and intergenerational environmental observation [48,49].

However, participants also expressed concern regarding the gradual decline of ecological observation practices among younger generations due to smartphones, social media, and increasing dependence on digital forecasting systems. While modernization improves access to information, the weakening of place-based environmental familiarity may reduce localized sensitivity to ecological warning signs. This finding raises important concerns regarding the long-term preservation of Indigenous ecological knowledge systems amidst rapid technological transformation.

Climate change further complicates the reliability of traditional forecasting systems. Participants frequently described weather conditions as becoming increasingly unpredictable compared to previous decades. Ecological signs once considered reliable were perceived as less consistent due to intensified rainfall, stronger typhoons, disrupted seasonal rhythms, and changing ocean conditions. Similar observations were documented in studies examining climate-related uncertainty and disaster vulnerability in Bicol and other hazard-prone regions [20,63,64]. Participants also expressed forms of climate anxiety and ecological uncertainty, particularly among elderly fisherfolk concerned about the environmental futures inherited by younger generations. These findings parallel studies on ecological grief and emotional distress associated with climate instability among communities highly dependent on natural ecosystems [56]. Nonetheless, participants continued valuing folk meteorology not necessarily for absolute predictive accuracy but for maintaining preparedness consciousness, environmental awareness, and collective vigilance amidst growing climatic uncertainty.

The study also carries important implications for disaster governance and community-based disaster risk reduction. Existing DRRM frameworks in the Philippines often prioritize centralized forecasting technologies while underestimating localized ecological knowledge already embedded within vulnerable communities. The findings suggest that culturally grounded preparedness systems can strengthen community participation, trust, psychosocial resilience, and localized risk communication. Integrating Indigenous ecological intelligence into DRRM education, evacuation planning, and early warning systems may therefore improve the effectiveness and social legitimacy of disaster preparedness interventions [15,64]. Similar studies further argue that integrating local

ecological intelligence into formal adaptation planning strengthens both resilience and social legitimacy in climate governance [38,45].

The findings are specific to typhoon-prone, fishing-dependent coastal communities in the Bicol Region, where forecasting practices are closely linked to marine livelihoods and repeated exposure to coastal hazards. As such, the findings may not be fully transferable to agricultural communities, which may rely on different environmental indicators, or to urban inland settings, where direct interaction with natural forecasting cues is less common. Future research should examine how folk meteorology and local ecological knowledge vary across different environmental, occupational, and cultural context. Finally, the study demonstrates that folk meteorology remains an important component of environmental interpretation, disaster preparedness, emotional resilience, and adaptive survival among coastal Bicolano communities. Despite climate uncertainty, modernization, and technological change, Indigenous ecological intelligence continues to shape how communities understand, anticipate, and respond to hazards. Rather than treating folk meteorology as obsolete superstition, the findings suggest that it should be recognized as a culturally grounded and socially embedded form of local ecological intelligence with significant implications for climate adaptation, resilience-building, environmental hermeneutics, and disaster governance in typhoon-prone regions of the Philippines.

5. Conclusions

Folk meteorology remains an important yet often overlooked component of disaster preparedness and environmental interpretation among coastal Bicolano communities. Rooted in generations of lived experience with typhoons, floods, and storm surges, local ecological knowledge continues to shape how communities anticipate hazards, interpret environmental changes, and respond to uncertainty. Observations of sea behavior, winds, clouds, animal movements, and other ecological signals remain deeply embedded within everyday preparedness practices and cultural memory. Rather than rejecting scientific forecasting systems, coastal residents actively combine Indigenous ecological observations with PAGASA advisories, television forecasts, social media updates, and mobile weather applications. Such findings demonstrate that traditional ecological knowledge complements rather than contradicts scientific forecasting technologies. Beyond prediction, folk meteorology also strengthens emotional resilience, environmental awareness, and community cohesion. Recognizing and integrating local ecological intelligence into disaster risk reduction and climate adaptation planning may therefore contribute to more culturally grounded, community-centered, and socially responsive resilience strategies in increasingly hazard-prone coastal environments.

Supplementary Materials

The additional data and information can be downloaded at: <https://media.scilit.com/articles/others/2608101058418991/JHRR-26050178-SM.pdf>.

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Institutional Review Board Statement

Participation in this study was voluntary, and informed consent was obtained from all participants prior to data collection. Participants were fully informed of the study objectives, the measures taken to ensure confidentiality, and their right to withdraw from the study at any time without penalty. To safeguard participants' privacy and anonymity, pseudonyms and generalized community identifiers were used throughout the reporting of the findings. Audio recordings, interview transcripts, and field notes were securely stored and used exclusively for research purposes. Permission to collect, process, analyze, and disseminate the data was obtained from the concerned Local Government Units. The study was conducted under the approved Disaster Analytics Project of the researchers' institution. As the institution does not currently have a formal Institutional Review Board (IRB) or Ethics Committee, no IRB approval number is available. Nevertheless, all research procedures were carried out in accordance with established ethical principles for academic and scientific research. All methodological procedures, analyses, and interpretations were conducted independently by the researcher without any experimental intervention or manipulation. The study relied on indirectly gathered socioeconomic and disaster-related information and did not involve experiments on humans or animals. All collected data were handled with strict confidentiality and managed in accordance with recognized ethical standards. The study did not collect or analyze social media posts, personal online communications, or identifiable digital content. References to

Facebook weather updates, social media information, and mobile weather applications emerged solely from participants' narratives describing their sources of weather and disaster-related information. Consequently, no personal social media data were accessed, collected, or used in this research.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Prior to data collection, all participants received a clear explanation of the study objectives, research procedures, the voluntary nature of participation, and the intended use of the findings. Participants were informed of their right to refuse participation or withdraw from the study at any time without penalty or consequence. They were also informed that anonymized findings and aggregated results may be used in academic publications, conference presentations, and other scholarly outputs. Written informed consent for the publication of anonymized information was obtained from all participants involved in the study. No personally identifiable information is included in this manuscript.

Data Availability Statement

The data supporting the findings of this study, including the supplementary materials and supporting research data, are publicly available in the Zenodo repository. The dataset has been archived to ensure long-term accessibility and preservation and can be accessed at: <https://media.sciltp.com/articles/others/2608101058418991/JHRR-26050178-SM.pdf>. The shared dataset has been anonymized and summarized to protect participant confidentiality. Any information that could directly identify individual participants has been removed in accordance with ethical and privacy requirements. The raw data containing personal, perception-based, and detailed socioeconomic information collected during the study are not publicly available due to confidentiality obligations, informed consent agreements, and ethical considerations protecting participant privacy.

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Conflicts of Interest

The author declares no conflict of interest. The author affirms that there are no financial, personal, professional, or institutional relationships that could be perceived as influencing the objectivity, integrity, or interpretation of the research.

Use of AI and AI-Assisted Technologies

During the preparation of this work, the author used artificial intelligence (AI) tools solely to assist with the creation of selected graphical illustrations and the summarization of notes during manuscript preparation. After using these tools, the author thoroughly reviewed and edited all generated content as needed and takes full responsibility for the accuracy, originality, integrity, and content of the published article. All research activities, including the conception and design of the study, data collection, data analysis, interpretation of findings, manuscript writing, revision, and final editorial decisions, were conducted independently by the author.

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