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Supplementary Materials

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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Folk meteorology, beliefs, and traditional typhoon prediction practices in the Bicol region:

(1) Strong roaring sounds from the sea indicate an approaching typhoon.
(2) Unusually dark seawater signals severe weather disturbances.
(3) Sudden calmness of the sea before a storm suggests an incoming strong typhoon.
(4) Large waves repeatedly crashing near the shore warn of rough weather.
(5) The expression “the sea fights the typhoon” signifies that the sea reacts violently against incoming storms and may weaken its impact.
(6) Fish moving deeper into the sea indicate bad weather.
(7) Crabs climbing higher ground suggest incoming floods or heavy rainfall.
(8) Jellyfish appearing near the shoreline indicate rough seas.
(9) Flying fish becoming unusually active signals changing weather conditions.
(10) Sudden disappearance of birds from coastal areas suggests an approaching storm.
(11) Birds flying inland are interpreted as warnings of strong winds or heavy rain.
(12) Seagulls flying lower than usual indicate worsening weather.
(13) Silence of birds before dawn is associated with severe weather disturbances.
(14) Restless dogs and continuous barking are believed to signal incoming calamities.
(15) Chickens refusing to leave their shelters indicate approaching storms.
(16) Frogs croaking loudly at unusual hours suggest heavy rainfall.
(17) Ants transferring eggs to elevated places signal flooding.
(18) Insects flying unusually low indicate rain and storms.
(19) Dragonflies appearing in large numbers suggest changes in atmospheric pressure.
(20) Coconut trees bending abnormally despite weak winds indicate a strong typhoon is near.
(21) Banana leaves folding tightly are believed to signal heavy rain.
(22) Sudden yellowing of leaves may indicate prolonged rainfall.
(23) The smell of the sea becoming unusually strong suggests an incoming storm.
(24) Heavy and humid air indicates approaching typhoons.
(25) Sudden extreme heat before rainfall signals severe weather.
(26) A reddish sunset is believed to precede storms.
(27) Dark clouds rapidly moving from the Pacific indicate typhoon formation.
(28) Low and fast-moving clouds suggest worsening weather conditions.
(29) Ring-shaped halos around the moon indicate an approaching storm.
(30) A pale or blurry moon suggests incoming rainfall.
(31) Extremely bright stars during unusual seasons are interpreted as signs of weather change.
(32) Sudden disappearance of stars indicates an approaching typhoon.
(33) Thunder without visible rainclouds signals atmospheric disturbance.
(34) Strong winds changing direction abruptly suggest typhoon intensification.

(35) Unusual stillness of air before rainfall is associated with dangerous storms.
(36) Sea tides rising faster than normal indicate storm surges.
(37) Saltwater reaching farther inland than usual signals rough seas and possible coastal flooding.
(38) Waves repeatedly hitting coastal rocks harder than normal suggest worsening storms.
(39) Fisherfolk avoid sailing when the sea appears “angry” or darker than usual.
(40) Elders observe mountain fog patterns to predict rainfall intensity.
(41) Thick fog covering coastal mountains indicates prolonged rain.
(42) Sudden disappearance of fireflies is associated with severe weather.
(43) Continuous lightning over the sea without rainfall suggests an approaching typhoon.
(44) Sharp pain in joints or body aches among elders are believed to indicate atmospheric pressure changes.
(45) Sudden headaches or dizziness among fisherfolk are interpreted as signs of changing weather.
(46) Strong ocean odors carried inland by the wind suggest an approaching storm.
(47) Sudden silence in coastal surroundings is considered a warning sign before severe weather.
(48) Traditional prayers and religious rituals are performed before anticipated typhoons.
(49) Boats are pulled farther inland when elders interpret environmental signs as dangerous.
(50) Community members store rice, water, dried fish, and firewood immediately after observing unusual environmental conditions associated with approaching storms.
(51) The phrase “makusog an dagat” (“the sea is strong”) is used to describe unusually violent wave behavior before typhoons.
(52) Continuous drizzle accompanied by strong sea winds is believed to indicate a longer-lasting storm.
(53) Sudden migration of bats away from coastal caves suggests severe weather disturbances.
(54) Tilapia and freshwater fish surfacing unusually often indicate abrupt atmospheric changes.
(55) Carabaos becoming restless or refusing to graze are interpreted as signs of heavy rainfall.
(56) Cats persistently hiding indoors are believed to signal strong winds or rain.
(57) Sudden swarming of mosquitoes before sunset suggests incoming rain.
(58) Bamboo poles producing creaking sounds despite weak winds indicate atmospheric instability.
(59) Palm fronds turning upward unusually fast are associated with approaching storms.
(60) Sudden murkiness of river water without upstream rainfall suggests incoming floods.
(61) Coastal residents observe unusual phosphorescence in seawater as a sign of rough seas.
(62) Fisherfolk interpret repeated failure to catch fish as a warning of worsening weather.
(63) Persistent strong easterly winds are associated with typhoon formation in the Pacific.
(64) A sudden drop in nighttime temperature despite humid conditions suggests an incoming storm.
(65) Repeated distant rumbling from the sea is believed to signal storm surges.
(66) Continuous formation of thick clouds over Mount *Isarog* indicates heavy rainfall in nearby communities.
(67) Fog descending rapidly from mountains toward coastal areas signals worsening weather.
(68) The smell of wet soil before rainfall is interpreted as a sign of an approaching typhoon band.
(69) Elders observe unusual wave intervals to predict storm intensity.
(70) Sudden rapid movement of clouds despite calm ground winds indicates upper-atmosphere disturbance.
(71) Rain falling while the sun is visible is sometimes interpreted as a precursor of unstable weather conditions.
(72) Unusually large and slow-moving clouds are associated with prolonged rainfall.
(73) Fisherfolk avoid traveling when seabirds circle repeatedly above the shoreline.
(74) The absence of insects during nighttime is interpreted as a sign of severe weather changes.
(75) Sudden increase in snake sightings on higher ground suggests flooding.
(76) Shrimp and small marine species moving closer to shore are believed to indicate rough offshore waters.
(77) Strong whirlpools or unusual sea currents are interpreted as warnings of storms.
(78) Sudden loud cracking sounds from trees during humid weather are associated with incoming strong winds.
(79) Cattle gathering closely together is believed to indicate heavy rain or cold weather disturbances.
(80) Continuous barking of dogs directed toward the sea is interpreted as a warning sign among some coastal communities.
(81) Sudden blooming of certain flowers outside normal seasons is associated with climatic irregularities.
(82) Elders monitor the behavior of swallows to predict rainfall intensity.
(83) Sudden cloud cover after extremely clear skies suggests abrupt weather changes.
(84) Repeated lightning flashes over mountains indicate approaching rainbands.
(85) Ocean waves producing unusually white foam are believed to signal stronger storms.
(86) Strong winds occurring during unusually clear weather suggest an approaching typhoon circulation.
(87) Fisherfolk interpret warm seawater temperatures as indicators of stronger typhoons.

(88) Sudden collapse of termite mounds is associated with heavy rainfall and flooding.
(89) Continuous crowing of roosters at unusual hours is interpreted as a sign of atmospheric disturbance.
(90) Coastal communities monitor tidal irregularities during full moons to anticipate storm surges.
(91) Sudden drying of shallow wells before storms is believed to indicate environmental imbalance.
(92) Strong echoes from the sea during calm evenings are interpreted as warnings of rough weather.
(93) Community elders compare current environmental patterns with memories from past destructive typhoons.
(94) Traditional knowledge from fisherfolk is shared orally across generations as part of disaster preparedness.
(95) Folk meteorological practices are often combined with PAGASA advisories before making evacuation decisions.
(96) Residents interpret simultaneous animal behavioral changes as stronger indicators of severe weather.
(97) Unusual silence of cicadas and crickets before evening is associated with heavy rainfall.
(98) Community members reinforce roofs and secure livestock after observing traditional environmental warning signs.
(99) Fisherfolk monitor cloud formations near the horizon to estimate incoming rainfall duration.
(100) Indigenous and local ecological knowledge remains an important complement to scientific weather forecasting in coastal Bicol communities.
(101) Many Bicolano households believe that combining traditional folk meteorology, lived experience, and modern forecasting technologies improves disaster preparedness and community resilience.

Table S1. Major clusters of folk meteorological knowledge identified among coastal Bicolano communities.

Cluster of Folk Meteorological Knowledge	Representative Beliefs and Practices	Relative Prominence
1. Sea Behavior and Ocean Conditions	Roaring waves, dark seawater, unusual tides, storm surges, rough currents, sea odor, wave intervals	Very Frequently Mentioned
2. Wind Patterns and Atmospheric Conditions	Amihan, habagat, salatan winds, sudden wind shifts, humid air, unusual heat, stillness before storms	Very Frequently Mentioned
3. Cloud Formations and Sky Observation	Dark clouds, fast-moving clouds, reddish sunsets, cloud cover, lightning patterns	Rarely Mentioned
4. Animal Behavior and Ecological Signals	Birds flying inland, restless dogs, frogs croaking, ants moving eggs, fish behavior, insects and bats	Frequently Mentioned
5. Coastal and Marine Ecological Indicators	Jellyfish near shore, phosphorescence, marine species movement, fish scarcity, seawater temperature	Very Rarely Mentioned
6. Vegetation and Landscape Indicators	Coconut and banana leaf behavior, mountain fog, river conditions, tree sounds, unusual flowering	Very Rarely Mentioned
7. Celestial and Astronomical Observations	Moon halos, disappearance of stars, bright stars, Arko ni Noe constellation	Moderately Mentioned
8. Embodied Environmental Knowledge	Headaches, body pain, dizziness, physical discomfort, perceived atmospheric pressure changes	Rarely Mentioned
9. Traditional Preparedness Practices	Pulling boats inland, storing food and water, securing livestock, reinforcing houses, religious rituals	Frequently Mentioned
10. Intergenerational and Hybrid Forecasting Knowledge	Oral transmission, disaster memory, elders' interpretations, integration with PAGASA advisories and digital forecasts	Moderately Mentioned

Table S2. Summary of *Walowalong Paros (Walowalong Hangin)* in Ancient Bicol Folk Meteorology.

Theme	Description	Key Terms (Bicol/Tagalog/English)
Definition	*Walowalong Paros* or *Walowalong Hangin* refers to eight consecutive days of strong Habagat winds experienced in Bicol, traditionally viewed as a period of protection from typhoons.	Walowalo, Walowalong Paros, Walowalong Hangin, Habagat
Meteorological Basis	The wind originates from the southwest (*Habagat*), bringing warm, humid, and rainy conditions. Traditionally, it is believed to influence the movement of tropical cyclones away from Bicol.	Habagat, southwest monsoon
Traditional Belief	Ancient Bicolanos regarded the *Walowalo* as a friendly and protective wind that prevents direct typhoon impacts on the region.	Kaibigan at Kakamping Hangin
Seasonality	Usually observed during July and August, serving as a seasonal indicator of relative safety from typhoon landfalls.	Hulyo, Agosto
Relationship with Typhoons	When the *Walowalo* is present, storms are believed to be diverted or weakened. When it ceases and the *Amihan* begins, communities become alert for possible typhoon landfalls.	Amihan, pag-berek, pag-agaw
Cultural Interpretation	The Habagat is considered a guardian wind that restrains destructive storms and protects coastal communities.	taga-saway, tagapangalaga, tagabantay
Community Response	Coastal residents traditionally welcomed the arrival of the *Walowalo* as a sign of protection and hoped it would continue to blow.	makabosbos, umiihip ang walowalo
Risk Perception	Failure of the *Walowalo* to develop or persist was interpreted as increased vulnerability to storms once the *Amihan* season arrived.	hindi makabosbos, delikado ang rehiyon
Regional Contrast	While Habagat is often viewed negatively in Tagalog, Ilocano, and Central Luzon areas due to heavy rainfall and flooding, Bicolanos traditionally regarded it as beneficial because of its perceived protective effect against typhoons.	Habagat bilang biyaya
Catanduanes Classification of Habagat	Ancient Catanduanes communities recognized four forms of Habagat based on direction and local climatic behavior.	Habagat sa Lagonoy, Habagat sa May-ong, Verdaderong Habagat, Habagat sa Bacong

Table S2. *Cont.*

Theme	Description	Key Terms (Bicol/Tagalog/English)
Coastal Bicol Classification	Coastal communities identified three major Habagat types associated with local sea currents (*sulog*).	Habagat sa *Isarog*, Habagat sa Asog, Natural na Habagat
Associated Ocean Currents	Wind interpretation was linked to sea-current patterns used in local forecasting and navigation.	sulog pa-lawod, sulog pahunas, sulog pa-nato, sulog pa-sabang, tuninong na sulog
Traditional Wind System	Ancient Bicol recognized an elaborate folk meteorological system consisting of multiple named winds used for weather prediction and hazard interpretation.	Hiraga, Amihan, Dumagsa, Habagat, Kanaway, Salatan
Strongest Wind	*Salatan* (southeast wind from the sea) was regarded as the strongest wind and the final wind that suppresses storms before they end.	Salatan, huring taga-saway, parapapundo kan bagrat
Indigenous Forecasting System	Weather forecasting was based on the observation of wind direction, ocean currents, cloud behavior, and environmental changes.	Indigenous Knowledge, Folk Meteorology
Cultural Significance	The Walowalo reflects the integration of environmental observation, disaster preparedness, spirituality, and local ecological knowledge in Bicolano culture.	Folk Meteorology, Local Ecological Intelligence
Contemporary Relevance	The tradition illustrates how Indigenous forecasting systems can coexist with modern meteorological science and disaster risk reduction efforts.	Hybrid Forecasting, Indigenous Knowledge Systems

Table S3. *Bolangiw kan Bulan* (Moonbow) in Bicolano Folk Meteorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	A nighttime rainbow or moonbow visible under bright moonlight and favorable atmospheric conditions.	Bolangiw kan Bulan, *Bahaghari sa Gabi*, Moonbow
Observed Location	Traditionally observed in coastal and upland areas of Bicol, particularly where moonlight and moisture conditions allow visibility.	Mt. *Isarog*, Palayan, coastal Bicol
Traditional Interpretation	Considered an environmental sign associated with approaching storms and heightened disaster awareness.	Disaster Folk Analytics
Incomplete Moonbow	A broken or partial *Bolangiw kan Bulan* is traditionally interpreted as a sign that a typhoon may pass through or directly affect Bicol.	Putol na Bolangiw, Kalahating Bahaghari
Complete Moonbow	A full or unbroken moonbow is traditionally interpreted as an indication that Bicol may avoid a direct typhoon landfall.	Buong Bolangiw
Typhoon Association	Regardless of direct landfall, the appearance of a moonbow at night is viewed as a warning that the region may experience heightened weather disturbances or disaster risks.	Bagyo, Unos, Peligro
Knowledge Source	Derived from long-term observation, oral tradition, and coastal environmental experience among Bicolano communities.	Indigenous Knowledge, Folk Meteorology
Disaster Function	Serves as an informal early-warning indicator that encourages vigilance and preparedness among community members.	Paghahanda, Pagmamatyag
Scientific Perspective	A moonbow is produced when moonlight is refracted, reflected, and dispersed through water droplets, similar to a daytime rainbow.	Moonbow, Atmospheric Optics
Contemporary Relevance	Folk interpretations are increasingly combined with scientific weather forecasts, hazard advisories, and disaster risk reduction strategies.	Hybrid Forecasting, PAGASA, Indigenous Science
Cultural Significance	Reflects the Bicolano tradition of reading environmental signs and integrating nature, culture, and hazard awareness into daily life.	Bolangiw kan Bulan, Pagbasa kan Kalikasan

Table S4. Amihan Season and Increased Typhoon Exposure in Bicol and Eastern Visayas.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Season	The *Amihan* season is characterized by cool, dry northeasterly winds originating from continental Asia, particularly Siberia and Northeast Asia.	Amihan, Northeast Monsoon
Wind Direction	Cold winds flow from the north and northeast toward the Philippines and the western Pacific.	Hilaga, Hilagang-Silangan
Traditional Observation	Coastal Bicolanos traditionally associate the onset of *Amihan* with increased vigilance for typhoons affecting eastern Philippine regions.	Panahon ng Amihan
Meteorological Mechanism	Tropical cyclones generally prefer warm ocean waters and warmer atmospheric conditions for intensification and maintenance.	Bagyo, Tropical Cyclone
Effect of Cold Air	Cold northeasterly air associated with Amihan may weaken tropical cyclones and discourage their movement toward higher latitudes.	Malamig na Hangin
Storm Track Influence	During Amihan season, many tropical cyclones follow a westward or west-southwestward track, increasing exposure of eastern Philippine coastlines.	Pakanluran, Timog-Kanluran, Padaosdos
Role of High-Pressure Area	A High-Pressure Area (HPA) over East Asia can act as a steering mechanism that redirects tropical cyclones toward the Philippines.	HPA, Pusher, Blocker
Regions Commonly Affected	Eastern-facing regions often experience greater typhoon exposure during Amihan months, particularly from October to December.	Bicol Region, Eastern Visayas
Historical Example	Communities frequently cite Typhoon Nina (2016), which struck Bicol during the Christmas season, as an example of an Amihan-season typhoon.	Bagyong Nina
Contrast with Habagat Season	During *Habagat* months, typhoon tracks often recurve farther north, increasing impacts on Northern and Central Luzon.	Habagat, Southwest Monsoon
Traditional Interpretation	In folk meteorology, *Amihan* is often viewed as a "kaaway" (adversarial wind) because its arrival coincides with increased typhoon risk for Bicol.	Kaaway na Hangin
Protective Counterpart	*Habagat* and the *Walowalo* are traditionally regarded as protective winds that help divert storms away from Bicol.	Habagat, Walowalo, Kakamping Hangin
Disaster Preparedness Implication	The onset of Amihan serves as a seasonal signal for heightened preparedness, monitoring, and coastal vigilance.	Paghahanda, Pagmamatyag, Pag-iingat
Cultural Significance	Reflects the integration of Indigenous weather interpretation, seasonal wind systems, and community disaster awareness in Bicolano culture.	Folk Meteorology, Local Ecological Intelligence

Table S5. *Pag-Berek (Ballos)*, Wind Shifts, and Sea Interpretation in Coastal Bicolano Folk Meteorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	*Pag-berek* refers to the shifting of wind direction during a tropical cyclone, often interpreted as a transition between phases of the storm.	Pag-berek, Ballos
Observed Wind Shift	Transition from northerly or northwesterly winds toward southwesterly winds during storm passage.	Amihan Kanaway, Habagat *Isarog*
Storm Interpretation	The wind shift is traditionally interpreted as the end of the first phase and the beginning of the second phase of a typhoon.	First Part, Second Part, Ballos
Role of Salatan	The arrival of the southeast wind often signals the weakening or departure of the storm system.	Salatan, Huring Taga-Saway, Parapapundo kan Bagrat
Sea-State Indicator	Coastal residents observe changes in wave height, current direction, and sea sounds to interpret storm intensity and potential hazards.	Hukol (Alon)
Storm Surge Interpretation	If winds shift toward the east (*Dumagsa*), communities may expect larger waves and storm surges along the eastern coast.	Dumagsa, Storm Surge
Absence of Sea Capture	When the sea does not produce unusually violent wave action despite strong winds, communities may say that the storm was not "captured" or "fought" by the sea.	Inagaw kan Dagat an Bagyo
Wave Sound as Environmental Signal	The sound of the sea is continuously monitored and interpreted by coastal residents as part of environmental awareness and hazard recognition.	Tunog kan Dagat, Hukol
Local Environmental Literacy	Experienced fisherfolk and elders distinguish between normal seasonal waves and dangerous storm-generated sea conditions.	Pagbasa kan Dagat, Folk Meteorology
Amihan Season Waves	Large waves during the Amihan season are generally considered normal unless accompanied by abnormal wind patterns or coastal flooding.	Amihan, Hukol
Community Knowledge Transmission	Knowledge of sea behavior is transmitted through lived experience, fishing activities, oral tradition, and observation.	Indigenous Knowledge, Oral Tradition
Disaster Preparedness Function	Wind shifts and sea conditions provide informal cues for coastal preparedness, fishing decisions, and hazard awareness.	Paghahanda, Pagmamatyag
Cultural Significance	The sea is viewed not only as a source of livelihood but also as a warning system whose sounds, waves, and currents communicate environmental change.	Dagat bilang Babala, Local Ecological Intelligence

Table S6. Flowering of *Madre de Cacao* and *Marokbarok* as Seasonal Indicators in Bicolano Ethnometeorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Knowledge System	Ancient Bicolanos used the flowering cycles of certain trees to anticipate seasonal changes, wind regimes, and potential weather conditions.	Ethno-meteorological Knowledge, Pagbasa kan Panahon
Madre de Cacao	The flowering of *Madre de Cacao* (*Gliricidia sepium*) is traditionally interpreted as the onset of the Habagat season.	Madre de Cacao, Habagat
Associated Season (Madre de Cacao)	Usually flowers between April and August, corresponding with the southwest monsoon period.	Abril–Agosto, Habagat Season
Traditional Meaning (Madre de Cacao)	Considered a sign that the Habagat winds are strengthening and that Bicol is relatively safer from direct typhoon landfalls.	Ligtas sa Bagyo, Kakamping Hangin
Marokbarok Tree	The flowering of *Marokbarok* (*Pongamia pinnata* Linn.) is traditionally associated with the arrival of the Amihan season and increased typhoon activity.	Marokbarok, Amihan
Associated Season (Marokbarok)	Usually flowers between September and December, coinciding with the northeast monsoon and peak typhoon season in Bicol.	Setyembre–Disyembre, Typhoon Season
Traditional Meaning (Marokbarok)	Serves as a natural indicator that communities should prepare for stronger storms and changing weather conditions.	Panahon kan Bagyo, Paghahanda
Ecological Basis	These interpretations are based on long-term observation of recurring relationships between plant phenology and seasonal climate patterns.	Phenology, Local Ecological Intelligence
Physical Characteristics	Both trees produce attractive pink blossoms that resemble East Asian flowering trees such as Sakura or Cherry Blossoms.	Pink na Bulaklak, Sakura, Cherry Blossom
Resilience to Typhoons	Both species are recognized for their durability and ability to withstand strong winds and repeated typhoon exposure.	Matuos (matibay)
Cultural Significance	The trees function as living environmental calendars that help communities interpret seasonal transitions without scientific instruments.	Kalendaryong Pangkalikasan, Folk Meteorology
Disaster Preparedness Role	Flowering patterns provide informal cues for anticipating shifts between Habagat and Amihan seasons and adjusting livelihood activities accordingly.	Pagmamatyag, Paghahanda, Pag-angkop
Contemporary Relevance	Illustrates how Indigenous environmental knowledge can complement modern climate and weather forecasting systems.	Hybrid Forecasting, Indigenous Knowledge Systems

Table S7. Traditional interpretation of *Ballos (Pag-berek)*, post-typhoon wind shifts, and associated coastal hazards in Bicolano folk meteorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	*Ballos* refers to the second phase of a typhoon following the passage of the eye, often associated with a reversal or shift in wind direction.	Ballos, Pag-berek
Geographic Use	The term is commonly used in Catanduanes and coastal districts of Bicol, although other communities may use different names.	Catanduanes, Coastal Bicol
Meteorological Interpretation	The phenomenon corresponds to the change in wind direction that occurs as a tropical cyclone passes and circulation shifts around the storm center.	Shifting Wind Direction
Traditional Importance	Coastal residents closely monitor the direction of the post-eye winds because it influences wave behavior, storm surges, and coastal hazards.	Pagmamatyag, Pagbasa kan Hangin
Scenario 1: Shift to Dumagsa	A transition from *Amihan* or *Kanaway* toward *Dumagsa* (easterly wind) is traditionally associated with intensified wave action and possible storm surges along eastern coastlines.	Dumagsa, Inagaw kan Dagat, Daluyong
Sea-Capture Interpretation	When strong easterly winds generate large waves and surges, communities describe the event as the sea "capturing" or "fighting" the storm.	Inagaw kan Dagat an Bagyo
Scenario 2: Shift to Habagat–Salatan	A transition from *Amihan* to *Habagat Isarog* and eventually to *Salatan* is interpreted as a sign that the storm is weakening and nearing its end.	Habagat *Isarog*, Salatan
Role of Salatan	Considered the strongest and most powerful wind in traditional Bicolano wind classification and the wind that ultimately suppresses or ends a storm.	Salatan, Gasuhay nin Bagyo
Traditional Saying	In Catanduanes tradition, Salatan is viewed as the only wind capable of stopping a typhoon.	*"Salatan! Siya sana an gasuhay nin bagyo".*
Wind Classification System	Ancient Bicolano communities recognized multiple named winds, each associated with specific weather outcomes and environmental interpretations.	11 Uri nin Hangin
Disaster Preparedness Role	Monitoring wind shifts helps coastal households anticipate storm surges, dangerous seas, flooding, and the likely progression of a storm.	Paghahanda, Hazard Awareness
Cultural Significance	Ballos reflects the deep environmental literacy of coastal Bicolano communities, where changes in wind direction are interpreted as meaningful indicators of hazard dynamics.	Folk Meteorology, Local Ecological Intelligence
Contemporary Relevance	Traditional interpretations of Ballos are increasingly combined with meteorological forecasts, satellite imagery, and disaster advisories.	Hybrid Forecasting, Indigenous Knowledge Systems

Table S8. Red or Pink Skies (*Mapulang Kalawakan*) in Bicolano Folk Meteorology and Environmental Interpretation.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	The appearance of red, pink, or orange skies during sunset, twilight, or afterglow conditions.	Mapulang Langit, Pink na Kalawakan, Takipsilim
Scientific Explanation	Caused primarily by the scattering of sunlight as it passes through a thicker portion of the atmosphere during sunrise or sunset.	Rayleigh Scattering, Mie Scattering
Role of Atmospheric Particles	Dust, smoke, volcanic ash, moisture, and aerosols can intensify red and pink colors in the sky.	Particulates, Aerosols, Volcanic Ash
Meteorological Influence	Weather systems such as monsoons, tropical cyclones, and moisture-laden air masses may enhance atmospheric conditions favorable for vivid sunsets.	Amihan, Habagat, Bagyo
Afterglow Effect	Red or pink coloration may persist after sunset due to sunlight scattering in the upper atmosphere.	Afterglow, Stratospheric Scattering
Traditional Weather Interpretation	A red sky is traditionally regarded as a sign of strengthening winds, approaching rainfall, or changing weather conditions.	"Pag mapula an langit, makusog an paros".
Typhoon Forecasting Indicator	Elderly residents often interpret unusual sky coloration as a warning of an approaching storm or climatic disturbance.	Paros, Bagyo, Kalamidad
Environmental Warning Function	Serves as a natural forecasting cue used before the widespread availability of scientific weather instruments.	Pagbasa kan Kalawakan, Folk Forecasting
Spiritual Interpretation	In some communities, unusual sky colors are interpreted as signs, warnings, reminders, or manifestations of spiritual significance.	Pangitain, Babala, Pagpapaalala
Knowledge Source	Derived from generations of observation linking sky appearance with subsequent weather conditions.	Indigenous Knowledge, Ethnometeorology
Disaster Preparedness Role	Encourages vigilance, preparedness, and environmental awareness among households and coastal communities.	Paghahanda, Pagmamatyag
Cultural Significance	Demonstrates how atmospheric phenomena are interpreted through both scientific reasoning and culturally embedded environmental knowledge.	Local Ecological Intelligence, Environmental Hermeneutics
Contemporary Relevance	Illustrates the coexistence of meteorological science and Indigenous forecasting traditions in understanding environmental change.	Hybrid Forecasting, Indigenous Science

Table S9. *Tagnong* as a Weather Indicator in Bicolano Folk Meteorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	*Tagnong* refers to a period of stillness when there is little or no wind and the environment becomes unusually calm.	Tagnong
English Equivalent	Often interpreted as the "calm before the storm", although it may also occur during dry-season conditions.	Calm Before the Storm
Environmental Characteristics	Air is still, vegetation remains motionless, and surrounding environmental activity appears subdued.	Kalmadong Paligid, Walang Hangin
Traditional Detection Method	The movement of coconut leaves is used to determine whether a *tagnong* condition exists.	Dahon kan Niyog
Interpretation of Coconut Leaves	When the tips of coconut fronds do not sway or flutter, elders interpret the condition as *tagnong*.	Dulong Dahon, Hindi Tumataboy
Weather Forecasting Function	Serves as an important indicator for identifying potential changes in weather and the possible arrival of storms.	Sama kan Panahon, Paghula kan Panahon
Typhoon-Related Tagnong	May indicate atmospheric instability or a temporary lull before the arrival of strong winds associated with a tropical cyclone.	Bagyo, Kalamidad
Dry-Season Tagnong	Can also occur during the hot season when weak pressure gradients result in calm atmospheric conditions.	Tag-init, Mainit na Panahon
Dual Interpretation	Coastal communities distinguish between storm-related *tagnong* and summer *tagnong* based on surrounding environmental signs.	Duwang Uri nin Tagnong
Role in Wind Analysis	Considered a transitional state from which a new dominant wind direction may emerge.	Pinag-uugatan kan Hangin
Associated Wind System	Ancient Bicolanos recognized multiple named winds used in environmental forecasting and hazard interpretation.	Hiraga, Amihan, Dumagsa, Habagat, Kanaway, Habagat *Isarog*, Habagat sa Mayon, Salatan
Most Powerful Wind	*Salatan* (southeast wind from the sea) is regarded as the strongest wind and the one capable of ending a storm.	Salatan, Pinakamakapangyarihang Hangin
Disaster Preparedness Role	Observation of *tagnong* conditions prompts heightened awareness of possible weather transitions and hazard development.	Pagmamatyag, Paghahanda
Knowledge Source	Derived from long-term observation of wind behavior, vegetation responses, and seasonal weather patterns.	Indigenous Knowledge, Folk Meteorology
Cultural Significance	Reflects the Bicolano practice of interpreting subtle environmental cues to understand atmospheric conditions and seasonal change.	Pagbasa kan Kalikasan, Local Ecological Intelligence

Table S10. *Pili* and *Ibah* Trees as Symbols of Resilience and Ecological Adaptation in Bicol.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	Certain native trees in Bicol are traditionally recognized for their exceptional ability to withstand frequent typhoons and recover rapidly after storms.	Pili, Ibah, Matuos
Environmental Context	Due to repeated exposure to tropical cyclones, large and old trees are relatively uncommon in many parts of Bicol.	Bagyo-prone Region, Unos
Pili Tree Characteristics	The Pili tree is known for its strong trunk, flexible structure, and resistance to wind damage, making it less likely to break or topple during storms.	Pili (*Canarium ovatum*)
Traditional Observation (Pili)	Communities observe that Pili trees often remain standing even after severe typhoons and may continue producing fruits despite adverse weather conditions.	Namumunga sa Gitna kan Bagyo
Ibah Tree Characteristics	The Ibah tree is regarded as one of the most durable local tree species, capable of surviving intense winds and rapidly regenerating after disturbance.	Ibah (*Averrhoa bilimbi)*
Traditional Observation (Ibah)	Shortly after major storms, Ibah trees frequently flower and bear fruit, demonstrating remarkable ecological recovery.	Namumulaklak Pagkatapos kan Unos
Adaptation Strategy	Both species exhibit traits associated with resilience, including structural flexibility, deep rooting systems, and rapid post-disturbance recovery.	Adaptation, Flexibility
Ecological Significance	These trees illustrate how native species adapt to long-term environmental pressures in typhoon-prone ecosystems.	Ecological Adaptation, Resilience
Folk Environmental Interpretation	The ability of these trees to thrive after storms is viewed as evidence that adversity can stimulate growth and renewal.	Pagbangon, Pag-uswag
Disaster Resilience Symbolism	Communities often use Pili and Ibah as metaphors for human perseverance, strength, and recovery following hardship.	Katatagan, Pagpupursige
Cultural Lesson	Storms are not always viewed solely as destructive events but also as forces that test, strengthen, and prepare living things for future growth.	"Mas Nagiging Matatag Habang Sinusubok"
Local Ecological Knowledge	Long-term observations of tree behavior contribute to Indigenous understanding of adaptation, environmental change, and resilience.	Local Ecological Intelligence, Indigenous Knowledge
Philosophical Interpretation	The post-typhoon flowering and fruiting of Pili and Ibah symbolize hope, transformation, and the possibility of flourishing after adversity.	Padagos, Mamunga Kahit may Unos
Contemporary Relevance	These species provide examples of nature-based resilience that can inform discussions on climate adaptation and disaster recovery.	Climate Adaptation, Resilience Thinking

Table S11. Children's Perceptions of Typhoons, Relief Goods, and Resilience in Coastal and Upland Bicol Communities.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Research Context	Findings emerged from Participatory Rural Appraisal (PRA) activities conducted among children and households in coastal and upland communities in Bicol.	PRA, Coastal Communities, Upland Communities
Central Question	Children were asked whether typhoons are good or whether they feel happy when typhoons occur.	"Mabuti ba ang Bagyo?"
Children's Response	Many children answered "yes", associating typhoons with the arrival of relief assistance and food supplies.	Masaya kapag may Bagyo
Relief Goods as Special Food	For some households, canned goods and processed foods are received primarily during disaster response operations.	Relief Packs, Sardinas, Corned Beef, Tuna, Noodles
Nutritional Significance	Children often associate relief operations with access to products rarely consumed during ordinary times.	Gatas, Milo, 3-in-1 Coffee Mix
Food Security Dimension	Some upland households rely primarily on root crops and consume rice more regularly only during periods when aid is distributed.	Root Crops, Bigas
Disaster-Culture Relationship	Relief assistance has become a familiar social component of typhoon experiences in some vulnerable communities.	Relief Culture, Disaster Experience
Positive Interpretation	The findings demonstrate the capacity of children to find hope, excitement, and positivity despite adverse conditions.	Resilience, Paglaom, Kasiyahan
Negative Interpretation	The findings also reveal persistent poverty and unequal access to food and consumer goods in vulnerable communities.	Kahirapan, Food Insecurity
Structural Concern	Children should not need to wait for disasters to access nutritious food, basic commodities, and social support.	Social Inequality, Development Gap
Most Vulnerable Groups	The greatest needs are often found among rural, coastal, upland, ridge-to-reef, and urban poor communities.	R2R Communities, Urban Poor
Governance Implication	The findings highlight the importance of improving livelihoods, food security, social protection, and public service delivery.	Good Governance, Accountability
Disaster Assistance Recognition	Acknowledges the role of government agencies, local governments, barangays, and volunteers in providing emergency support.	DSWD, LGU, DILG, DRRMC, Barangay Officials
Theoretical Insight	The phenomenon illustrates the dual nature of disaster experiences: resilience amid adversity and the persistence of structural poverty.	Resilience Paradox, Disaster Sociology
Cultural Significance	Demonstrates how disaster experiences become embedded within community memory, childhood perceptions, and everyday life in hazard-prone regions.	Community Resilience, Lived Experience, Environmental Memory

Table S12. Typhoons as Everyday Life, Culture, and Community Resilience in Bicol.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Cultural Context	In Bicol, typhoons are not viewed solely as disasters but as recurring events deeply embedded in everyday life, culture, traditions, and collective memory.	Bagyo, Kultura, Tradisyon
Normalization of Hazards	Frequent exposure to tropical cyclones has fostered a social environment where communities rapidly adapt and recover after storms.	Bahagi na ng Buhay
Community Recovery	Households typically begin cleaning, repairing, and rebuilding immediately after a typhoon without waiting for external assistance.	Kanya-kanyang Linis, Kanya-kanyang Ayos
Collective Action	Barangays often conduct rapid clearing operations, allowing roads and transportation networks to become passable shortly after the storm.	Clearing Operations, Barangay Response
Infrastructure Damage	Fallen trees, damaged houses, collapsed utility poles, and disrupted communication systems are common post-disaster challenges.	Natumbang Puno, Sirang Bahay, Natumbang Poste
Evacuation Culture	Evacuation centers function not only as shelters but also as social spaces where residents share experiences and await relief assistance.	Evacuation Center, Ayuda, Relief Goods
Community Morale	Despite losses and hardships, many residents maintain optimism, humor, and social cohesion following disasters.	Pagkakaisa, Pag-asa, Katatagan
Economic Recovery	Local markets, stores, fuel stations, and commercial activities often resume quickly, even before full restoration of electricity and communications.	Consumption Economics, Market Systems
Consumer Welfare	The restoration of access to food, fuel, and basic commodities is viewed as a critical step toward community recovery.	Consumer Welfare, Kabuhayan
Utility Restoration Challenges	Recovery of electricity and telecommunications may take longer due to damaged power lines, poles, and network infrastructure.	Kuryente, Signal, Kable
Hidden Impacts	Physical and emotional fatigue, disrupted schooling, agricultural losses, and damaged infrastructure often persist after the immediate crisis ends.	Pagod, Edukasyon, Agrikultura
Resilience Interpretation	Community resilience is reflected not only in survival but also in the rapid resumption of daily activities and economic participation.	Resilience, Adaptive Capacity
Development Perspective	Long-term recovery requires rebuilding education systems, agriculture, infrastructure, and public services alongside economic restoration.	Recovery, Reconstruction, Development
Environmental Memory	Repeated encounters with typhoons have shaped a shared understanding of hazards, preparedness, and post-disaster behavior.	Environmental Memory, Lived Experience
Cultural Significance	Typhoons are woven into Bicolano identity, influencing local narratives, values, social practices, and perceptions of resilience.	Bicolano Resilience, Local Ecological Intelligence

Table S13. Community Response, Traditional Practices, and Resilience During Typhoons in Bicol.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Cultural Context	Typhoons are deeply integrated into everyday life in Bicol, shaping preparedness practices, community cooperation, and collective resilience.	Bagyo, Bicolano Resilience
Pre-Typhoon Preparation	Communities begin reinforcing homes before landfall by securing roofs, tying structures, and moving valuable belongings to safer locations.	Tali Dito, Tali Doon, Pagpapatibay ng Bubong
Community Evacuation	Large and sturdy houses often become informal evacuation centers for relatives, neighbors, livestock, and vulnerable households.	Evacuation Center, Kalabaw, Lipat-Bahay
Emergency Resources	Families rely on basic survival tools and supplies during the height of the storm.	Radyo, Flashlight, Raincoat, Bota, Helmet
Role of Faith	Prayer and spiritual practices provide emotional support and psychological resilience during disasters.	Dasal, Pananampalataya
Eye of the Typhoon	Communities closely observe the arrival of the storm's eye, recognizing it as the temporary calm between the first and second phases of the cyclone.	Mata ng Bagyo, Eye of the Typhoon
Traditional Housing Practice	Some households open windows opposite the strongest winds to reduce internal pressure and minimize roof damage.	Pagbukas ng Bintana, Pressure Management
Second Phase of the Storm	The most intense winds are often associated with the second half of the storm after the eye passes.	Ballos, Pag-berek
Associated Winds	Strong post-eye winds are traditionally linked with specific wind systems recognized in Bicolano folk meteorology.	Salatan, Dumagsa
End-of-Storm Indicator	Irregular or weakening wind patterns signal that the typhoon is ending and recovery can begin.	Patapos na ang Bagyo
Immediate Recovery Activities	Residents quickly leave their homes to salvage materials, gather fallen resources, and begin rebuilding.	Pamumulot ng Yero, Kahoy, Niyog, Saging
Community Cooperation	Recovery is characterized by mutual aid, shared labor, and neighbor-to-neighbor assistance.	Nagtutulungan, Nagdadamayan
Psychological Resilience	Communities emphasize action and recovery rather than despair, focusing on practical solutions after the disaster.	Pagbangon, Katatagan
Temporary Shelter Reconstruction	Damaged houses are often repaired immediately using salvaged materials and temporary roofing.	Trapal, Improvised Shelter
Food and Livelihood Adaptation	Families utilize available resources, including fallen crops and vegetables, while normal food systems recover.	Napulot na Gulayin, Adaptation
Social Recovery	Storytelling, conversation, and communal gatherings become important mechanisms for coping and rebuilding social cohesion.	Kwentuhan, Pagkakamustahan
Power Outages and Adaptation	Communities continue social activities despite prolonged electricity disruptions.	Walang Kuryente, Andap-andap na Ilawan
Environmental Familiarity	Repeated exposure to typhoons has produced detailed local knowledge about storm behavior, housing adaptation, and survival strategies.	Local Ecological Intelligence, Folk Meteorology
Disaster Resilience Framework	Recovery is driven by preparedness, social capital, local knowledge, and collective action rather than external assistance alone.	Community Resilience, Adaptive Capacity
Cultural Significance	The typhoon experience functions as a shared cultural narrative that reinforces identity, solidarity, and resilience among Bicolanos.	Environmental Memory, Bicolano Identity

Table S14. Perceptions of Typhoon Intensity, Vulnerability, and Disaster Risk in Bicol.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Central Question	The discussion challenges whether modern disasters are caused primarily by stronger typhoons or by increasing human vulnerability.	"Lumalakas ba ang Bagyo o Humihina ang Tao?"
Main Argument	Disaster impacts are influenced not only by hazard intensity but also by social, economic, and environmental vulnerability.	Vulnerability, Disaster Risk
Interdisciplinary Perspective	Understanding typhoons requires integrating natural sciences, social sciences, and quantitative methods.	Natural Science, Social Science, Data Science, Econometrics
Hazard Dimension	Typhoons are natural climatic phenomena whose impacts depend on their intensity, size, path, and duration.	Hazard, Bagyo
Internal Vulnerability Factors	Household-level conditions that influence disaster outcomes.	Kita, Uri ng Bahay, Kalusugan, Access to Resources

Table S14. *Cont.*

Aspect	Description	Key Terms (Bicol/Tagalog/English)
External Vulnerability Factors	Structural conditions affecting community resilience and adaptive capacity.	Corruption, Infrastructure, Environmental Degradation, Climate Change
Historical Perspective	Historical records indicate that destructive typhoons and super typhoons have long affected the Philippines and Bicol.	Historical Storm Records
Bicol Storm Clusters	Local historical memory recalls periods of unusually frequent typhoon activity.	Pito-Pito, Typhoon Parade, Super Typhoon Triplets
1970 Example	Communities remember the succession of major storms such as Sening, Titang, and Yoling within a short period.	Sening, Titang, Yoling
Changing Exposure	Population growth and settlement expansion have increased the number of people living in hazard-prone areas.	Danger Zones, Population Growth
Loss of Environmental Knowledge	Reduced familiarity with traditional preparedness practices may contribute to greater vulnerability.	Cultural Memory, Indigenous Knowledge
Dependence on Modern Systems	Increased reliance on infrastructure, electricity, communications, and supply chains can create new vulnerabilities during disasters.	Modern Systems Dependency
Disaster Risk Framework	Disaster risk is viewed as the interaction of hazard, exposure, and vulnerability.	Risk = Hazard × Exposure × Vulnerability
Exposure Component	Refers to people, assets, infrastructure, and ecosystems located in areas susceptible to hazards.	Exposure
Preparedness and Resilience	Strong preparedness systems can reduce disaster impacts even when hazards are severe.	Preparedness, Resilience
Community Adaptation	Traditional adaptation practices, environmental awareness, and collective action contribute to resilience.	Ancestral Adaptation Practices, Community Preparedness
Governance Dimension	Effective disaster governance, transparency, and accountability are viewed as essential for reducing vulnerability.	Government Accountability, Transparency
Ecological Awareness	Maintaining connections with local environments can strengthen hazard awareness and adaptive decision-making.	Ecological Awareness, Local Ecological Intelligence
Theoretical Interpretation	Disaster severity is influenced not only by the physical characteristics of storms but also by the social conditions that shape vulnerability and recovery.	Disaster Risk Science, Adaptive Capacity
Policy Implication	Sustainable disaster risk reduction requires investments in resilience, environmental stewardship, preparedness, and institutional capacity.	Disaster Governance, Risk Reduction

Table S15. *Pag-agaw kan Dagat* as a Coastal Hazard Indicator in Bicolano Folk Meteorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	*Pag-agaw kan dagat* refers to the observed increase in wave height and sea turbulence that coastal communities traditionally associate with the weakening or departure of a typhoon.	Pag-agaw kan Dagat
Literal Meaning	The expression suggests that the sea is “taking”, “capturing”, or “fighting” the storm.	Inaagaw kan Dagat an Bagyo
Traditional Interpretation	Large waves and intensified sea activity are viewed as signs that the storm is nearing its end and that environmental conditions are beginning to change.	Pagtatapos kan Bagyo
Community Observation	Fisherfolk and coastal residents monitor wave behavior, sea sounds, and coastal currents as indicators of storm progression.	Pagbasa kan Dagat, Hukol (Alon)
Relationship to Ballos	The phenomenon is often associated with the latter stages of a storm, particularly during or after *Ballos* (the second phase of the typhoon).	Ballos, Pag-berek
Scientific Interpretation	May correspond to changing wind fields, wave rebound, storm-surge dynamics, and ocean responses as a tropical cyclone weakens or moves away.	Storm Surge Dissipation, Wave Rebound
Wind-Direction Influence	Changes in wind direction can generate larger coastal waves and altered current patterns that become visible to coastal observers.	Salatan, Dumagsa, Habagat
Storm Surge Connection	Despite being interpreted as a sign of an ending storm, elevated water levels and large waves may still pose hazards to coastal communities.	Storm Surge, Coastal Flooding
Environmental Warning Function	Serves as a natural indicator that a significant transition in storm conditions is occurring.	Natural Forecasting, Environmental Signal

Table S15. *Cont.*

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Ecological Knowledge Source	Derived from generations of observation among fisherfolk, seafarers, and coastal households exposed to recurring typhoons.	Indigenous Knowledge, Local Ecological Intelligence
Cultural Meaning	Symbolizes a struggle between the sea and the storm, reflecting how coastal communities personify and interpret environmental processes.	Pakikibaka kan Dagat asin Bagyo
Disaster Preparedness Role	Helps communities anticipate changing coastal conditions and make decisions regarding fishing, evacuation, and post-storm activities.	Paghahanda, Hazard Awareness
Environmental Hermeneutics	Illustrates how natural phenomena are interpreted as meaningful environmental messages rather than merely physical processes.	Environmental Hermeneutics
Science–Culture Integration	Demonstrates convergence between Indigenous environmental observation and scientific understanding of coastal storm dynamics.	Hybrid Forecasting, Science and Indigenous Knowledge
Contemporary Relevance	Remains an important element of coastal folk meteorology in Bicol, particularly among fishing communities and older residents.	Folk Meteorology, Coastal Resilience

Table S16. The Calinigan Mountain Range as a Natural Barrier and Disaster Buffer in Partido District, Bicol.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Geographic Feature	The Calinigan Mountain Range is a chain of mountains located in the Partido District of Camarines Sur, strategically situated between coastal and inland communities.	Calinigan Mountain Range, Calinigan Mountains
Primary Function	Serves as a natural barrier that reduces the direct impact of strong winds, heavy rainfall, and coastal hazards associated with tropical cyclones.	Natural Wind Barrier, Pananggalang sa Bagyo
Protection from North-Coast Typhoons	When storms approach through the northern coast, the mountain range absorbs the initial force of wind and rain before reaching inland areas.	Siruma, Tinambac, Lagonoy, Presentacion, Garchitorena, Caramoan
Protection of Mainland Partido	The mountains help shield interior municipalities from the strongest wind impacts.	Mainland Partido, Goa, San Jose, Tigaon
Wind-Speed Reduction	Mountain slopes disrupt and slow airflow, creating turbulence that weakens wind intensity on the leeward side.	Windbreak Effect, Turbulent Airflow
East-Coast Storm Protection	During storms approaching from the east, the mountain range provides partial protection to northern coastal communities.	Northern Partido, North Coast Towns
Orographic Rainfall Function	Moist air from the sea rises along mountain slopes, cools, and condenses, causing rainfall before reaching inland areas.	Orographic Rainfall, Moist Air Uplift
Flood-Mitigation Role	By slowing runoff and intercepting rainfall, the mountain range helps reduce sudden flooding and stormwater surges in downstream communities.	Flash Flood Reduction, Stormwater Control
Storm Surge Buffer	The mountain chain acts as a physical barrier between coastal waters and inland settlements, limiting the inland penetration of storm-driven winds and surge effects.	Storm Surge Buffer, Coastal Protection
Strategic Position	Located between San Miguel Bay and the Bicol River Basin, influencing local hydrology and hazard exposure patterns.	San Miguel Bay, Bicol River Basin
Historical Example	During Super Typhoon Anding (1981), severe impacts were reported in coastal communities while inland Partido areas experienced comparatively reduced effects.	Super Typhoon Anding (1981)
Agricultural Benefits	The mountain range helps protect agricultural lands and settlements from extreme wind damage, supporting faster post-disaster recovery.	Agricultural Protection, Recovery
Biodiversity and Ecosystem Services	Provides ecological functions including watershed protection, habitat conservation, and regulation of local climate conditions.	Watershed Protection, Ecosystem Services
Economic Importance	Supports livelihoods through agriculture, forestry resources, water regulation, and environmental sustainability.	Sustainable Livelihoods, Local Development
Disaster Risk Reduction Role	Functions as a natural infrastructure system that reduces hazard exposure and strengthens regional resilience.	Nature-Based Disaster Risk Reduction
Local Ecological Knowledge	Coastal and upland residents recognize the Calinigan Mountains as a protective landscape feature that influences weather, rainfall, and storm impacts.	Local Ecological Intelligence, Environmental Knowledge
Cultural Significance	The mountain range is often viewed as a natural guardian of Partido communities, contributing to local perceptions of safety and resilience.	Natural Pananggalang, Community Resilience

Table S17. The BBS (Bicol–Batanes–Samar) Hypothesis: Disaster Exposure, Adaptive Capacity, and Economic Implications of Typhoon Landfalls.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Concept	The BBS hypothesis proposes that typhoons affecting Bicol, Batanes, and Samar may generate lower nationwide disruption because these regions possess extensive experience and adaptation to recurring storms.	BBS (Bicol–Batanes–Samar)
Geographic Context	These regions are among the most frequently exposed to tropical cyclones entering the Philippine Area of Responsibility from the Pacific Ocean.	Typhoon Corridor, Pacific Gateway
Local Descriptions	Bicol, Samar, and Batanes are often characterized in local narratives as communities shaped by frequent encounters with severe weather.	Land of Howling Winds, Typhoon Capital, Land of Hundred Storms
Adaptive Capacity	Repeated exposure has encouraged the development of coping strategies, preparedness measures, and recovery mechanisms.	Adaptive Capacity, Preparedness
Community Experience	Residents often possess extensive practical knowledge of evacuation, housing reinforcement, food storage, and post-disaster recovery.	Local Ecological Intelligence, Disaster Experience
Resilience Theory	Communities repeatedly exposed to hazards may develop stronger institutional and social capacities for recovery.	Resilience Theory
Economic Relativity Argument	The hypothesis suggests that storm tracks crossing BBS regions may affect fewer highly populated provinces compared with alternative pathways through major economic corridors.	Economic Relativity
Preparedness Investments	Long-term exposure often encourages investments in disaster response systems, early warning mechanisms, and risk awareness.	Disaster Preparedness, Early Warning Systems
Economies of Scale	Repeated disaster experience may allow communities and institutions to develop more efficient response systems over time.	Economies of Scale, Collective Action
Cost–Benefit Perspective	Investments in preparedness may reduce long-term recovery costs and improve disaster response efficiency.	Cost–Benefit Analysis
Infrastructure Adaptation	Housing, evacuation practices, and local governance structures may become more adapted to recurring hazards.	Disaster-Adapted Infrastructure
National Economic Perspective	The argument proposes that concentrated impacts in highly adapted regions may produce lower nationwide economic disruption than impacts in less-prepared regions.	National Economic Impact
Social Cost Dimension	Despite adaptive capacity, repeated exposure can contribute to persistent poverty, infrastructure damage, and development constraints.	Social Costs, Development Burden
Poverty Connection	Regions frequently exposed to hazards often experience recurring losses that may slow long-term economic development.	Poorest Region of Luzon, Eastern Visayas Vulnerability
Risk Framework	Disaster outcomes depend on the interaction of hazard, exposure, vulnerability, and resilience.	Risk = Hazard × Exposure × Vulnerability
Policy Implication	Disaster planning should strengthen resilience in all regions while reducing the concentration of hazard burdens borne by frequently affected communities.	Disaster Governance, Risk Reduction
Environmental Justice Consideration	The benefits of national resilience should not obscure the disproportionate costs repeatedly borne by frontline coastal communities.	Environmental Justice, Unequal Risk Burden
Research Significance	Highlights the importance of integrating disaster economics, adaptive capacity, local knowledge, and regional development into hazard assessments.	Disaster Economics, Community Resilience

Table S18. Ducks (*Pato*) as Biological Indicators of Approaching Typhoons in Bicolano Folk Meteorology.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	Changes in duck behavior are traditionally interpreted as signs of approaching storms or major weather disturbances.	Pato, Senyales ng Bagyo
Traditional Observation	Ducks may move to elevated, sheltered, or unusual locations before the arrival of severe weather.	Paglipad sa Mataas na Lugar, Pagdapo sa Bubong
Indigenous Interpretation	Coastal and rural communities regard unusual bird behavior as a natural warning signal that environmental conditions are changing.	Folk Meteorology, Pagbasa kan Kalikasan
Atmospheric Sensitivity	Ducks and other birds are believed to detect changes in atmospheric conditions before they become noticeable to humans.	Atmospheric Pressure, Humidity, Hangin
Scientific Basis	Many bird species can respond to changes in barometric pressure, wind patterns, humidity, and environmental cues associated with approaching storms.	Barometric Pressure, Animal Behavior
Behavioral Response	Prior to severe weather, birds may seek safer locations, reduce movement, alter feeding behavior, or relocate temporarily.	Shelter-Seeking Behavior
Historical Forecasting Tool	Before modern meteorological services, animal behavior was among the environmental indicators used to anticipate weather changes.	Pre-Instrument Forecasting
Associated Animals	Similar observations are traditionally made for other birds, domestic animals, insects, and marine organisms.	Ibon, Hayop, Insekto
Environmental Warning Function	Unusual animal activity serves as an informal early-warning indicator within community-based forecasting systems.	Natural Early Warning System
Local Ecological Knowledge	The interpretation of animal behavior is based on long-term observation accumulated through generations of interaction with the local environment.	Indigenous Knowledge, Local Ecological Intelligence
Disaster Preparedness Role	Animal behavior observations often complement environmental signs such as wind direction, cloud formations, sea conditions, and plant indicators.	Hybrid Forecasting, Paghahanda
Cultural Significance	Ducks are viewed not only as domestic animals but also as participants in the environmental signals used to interpret weather conditions.	Animal-Based Forecasting
Risk Reduction Function	Such observations may encourage communities to prepare for possible storms, secure property, and monitor official advisories.	Hazard Awareness, Preparedness
Science–Culture Integration	Illustrates the convergence between Indigenous observations of animal behavior and scientific studies of biological responses to atmospheric change.	Ethnometeorology, Biological Indicators
Contemporary Relevance	Animal-based forecasting remains part of environmental awareness in some rural and coastal communities, although it is increasingly used alongside modern weather forecasts.	PAGASA, Community Forecasting

Table S19. August Typhoon Scarcity in Bicol: Seasonal Wind Patterns and Traditional Climate Interpretation.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	August is traditionally regarded as one of the least typhoon-prone months for direct impacts in the Bicol Region.	Agosto, Kaunting Bagyo
Historical Observation	Historical records indicate relatively few typhoons directly affecting Bicol during August compared with other months of the typhoon season.	Historical Storm Patterns
Rare Exception	Typhoon Herming (Betty) in 1987 is remembered as an unusual August event that significantly affected Bicol.	Bagyong Herming (Betty)
Dominant Storm Tracks	During August, many tropical cyclones tend to move toward northern latitudes, affecting Northern Luzon or passing east of Extreme Northern Luzon.	Northward Shift, Northern Luzon Track
Influence of the ITCZ	Seasonal positioning of the Intertropical Convergence Zone influences tropical cyclone formation and movement patterns.	ITCZ
Role of the Pacific Subtropical High	Atmospheric circulation patterns associated with the Pacific Subtropical High may favor northward-moving storm tracks during this period.	Pacific Subtropical High
Habagat Dominance	August coincides with the peak influence of the southwest monsoon, which often becomes the dominant weather system affecting the region.	Habagat, Southwest Monsoon
Monsoon Effects	Even without direct typhoon landfalls, Habagat can bring substantial rainfall and weather disturbances.	Monsoon Rains, Pag-ulan
Traditional Interpretation of Habagat	In Bicolano folk meteorology, Habagat is often regarded as a protective or favorable wind that helps keep many storms away from the region.	Kakamping Hangin, Habagat
Bicol's Geographic Exposure	Bicol is generally more exposed to tropical cyclones following lower-latitude westward tracks.	Low-Latitude Track, Pakanluran
Amihan Transition	As the Amihan season approaches, storm tracks may shift southward, increasing the likelihood of Bicol landfalls.	Amihan, Southward Shift
High-Pressure Influence	High-pressure systems north of the Philippines may steer storms toward Eastern Visayas and Bicol during later months.	High Pressure Area (HPA)
Peak Bicol Typhoon Season	The highest frequency of direct impacts traditionally occurs during the transition from Habagat to Amihan.	Oktubre–Disyembre, Typhoon Season
Traditional Seasonal Indicator	The relative absence of August typhoons reinforces local beliefs regarding the protective role of Habagat and the *Walowalo* winds.	Walowalo, Habagat
Disaster Preparedness Implication	Despite lower historical frequency, communities remain vigilant because atypical typhoon tracks can still occur.	Preparedness, Hazard Awareness
Environmental Knowledge Source	Conclusions are derived from long-term observations of storm paths, seasonal winds, and regional climate patterns.	Folk Climatology, Local Ecological Intelligence
Science–Culture Integration	The explanation combines meteorological concepts with Indigenous interpretations of seasonal winds and typhoon behavior.	Hybrid Forecasting, Ethnometeorology
Contemporary Relevance	Understanding seasonal storm-track variability can support localized disaster preparedness and climate adaptation planning.	Climate Adaptation, Disaster Risk Reduction

Table S20. Traditional Storm Surges and Extreme Sea Hazard Indicators in Coastal Bicolano Knowledge Systems.

No.	Traditional Sign/Indicator	Description	Key Terms (Bicol/Tagalog/English)
1	Sudden retreat of seawater	Rapid withdrawal of seawater exposing reefs, rocks, and seabed areas normally submerged. Considered one of the strongest warnings of an approaching giant wave.	Darakulang Hukol, Pag-atras kan Dagat
2	Unusual marine organisms caught by fishers	The sudden appearance of rare fish or marine organisms not normally observed in local waters is interpreted as a disturbance beneath the sea.	Kakaibang Lamang-Dagat
3	Deep-sea fish moving toward shore	Fish that normally inhabit deeper waters unexpectedly appear near coastal areas.	Isdang Pang-ilalim
4	Absence of fish schools for extended periods	Long periods without the appearance of fish schools are interpreted as a warning of abnormal ocean conditions.	Pag-gipao, School of Fish
5	Frequent appearance of "dalaan" at night	Repeated sightings of groups of luminous or shimmering fish during nighttime are considered signs of unusual marine activity.	Dalaan
6	Repeated appearance of the "Barkong Bulawan"	The reported appearance of a mysterious "golden ship" twice within a month is interpreted in folklore as a warning of impending danger.	Barkong Bulawan
7	Sea snakes coming ashore	Frequent emergence of marine snakes onto beaches is believed to indicate disturbances beneath the ocean floor.	Anikig, Ogdok, Walo-walo
8	Unusual behavior of the Kanaway bird	Continuous circling, agitation, or abnormal flight behavior is interpreted as an environmental warning signal.	Kanaway
9	Animal migration to higher ground	Coastal animals become restless and move inland or uphill before a hazardous event.	Kalasakas (Alimasag), Mukoy, Omang, Seabirds, Dogs
10	Strong and prolonged earthquake	A powerful earthquake lasting several seconds is regarded as a direct warning of a possible tsunami.	Lindol, Darakulang Hukol
11	Changes in smell, temperature, or character of sea winds	Experienced fisherfolk detect unusual odors, salinity, warmth, or coolness in winds coming from the sea.	Amoy kan Dagat, Hangin sa Dagat
12	Ancestral stories and oral traditions	Folklore, legends, and inherited warnings are used to interpret unusual environmental conditions and potential hazards.	Mga Kwento nin Ninuno, Alamat
13	Unnaturally calm sea after an earthquake	A sudden and unusual calmness of the sea following an earthquake is interpreted as the ocean "gathering strength" before producing a large wave.	Tahimik na Dagat, Nag-iipon nin Kusog
14	Strange environmental phenomena	Unusual combinations of weather, sea behavior, animal movement, and atmospheric conditions are collectively interpreted as signs of danger.	Kakaibang Pangyayari sa Kalikasan
		Categories of Traditional Indicators	
Category		**Indicators**	
Oceanographic Signs		Retreating seawater, deep-sea fish near shore, absence of fish schools, dalaan, unusual waves	
Animal-Based Signs		Sea snakes, *Kanaway* birds, crabs, hermit crabs (*omang*), dogs, seabirds	
Geophysical Signs		Strong earthquakes, unusual sea calmness after shaking	
Atmospheric Signs		Changes in wind odor, temperature, humidity, and air characteristics	
Cultural and Spiritual Signs		*Barkong Bulawan*, ancestral narratives, *diwata* stories, traditional warnings	

Table S21. Traditional tsunami and extreme sea-hazard indicators recognized by coastal Bicolano communities.

Warning Domain (Bicolano)	English Translation	Traditional Indicators
1. Pagbasa kan Dagat	Reading the Sea	Retreating seawater before large waves
		Deep-sea organisms surfacing near the coast
		Sudden absence of fish schools in nearshore waters
		Unusual wave behavior or abnormal sea movement
2. Pagbasa kan Hayop	Reading Animal Behavior	Sea snakes emerging from the sea
		Unusual behavior of kanaway birds
		Crabs and hermit crabs moving inland
		Restless or unusual behavior of coastal animals
3. Pagbasa kan Kalangitan asin Hangin	Reading the Sky and Wind	Unusual odor carried by sea winds
		Sudden changes in air temperature
		Atmospheric anomalies preceding hazardous events
4. Pagbasa kan Kalibutan	Reading the Earth	Strong earthquakes felt along the coast
		Sudden sea calmness immediately after ground shaking
		Simultaneous occurrence of multiple environmental anomalies indicating imminent danger

Table S22. Typhoon Emong and the Relative Rarity of Direct Typhoon Landfalls in the Ilocos Region.

Aspect	Description	Key Terms (Bicol/Tagalog/English)
Phenomenon	The Ilocos Region experiences relatively fewer direct typhoon landfalls compared with eastern Philippine regions exposed to the Pacific Ocean.	Ilocos Region, Direct Landfall
Geographic Position	Located on the western side of Luzon, the region is partially shielded from many Pacific-origin tropical cyclones.	Western Luzon
Primary Typhoon Corridor	Most Philippine typhoons first encounter eastern coastal regions before reaching western areas.	Eastern Seaboard, Pacific Ocean
Most Exposed Regions	Eastern Luzon and eastern Philippine coastlines are generally the first areas affected by westward-moving tropical cyclones.	Bicol Region, Cagayan, Isabela, Batanes
Storm Track Characteristics	Many tropical cyclones move toward the northwest before recurving toward Taiwan, East Asia, or northern Luzon.	Northwest Track, Recurvature
Role of the Coriolis Effect	Tropical cyclones in the Northern Hemisphere generally curve poleward and westward due to large-scale atmospheric circulation.	Coriolis Effect
Sierra Madre Influence	The Sierra Madre mountain range absorbs part of a cyclone's energy before storms reach western Luzon.	Sierra Madre
Cordillera Influence	Mountain barriers further reduce wind intensity and modify rainfall patterns reaching the Ilocos Region.	Cordillera Mountains
Rain-Shadow Effect	Some portions of Ilocos receive reduced rainfall compared with eastern slopes because of topographic influences.	Rain Shadow
Historical Frequency	Direct landfalls in Ilocos occur less frequently than in eastern Philippine regions.	Rare Landfall Events
Typhoon Emong (2025)	Considered unusual because of its projected or observed direct impact on the Ilocos Region.	Bagyong Emong (2025)
Western Landfall Scenario	The storm's trajectory represented an atypical pathway affecting the western side of Luzon.	Western Landfall, Reverse Track
Rapid Intensification	Emong was described as undergoing a period of rapid strengthening over favorable oceanic conditions.	Rapid Intensification, West Philippine Sea
Nighttime Landfall Risk	Landfalls occurring at night increase operational challenges for emergency response and hazard monitoring.	Nighttime Landfall
Historical Parallel	Comparisons were drawn with Typhoon Emong (Chan-hom) of 2009 due to similarities in name and regional impact.	Typhoon Emong (2009), Chan-hom
Disaster Risk Perspective	Rare events may create heightened risk because communities experience them less frequently than regularly exposed regions.	Risk Perception, Preparedness
Adaptive Capacity Consideration	Regions repeatedly exposed to hazards often develop stronger preparedness routines and disaster awareness.	Adaptive Capacity, Community Preparedness
Local Climatological Interpretation	The event is viewed as an example of an atypical storm track deviating from more common historical patterns.	Storm Track Anomaly
Research Significance	Highlights the importance of combining historical climatology, geographic analysis, and local disaster knowledge in understanding tropical cyclone risk.	Historical Data Analytics, Disaster Risk Science
Science–Culture Integration	Demonstrates how local interpretations of unusual storms can be examined through meteorology, geography, and disaster studies.	Hybrid Risk Assessment, Environmental Knowledge

Table S23. Traditional Bicol Wind-Based Heuristic for Locating a Typhoon or Low-Pressure Area (LPA).

Observed Wind Direction (*Pinanggagalingan ng Hangin*)	Local Bicol/Tagalog Term	Traditional Interpretation (*Sinaunang Pagbasa*)	Inferred Position of Bagyo/LPA (Right-Hand Rule)	Expected Situation in Bicol
North	*Amihan*, Hilaga	Harapin ang pinanggagalingan ng hangin; ang bagyo ay nasa kanang bahagi ng katawan	East–Southeast of observer	Ang bagyo ay nasa dagat pa at hindi pa nakakalagpas sa Bicol
Northeast	Hilagang-Silangan	Malamig at pababang hangin mula hilaga	Southeast of observer	Posibleng papalapit pa lamang ang bagyo sa rehiyon
Northwest	Hilagang-Kanluran	Hangin mula kanlurang bahagi ng hilaga	Northeast–East of observer	Hindi pa ligtas ang Bicol; maaaring nasa karagatan pa ang sistema
South	*Habagat*, Timog	Mainit at mahalumigmig na hangin mula timog	West of observer	Nakalagpas na ang bagyo sa Bicol at kumikilos pahilaga
Southwest	Timog-Kanluran	Karaniwang kasabay ng maulang panahon	Northwest of observer	Ang bagyo ay nasa ibabaw o hilaga na ng Bicol
Southeast	Timog-Silangan	Hangin mula karagatang silangan	Northeast of observer	Maaaring nakatawid na o halos nakatawid na sa mainland Bicol
East	*Silangan*, Silangan	Hangin mula Pacific Ocean	South of observer	Ang bagyo ay maaaring nasa timog na bahagi ng Bicol o malapit sa landfall area
Variable/Shifting Winds	*Paiba-ibang hangin*	Senyales ng pagbabago ng panahon	Hindi matiyak	Posibleng may nabubuong LPA o papalapit na sistema

Table S23. *Cont.*

Observed Wind Direction (*Pinanggagalingan ng Hangin*)	**Local Bicol/Tagalog Term**	**Traditional Interpretation (*Sinaunang Pagbasa*)**	**Inferred Position of Bagyo/LPA (Right-Hand Rule)**	**Expected Situation in Bicol**
Key Indigenous Concepts and Terms				
Term	**Language**	**Literal Meaning**	**Context in Folk Meteorology**	
Bagyo	Tagalog/Bikol	Tropical cyclone	Pangunahing panganib na sinusubaybayan	
LPA	Modern meteorological term	Low Pressure Area	Maagang yugto ng pagbuo ng bagyo	
Amihan	Filipino	Northeast monsoon	Malamig na hanging mula hilaga-silangan	
Habagat	Filipino	Southwest monsoon	Mainit at mahalumigmig na hanging mula timog-kanluran	
Sidlangan	Bikol	East	Direksyon ng pagsikat ng araw at Pacific Ocean	
Geomansiya (*Geomancy*)	Adapted term	Pagbasa ng kalikasan at kapaligiran	Tradisyunal na interpretasyon ng mga palatandaan sa kalikasan	
Paghurup-hurup kan panahon	Bikol	Pagmamasid sa panahon	Lokal na obserbasyon sa pagbabago ng klima at panahon	
Kanang Kamay na Patakaran	Local heuristic	Right-hand rule	Tradisyunal na paraan ng pagtukoy sa lokasyon ng bagyo mula sa direksyon ng hangin	

Table S24. Bicolano Disaster Humor, Resilience, and Cultural Coping Mechanisms.

Cultural Theme	**Local Term/Expression**	**English Translation**	**Cultural Interpretation**	**Function During Disasters**
Humor as Anxiety Relief	*Pagsurubahan/joking during storms*	Making jokes despite danger	Humor reduces fear and uncertainty associated with typhoons	Psychological coping mechanism
Roof Weights	*Pagabat*	Heavy object used to secure roofs	Objects are placed on roofs to prevent wind damage	Practical disaster preparation
Self-Deprecating Humor	*"Itaong pagabat sa atop ang tawong pagabat"*	"Put the useless family member on the roof as weight"	Turning vulnerability into humor	Reduces collective anxiety
Relief Package Humor	*"Lucky Me na tulos isira mi"*	"We are already eating Lucky Me noodles before the typhoon arrives"	References the common association of noodles and sardines with post-disaster relief	Anticipatory coping and community bonding
Duck Forecasting Belief	*Pato sa atop o kahoy*	Duck flying onto roofs or trees	Traditional sign interpreted as a coming strong typhoon	Folk meteorological indicator
Duck Joke	*"Gulgulan na an pato"*	"Cook the duck before it flies"	Humor directed at traditional weather signs	Converts fear into laughter
Storytelling Tradition	*Istorya nin bagyo*	Typhoon narratives	Every major typhoon becomes part of collective memory	Cultural transmission of experience
Competitive Resilience	*"Maoragon, pero mas maurag kami"*	"The storm is strong, but we are stronger"	Expression of communal pride and endurance	Reinforces identity and solidarity
Historical Comparison	*"Dugay na!"*	"We've seen worse before"	Present disasters are compared with more severe past events	Builds confidence and perspective
Hyperbolic Storytelling	*"Nag titiriko an ilaw kan ispat"*	"Even the flashlight beam bent in the wind"	Exaggerated descriptions of typhoon strength	Oral tradition and entertainment
Collective Recovery	*Pagbangon*	Rising again after hardship	Recovery is viewed as a shared community effort	Strengthens social cohesion
Accountability Consciousness	*Bantayan an mga kurakot para sa hustisya asin serbisyo*	Demand for accountability and public service	Resilience should not excuse poor governance	Encourages civic engagement
Selected Bicolano Expressions Associated with Typhoon Culture				
Bicolano Expression	**Literal Translation**	**Cultural Meaning**		
Buray nyang bagyo niho, maoragon, pero mas maurag kami.	The typhoon is very strong, but we are stronger.	Pride in resilience and endurance.		
Dai pa ngani nag-aabot an bagyo, Lucky Me na tulos isira mi.	The typhoon has not yet arrived, but we're already eating Lucky Me noodles.	Humor about expected disaster relief supplies.		
Para dai na makalupad an pato, gulgulan na.	To stop the duck from flying, cook it already.	Playful response to folk weather signs.		
Dugay na! Kaito daw, mas grabe pa.	That's nothing! Back then it was worse.	Intergenerational comparison of disasters.		
Pag minabagyo, nag titiriko an ilaw kan ispat.	During typhoons, even flashlight beams bend.	Hyperbolic storytelling emphasizing storm intensity.		
Kang bagyong Sening, huhubaan ka kan paros.	During Typhoon Sening, the wind could strip your clothes off.	Folk exaggeration used to preserve historical memory.		
Cultural Econometric Interpretation				
Dimension	**Observed Behavior**	**Theoretical Interpretation**		
Risk Perception	Acknowledges danger while joking about it	Dual processing of risk (fear and humor simultaneously)		
Social Capital	Shared jokes, stories, and memories	Strengthens community bonds during crises		
Collective Memory	Frequent retelling of past typhoon experiences	Preservation of disaster knowledge across generations		
Psychological Resilience	Humor despite uncertainty	Emotional regulation and stress reduction		
Cultural Identity	Pride in surviving disasters	Formation of the "Oragon" identity		
Adaptive Capacity	Combining preparation with optimism	Enhances community readiness and recovery		

Table S25. Indigenous Bicolano Atmospheric Signs Associated with Typhoon Forecasting.

Environmental Indicator	Local Bicolano Term	Traditional Interpretation	Scientific Explanation	Indigenous DRRM Significance
Deep red or blood-red sunrise	*Pulang pagsirang*	A strong storm or prolonged bad weather may arrive within days or weeks	Increased scattering of sunlight by moisture, aerosols, dust particles, and atmospheric instability	Early warning signal used by elders and coastal communities
Deep red sunset	*Pulang pagsulnop kan aldaw*	Indicates changing weather patterns and possible incoming disturbances	Associated with high concentrations of atmospheric particles and moisture	Used together with other environmental indicators
Bright linear band of light extending from the sea toward the mountains	*Linya nin Liwanag*	If aligned directly toward Mt. *Isarog*, a strong typhoon is expected; if misaligned, a weaker storm may occur	Potential optical effect caused by cloud formations, solar angles, and atmospheric conditions	Traditional directional forecasting method
Unusual behavior of birds	*Osipon kan mga Gamgam*	Birds seek shelter earlier than normal before severe weather	Many bird species respond to pressure changes and environmental disturbances	Animal-based forecasting indicator
Unusual behavior of ducks	*Pato sa atop o kahoy*	Ducks flying to elevated locations may indicate an approaching strong storm	Animals may respond to changes in humidity, wind patterns, and pressure	Folk meteorological warning
Sudden changes in wind direction	*Pagbalyo kan huyop*	Sign of a developing low-pressure system	Associated with circulation around tropical disturbances	Common coastal forecasting tool
Abnormal sea conditions	*Pagbag-o kan dagat*	Rough seas without visible storms may indicate a distant weather system	Swells can travel ahead of tropical cyclones	Important for fisherfolk preparedness
Unusual cloud formations	*Panundon sa panganoron*	Certain cloud patterns indicate approaching storms	Cloud morphology reflects atmospheric instability and moisture transport	Visual forecasting technique

Indigenous Terminologies Related to Disaster Forecasting in Bicol		
Indigenous Term	**Approximate Translation**	**Description**
Osipon	Observation or sign	Environmental cues interpreted as warnings from nature
Panundon	Reminder or warning	Natural phenomena believed to foreshadow events
Suanoy na paghula	Traditional forecasting	Indigenous prediction based on environmental observations
Riplan kan mga gurang	Wisdom of the elders	Collective environmental knowledge passed through generations
Magna Gugurang	Ancestors/Elders	Custodians of traditional ecological knowledge
Pagsirang	Sunrise	Often observed for atmospheric warning signs
Pagsalop	Sunset	Another indicator used in traditional weather reading
Huyop	Wind	Critical variable in indigenous forecasting systems

Comparative Framework: Indigenous and Scientific Disaster Forecasting		
Dimension	**Indigenous Knowledge System**	**Scientific Meteorology**
Source of Information	Environmental observations, animal behavior, oral traditions	Satellite imagery, radar, numerical weather models
Data Collection	Continuous community observation	Instrument-based monitoring
Time Horizon	Days to weeks before an event	Hours to weeks depending on forecast models
Knowledge Transmission	Oral tradition and intergenerational learning	Formal education and scientific institutions
Validation Method	Historical experience and collective memory	Statistical verification and model evaluation
Primary Strength	Localized environmental sensitivity	Regional and global predictive capability
Limitation	Subjective interpretation and local applicability	May overlook highly localized cultural observations

Conceptual Framework for Integrated Disaster Risk Reduction and Management (DRRM)	
Component	**Role**
Scientific Approaches	Satellite monitoring, weather models, hazard mapping, forecasting
Indigenous Approaches	Environmental observation, ancestral knowledge, local forecasting practices
Community Participation	Validation and contextualization of risk information
Integrated Early Warning System	Combines scientific forecasts with local observations
Disaster Preparedness	Improved evacuation, resource mobilization, and risk communication
Resilience Outcomes	Reduced vulnerability and strengthened adaptive capacity

Table S26. Indigenous Typhoon Forecasting System of Coastal Bicolanos.

Forecasting Domain	Indigenous Indicator	Local Bicolano Term	Traditional Interpretation	Forecasting Function
Atmosphere	Cloud formations	*Panganoron*	Changes in cloud structure, height, and movement indicate approaching weather disturbances	Early storm detection
Astronomy	Stars and constellations	*Bituon*	Seasonal appearance and visibility patterns are associated with weather changes	Seasonal forecasting
Plant Phenology	Calachuchi fruit behavior	*Bunga kan Kalachuchi*	Unusual fruiting patterns are believed to precede climatic disturbances	Long-range forecasting
Animal Behavior	Duck behavior	*Pato*	Ducks seeking elevated locations or displaying unusual behavior may indicate severe weather	Storm warning
Animal Behavior	Chicken behavior	*Manok*	Changes in feeding and roosting behavior may signal atmospheric disturbances	Supplemental indicator
Marine Environment	Sea odor	*Baho kan Dagat*	Stronger or unusual sea scent suggests changes in atmospheric pressure and ocean conditions	Weather change indicator
Marine Environment	Wave size and movement	*Laod*	Larger or irregular waves may indicate distant storms	Offshore disturbance detection
Marine Environment	Bubble formation in water	*Burbola*	Increased bubble activity may indicate environmental changes associated with storms	Supporting indicator
Wind System	Wind direction and intensity	*Huyop*	Primary indicator used to determine storm location and movement	Core forecasting variable
Avian Behavior	Bird activity	*Tamsi*	Changes in flight paths, feeding patterns, and timing serve as warning signs	Forecast validation
Atmospheric Optics	Red sunrise and sunset	*Pulang Pagsirang*/*Pulang Pagsalop*	Associated with incoming weather disturbances and storms	Medium-range forecasting
Atmospheric Optics	Linear band of light toward Mt. *Isarog*	*Linya nin Kapawa*	Alignment toward Mt. *Isarog* suggests stronger storms; misalignment suggests weaker systems	Typhoon intensity assessment

Table S27. Indigenous Wind Classification System of Coastal Bicolanos.

Indigenous Wind Term	Approximate Direction	Geographic Reference	Traditional Forecasting Significance
Kanaway	Northwest	Pacific–Luzon sector	Associated with changing weather conditions
Amihan	Northeast	Northeast monsoon	Cooler and drier conditions
Dumagsa	East wind	East blows	Indicates seasonal transition
Salatan	South	Southern sector	Sign of atmospheric change
Habagat	Southwest	Southwest monsoon	Associated with peaceful weather in Bicol
Habagat sa Isarog	Southwest	Aligned with Mt. *Isarog*	Localized forecasting indicator
Habagat sa Iriga	Southwest	Aligned with Mt. Iriga	Localized forecasting indicator
Verdaderong Habagat	True Southwest	Open ocean sector	Considered the “true” monsoon wind
Habagat sa Lagonoy	Southwest	Lagonoy Gulf	Important for coastal and fishing communities
Habagat sa May-ong	Southwest	Mt. Mayon sector	Local weather indicator
Habagat sa Bacong	Southwest	Bacong area	Community-specific forecasting reference

Table S28. Indigenous Validation System for Typhoon Forecasting.

Validation Source	Observed Phenomenon	Traditional Interpretation	Purpose
Birds	Unusual flight patterns	Approaching weather disturbance	Forecast confirmation
Ducks	Movement to elevated locations	Potential severe typhoon	Hazard warning
Chickens	Early roosting or behavioral changes	Weather deterioration	Forecast confirmation
Sea Conditions	Rough seas despite calm weather	Distant storm activity	Hazard monitoring
Wind Direction	Persistent directional shifts	Presence of low-pressure systems	Storm tracking
Sky Coloration	Red sunrise/sunset	Impending atmospheric disturbance	Early warning
Cloud Patterns	Rapid cloud development	Approaching storm system	Forecast confirmation

Table S29. Conceptual Framework for Indigenous Typhoon Forecasting.

Component	Description	Role in Forecasting
Environmental Observation	Continuous monitoring of atmosphere, sea, plants, and animals	Primary data source
Indigenous Knowledge	Intergenerational transmission of forecasting practices (*Riplan kan mga Gurang*)	Knowledge repository
Pattern Recognition	Interpretation of recurring environmental signals	Forecast generation
Community Validation	Cross-checking observations among fishers and elders	Quality control
Decision-Making	Preparation of households, boats, and fishing activities	Risk reduction
Disaster Preparedness	Evacuation, food storage, and asset protection	Hazard mitigation

Table S30. Indigenous Terminologies Associated with Coastal Bicolano Weather Forecasting.

Indigenous Term	English Translation	Context
Osipon	Sign or observation	Environmental indicator used for forecasting
Panundon	Warning or reminder	Natural warning signal
Suanoy na Paghula	Traditional forecasting	Indigenous weather prediction system
Riplan kan mga Gurang	Wisdom of the elders	Collective environmental knowledge
Huyop	Wind	Principal forecasting variable
Panganoron	Clouds	Atmospheric indicator
Lawod	Sea/Waves	Marine forecasting indicator
Gamgam	Birds	Biological forecasting indicator
Pagsirang	Sunrise	Atmospheric observation period
Pagsulnop	Sunset	Atmospheric observation period
Bituon	Stars	Astronomical forecasting indicator
Magna Gurang	Ancestors/Elders	Custodians of indigenous knowledge

Table S31. Traditional Belief Linking the *Peñafrancia* Procession and Tropical Cyclone Activity in the Bicol Region.

Year	Cultural Narrative/Traditional Belief	Documented Procession Event	Tropical Cyclone Data Affecting Bicol	Scientific Interpretation
1992	A traditional Bicolano belief suggests that a disorderly *Traslación* or *Fluvial* Procession of Our Lady of *Peñafrancia* may be followed by strong typhoons affecting the Bicol Region.	Historical accounts describe the first reported accidental disrobing ("*nahubaran*") of the image during the procession.	Four tropical cyclones affected Bicol: *Biring, Ditang, Ningning,* and *Paring*. *Paring* caused extensive damage in the region.	The temporal occurrence of both events does not establish causation. Bicol is climatologically exposed to frequent tropical cyclones, requiring long-term statistical analysis to determine whether any relationship exists.
1993	According to local narratives, the effects of an "unfavorable" procession may continue into the succeeding year.	No major procession anomaly documented.	Five tropical cyclones affected Bicol: *Elang, Huling, Saling, Monang*, and *Naning*. *Naning* was among the strongest, while *Monang* was associated with severe coastal geomorphic changes, including the reported separation of *Sabang* Mainland and *Monang* Island in San Jose, Camarines Sur.	Consecutive years with multiple typhoons are common in the western North Pacific and may reflect natural climatic variability rather than cultural events.
1995	The traditional belief was reinforced by reports of a violent or chaotic procession.	Historical accounts describe the procession as unusually disorderly and violent.	Nine tropical cyclones affected Bicol: *Auring, Diding, Helming, Ising, Mameng, Teding, Oniang, Sendang*, and *Rosing*. *Rosing* produced severe winds and widespread destruction.	Although the coincidence is notable in local memory, scientific inference requires testing against long-term historical records rather than isolated years.
1996	Some community members viewed the succeeding year as a continuation of the previous year's perceived omen.	No unusual procession event documented.	Two tropical cyclones affected Bicol: *Bering* and *Toyang*.	Annual typhoon frequency naturally fluctuates; lower activity in subsequent years demonstrates the importance of evaluating complete time series rather than anecdotal evidence.
2020	Some discussions questioned whether the absence of the *Peñafrancia* procession due to the COVID-19 pandemic influenced typhoon activity.	Public religious processions were cancelled because of COVID-19 restrictions.	Approximately ten tropical cyclones affected or influenced Bicol, including *Ambo, Butchoy, Sinlaku, Leon, Linfa, Ofel, Tonyo, Quinta, Rolly (Goni),* and *Ulysses. Rolly (Goni)* became the strongest tropical cyclone ever recorded at landfall according to JTWC.	The occurrence of multiple intense typhoons during a year without a procession neither confirms nor disproves the traditional belief. Tropical cyclone formation is governed by atmospheric and oceanic conditions rather than documented religious events.

Table S32. Statistical Assessment of the Traditional Belief Linking Violent *Peñafrancia* Processions and Supertyphoon Occurrence in the Bicol Region (1947–2023)

Component	Description	Evidence/Results	Interpretation
Research Question	Do violent or disrupted *Traslación* and *Fluvial* Processions of Nuestra Señora de *Peñafrancia* increase the likelihood of supertyphoons in the Bicol Region?	Examined using annual records from 1947–2023.	Tested scientifically using historical and econometric analyses.
Traditional Belief (Folk Meteorology)	A long-standing Bicolano belief suggests that a violent, disorderly, or unusual *Peñafrancia* procession may be followed by destructive typhoons.	Oral tradition documented in local communities. The belief is not an official teaching of the Catholic Church.	Represents local ecological knowledge and cultural interpretation rather than scientific evidence.
Historical Examples Frequently Cited	1993—violent procession; Typhoon *Monang*. 1995—accidental disrobing ("*nahubaran*") of the image; Super Typhoon Rosing. 2020—no public procession because of COVID-19; Super Typhoon *Rolly* (*Goni),* together with *Quinta* and *Ulysses*, affected Bicol.	These events are commonly cited as supporting examples.	These observations demonstrate temporal coincidence (correlation) only and cannot establish causality.
Study Period	Annual observations from 1947–2023.	221 tropical cyclones affected the Bicol Region during the study period.	Provides sufficient historical coverage for statistical testing.
Dependent Variable	Occurrence of Supertyphoon (Yes/No) and annual count of supertyphoons.	Historical typhoon records.	Outcome variable in regression models.
Independent Variable	Occurrence of Violent Procession/*Traslación* (Yes/No).	Historical religious records and documented procession incidents.	Main explanatory variable.
Control Variable	Number of tropical cyclones occurring during September.	PAGASA and JTWC records.	Controls for seasonal typhoon activity.
Data Sources	Tropical cyclone database, historical procession records, and documentary sources.	JTWC, PAGASA, WMO, historical church and local historical accounts.	Multiple independent data sources were integrated.
Logit Regression	Tested whether violent processions predict supertyphoon occurrence.	Violent Procession: Not significant ($p \approx 0.90$).	No evidence that violent processions increase the probability of supertyphoons.
Poisson Regression	Tested annual number of supertyphoons.	Violent Procession: Not significant; September typhoon activity positive but not statistically significant.	No evidence of causal influence.
OLS Regression	Examined linear association.	Violent Procession coefficient not statistically significant.	Results consistent with other models.
Contemporaneous Time-Series Regression	Evaluated same-year relationships.	Violent Procession remained statistically insignificant. September typhoon occurrence exhibited stronger association with supertyphoon occurrence.	Seasonal climatic conditions better explain annual typhoon activity.
Chi-square Test of Independence	Tested categorical association between violent processions and supertyphoon occurrence.	$p > 0.05$.	No significant association.
Fisher's Exact Test	Confirmatory test for sparse observations.	$p > 0.05$.	No significant association.
Overall Statistical Conclusion	Results from all econometric and statistical models.	Logit, Poisson, OLS, Time-Series Regression, Chi-square, and Fisher's Exact Test consistently produced non-significant results.	Fail to reject the null hypothesis. There is no statistical evidence that violent *Peñafrancia* processions cause or increase the occurrence of supertyphoons in the Bicol Region.
Scientific Explanation	Seasonal typhoon climatology.	Peak typhoon activity occurs between September and November, coinciding with the *Peñafrancia* festivities.	The observed coincidences are more plausibly explained by the natural timing of the Northwest Pacific typhoon season than by religious events.
Cultural Significance	Religious processions remain an important expression of Bicolano faith, identity, and cultural heritage.	The statistical findings do not diminish their spiritual or cultural value.	Faith and scientific inquiry address different dimensions of human experience.

Table S33. Summary of Religious Narratives and Evidence Concerning Typhoon Occurrence in the Bicol Region.

Theme	Community Narrative/Claim	Historical, Scientific, or Theological Context	Interpretation
Natural history of typhoons	Some community members attribute destructive typhoons in Bicol to divine punishment associated with the veneration of religious images ("diyos-diyosan").	Historical records indicate that the Bicol Region had already been experiencing tropical cyclones long before the arrival of Spanish colonization and the introduction of Marian devotion.	Typhoons are a long-standing natural phenomenon in the western North Pacific and predate Christianity in the region.
Peñafrancia devotion	Some claim that the devotion to Nuestra Señora de *Peñafrancia* invites calamities.	The *Peñafrancia* devotion began only during the Spanish colonial period, whereas historical and paleoclimatic evidence shows that typhoons affected Bicol centuries earlier.	Temporal coincidence does not demonstrate causation.
Disaster impacts across religions	If disasters are divine punishment for a particular religious practice, they should primarily affect its practitioners.	Floods, storm surges, landslides, and typhoons affect people regardless of religious affiliation, including Catholics, Protestants, Born-again Christians, Muslims, indigenous communities, and non-believers.	Natural hazards are non-discriminatory and are governed by physical processes rather than religious affiliation.
Environmental stewardship	Some interpret disasters primarily as punishment for religious practices.	Environmental science demonstrates that deforestation, ecosystem degradation, climate change, poor land-use planning, and settlement in hazard-prone areas substantially increase disaster risk.	Human interaction with the environment provides a more evidence-based explanation for increasing disaster impacts.
Biblical interpretation: God's jealousy	Exodus and Leviticus describe God as "a jealous God."	In biblical scholarship, God's jealousy refers to worship directed toward false gods or idols. Within Catholic theology, *Nuestra Señora de Peñafrancia* is venerated as the Mother of Jesus, while the Santo Niño represents Christ.	Interpretations differ across Christian traditions; theological claims should not be treated as empirical evidence for natural hazards.
Sacred images in Scripture	Some argue that all religious images are prohibited by the Bible.	The Bible also records instances in which God instructed the creation of sacred objects and images, including the bronze serpent (Numbers 21:8–9), the Ark of the Covenant (Exodus 25), and the cherubim in Solomon's Temple (1 Kings 6).	Biblical interpretation varies among Christian denominations and should be understood within broader theological and historical contexts.
Judgment of others	Some disasters are interpreted as evidence that God is judging particular groups.	Christian teachings across many traditions emphasize humility and caution against judging others (e.g., Matthew 7:1–5; Romans 14:10–13).	Assigning divine causes to disasters affecting particular communities is a theological interpretation rather than an empirically verifiable conclusion.
Community response	Public discourse sometimes attributes disasters to religious beliefs or traditions.	Disaster risk reduction emphasizes preparedness, environmental stewardship, mutual aid, and community resilience regardless of religious affiliation.	Constructive disaster response focuses on helping affected communities rather than assigning blame.
Overall conclusion	Competing religious interpretations exist regarding the causes of disasters in Bicol.	Historical evidence, climatology, and the statistical analyses conducted in this study found no evidence that religious processions, Marian devotion, or religious affiliation influence the occurrence of typhoons or supertyphoons.	Tropical cyclone occurrence is best explained by atmospheric and oceanographic processes, while religious beliefs remain part of the region's cultural and spiritual heritage.