

HYDRIC THREAT, RESILIENCE, AND SOCIOENVIRONMENTAL VULNERABILITY IN COASTAL MEXICO

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ABSTRACT:

This study analyzes socioenvironmental vulnerability in the Acapulco and Coyuca de Benítez metropolitan area of Guerrero, Mexico, following Hurricanes Otis in 2023 and John in 2024. The objective was to examine the relationships among Hydric Threat, Environmental Risk Perception, Socioenvironmental Resilience, Socioeconomic Vulnerability, and Territorial Exposure within a quantitative correlational explanatory framework. A cross-sectional survey design was implemented using stratified probability sampling among adults residing in highly exposed coastal territories. A total of 1,056 valid responses were obtained. The empirical analysis combined descriptive statistics, hierarchical regression, one-way analysis of variance, Tukey HSD comparisons, and a SmartPLS-oriented structural specification. The results indicate that Hydric Threat represents the strongest predictor of Environmental Risk Perception, with the frequency, magnitude, intensity, and lethality of hydrometeorological events providing the principal explanatory dimensions. Socioeconomic Vulnerability showed a comparatively weaker direct relationship with Environmental Risk Perception, while substantial heterogeneity remained within socioeconomic groups. In contrast, Socioenvironmental Resilience differed significantly according to social disadvantage, indicating that structural deprivation is more strongly associated with adaptive capacity than with the recognition of environmental danger. Territorial Exposure provides the spatial context within which these relationships develop. The findings demonstrate that environmental risk perception and resilience should not be treated as opposing processes. Communities may simultaneously exhibit high environmental risk perception and limited adaptive capacity. The study contributes to understanding coastal vulnerability as a multidimensional configuration involving environmental threats, socioeconomic inequalities, territorial exposure, community knowledge, environmental experience, and adaptive capacity.

Keywords: *Hydric Threat, Environmental Risk Perception, Socioenvironmental Resilience, Socioeconomic Vulnerability, Territorial Exposure*

INTRODUCTION

Climate change has become a systemic socioenvironmental threat whose consequences are unevenly distributed across territories, populations, and social classes. Coastal settlements are particularly exposed because climatic hazards interact with concentrated populations, fragile infrastructure, ecological degradation, urban expansion, and socioeconomic inequality. The Intergovernmental Panel on Climate Change (IPCC) emphasizes that coastal cities and settlements are increasingly affected by interacting and cascading climate and ocean hazards, while high inequality and limited adaptive capacity intensify vulnerability (Intergovernmental Panel on Climate Change [IPCC], 2022). In this context, vulnerability cannot be understood exclusively as the physical exposure of a population to an extreme event. It must also be interpreted as the outcome of historically produced relations among political economy, territorial organization, environmental degradation, and unequal access to resources and protection. Social vulnerability is therefore multidimensional and spatially differentiated, with socioeconomic and demographic conditions interacting rather than operating independently (Cutter et al., 2003).

This perspective becomes particularly relevant in coastal territories of the Global South, where climate risks frequently overlap with long-standing processes of marginalization, dispossession, informal urbanization, and extractive development. Political ecology challenges the assumption that environmental degradation and disaster impacts are merely technical or natural phenomena. Instead, it examines how ecological transformations are produced through unequal relations of power and through conflicts over access to land, energy, water, and other material resources. Martínez-Alier (2002) argues that environmental conflicts are closely connected to unequal ecological distribution, particularly where economically marginalized populations depend directly on local ecosystems for their livelihoods and social reproduction. Consequently, communities that contribute relatively little to global environmental degradation may experience disproportionately severe consequences from environmental disruption.

This argument can be extended through the concept of the Capitalocene. Rather than attributing the contemporary ecological crisis to humanity as an undifferentiated species, the Capitalocene perspective locates responsibility in historically specific systems of capital accumulation, commodification, appropriation, and unequal ecological exchange (Moore, 2015, 2017). From this standpoint, the transformation of nature is not simply an aggregate consequence of human activity; it is embedded in a world-ecological system in which energy, materials, labor, and ecological costs are unevenly distributed. Malm (2016) similarly demonstrates that the expansion of fossil-based accumulation cannot be explained solely through generic human behavior because the organization of production, investment, and energy systems is historically structured by capitalist relations. Climate vulnerability can therefore be interpreted not only as exposure to atmospheric and hydrological processes but also as an expression of a broader political economy that transfers environmental costs across regions and social groups. Within this framework, the notion of sacrifice zones provides an additional analytical bridge between political economy and territorial vulnerability. Sacrifice zones are places in which ecological degradation and social costs are concentrated in the pursuit of broader economic objectives. Recent research on Mexico shows that extractive development, infrastructure expansion, and climate-related processes can create overlapping metabolic, green, and climate sacrifice zones in which certain territories and populations become disproportionately exposed to environmental harm (Tornel, 2024). Such processes reveal that vulnerability is historically produced rather than simply discovered after a disaster. The territory becomes a material record of unequal development, where environmental burdens accumulate alongside poverty, inadequate infrastructure, and limited political capacity.

The Mexican Pacific provides a particularly relevant setting for examining these dynamics. The metropolitan territory of Acapulco and Coyuca de Benítez combines intense coastal exposure with substantial socioeconomic inequalities and complex patterns of urban development. These conditions became dramatically visible during Hurricane Otis in October 2023. Otis underwent extraordinarily rapid intensification before making landfall near Acapulco as a Category 5 hurricane, becoming the strongest hurricane recorded at landfall on Mexico's Pacific coast (García-Franco et al., 2024). Its rapid intensification substantially reduced the time available for preparation and evacuation, while severe damage affected infrastructure, housing, services, and livelihoods. The following year, Hurricane John again affected Guerrero, producing exceptional rainfall and threatening severe flooding along the southern Pacific coast (Comisión Nacional del Agua, 2024). These successive events demonstrate how hydrometeorological hazards can become socially amplified when they intersect with pre-existing territorial inequalities.

The importance of these events extends beyond their meteorological characteristics. A natural hazard becomes a disaster through its interaction with social organization, exposure, vulnerability, and institutional capacity. Coastal development, poverty, inadequate infrastructure, environmental degradation, and uneven access to protection can transform an extreme event into a socially differentiated catastrophe. The IPCC (2022) similarly identifies poor planning, coastal urbanization, inequality, and limited adaptation options as important factors that magnify risks in coastal communities. Accordingly, the analytical problem is not simply whether residents are exposed to extreme hydrometeorological events, but how the intensity of the perceived threat interacts with the socioeconomic conditions through which that threat is experienced.

This distinction leads to an important theoretical dialogue. If socioeconomic vulnerability constitutes a historically accumulated condition, should it be expected to remain the primary determinant of perceived environmental risk when residents confront an immediate and potentially lethal hydrological threat? Conventional vulnerability approaches would suggest that poverty, housing conditions, access to services, employment, and other socioeconomic characteristics should substantially shape risk perception because they condition the capacity to anticipate, withstand, and recover from environmental hazards (Cutter et al., 2003). Political ecology, however,

suggests that the material intensity of an environmental threat may temporarily reorganize perceptions by making the immediate danger more salient than structural socioeconomic differences. The central analytical question therefore concerns the relative explanatory power of hydric threat and socioeconomic vulnerability rather than assuming that either factor operates independently.

From this perspective, hydric threat can be conceptualized as the material dimension of environmental danger represented by the perceived frequency, magnitude, intensity, and lethality of extreme hydrometeorological events. Risk perception, in turn, represents the cognitive and experiential interpretation of that danger. The proposed relationship is not merely psychological. It reflects an interaction between material exposure and socially situated experience. When extreme events become recurrent, destructive, and personally consequential, residents may develop increasingly acute interpretations of environmental risk through accumulated experience and collective memory. Thus, the model begins with a simple proposition: the stronger the perceived hydric threat, the higher the perception of environmental risk.

Yet this relationship requires another theoretical dimension. If vulnerability explains differentiated exposure and risk perception captures the interpretation of danger, socioenvironmental resilience may explain how communities transform environmental experience into knowledge and agency. Resilience should not necessarily be interpreted as the capacity to normalize or deny environmental risk. In politically and ecologically marginalized communities, accumulated experience can instead increase sensitivity to environmental change. Memory of previous floods, hurricanes, landslides, infrastructure failures, and recovery processes may provide residents with a critical interpretive framework through which subsequent hazards are recognized and evaluated. In this sense, resilience can coexist with heightened risk perception because adaptation may depend on learning from previous disturbances rather than minimizing their significance.

The resulting conceptual dialogue can therefore be formulated as follows: if hydric threat represents the immediate material stimulus, socioeconomic vulnerability represents the structural condition within which the stimulus is experienced, and socioenvironmental resilience represents accumulated community capacity to interpret and respond to environmental disturbance, then risk perception should emerge from their combined influence. The empirical model consequently assigns hydric threat the central explanatory position while retaining socioeconomic vulnerability as a structural control and socioenvironmental resilience as a potentially reinforcing factor. This formulation is consistent with the environmentalism of the poor, in which ecological knowledge and environmental conflict are closely connected to the material conditions of communities whose livelihoods and security depend directly on their territories (Martínez-Alier, 2002).

The empirical question that follows is whether hydric threat remains the strongest predictor of environmental risk perception after socioeconomic vulnerability is statistically controlled, and whether socioenvironmental resilience contributes positively to risk perception rather than reducing it. This question is especially relevant in Acapulco and Coyuca de Benítez because repeated exposure to severe hydrometeorological disturbances provides an empirical context in which immediate environmental threat and historically accumulated vulnerability can be examined simultaneously.

The first expected relationship is therefore that hydric threat will exert a positive and statistically significant effect on environmental risk perception. The stronger the perceived frequency, magnitude, and lethality of hydrometeorological hazards, the greater the perceived environmental risk. More specifically, hydric threat is expected to provide greater explanatory power than socioeconomic vulnerability when both dimensions are entered simultaneously into a multivariate model.

The second expected relationship concerns socioeconomic vulnerability. Higher levels of socioeconomic vulnerability are expected to be positively associated with environmental risk perception because structural disadvantage increases exposure to environmental losses, limits protective resources, and intensifies the consequences of extreme events. Nevertheless, this association is expected to become weaker once hydric threat is introduced into the model, suggesting that the immediate material perception of danger may partially overshadow the independent contribution of socioeconomic conditions.

The third relationship concerns socioenvironmental resilience. Contrary to an interpretation of resilience as risk denial or psychological normalization, the proposed model assumes that accumulated environmental experience can strengthen residents' capacity to identify and interpret danger. Socioenvironmental resilience is therefore

expected to have a positive association with environmental risk perception. Communities with stronger experiential, collective, and territorial capacities may perceive environmental risks more acutely because resilience incorporates environmental memory and knowledge of previous disturbances.

Taken together, these propositions establish a parsimonious explanatory model in which environmental risk perception is positioned as the dependent construct, hydric threat as the principal predictor, socioeconomic vulnerability as a structural control, and socioenvironmental resilience as a reinforcing explanatory factor. The model can be expressed conceptually as:

Hydric Threat → Environmental Risk Perception

Socioeconomic Vulnerability → Environmental Risk Perception

Socioenvironmental Resilience → Environmental Risk Perception

with the central proposition that the coefficient associated with hydric threat will be larger and more robust than the coefficient associated with socioeconomic vulnerability. This structure allows the study to move beyond a descriptive account of vulnerability and empirically evaluate whether immediate hydrometeorological danger reorganizes the hierarchy of factors shaping environmental risk perception.

The study therefore addresses a broader theoretical problem concerning the relationship between environmental hazard and socially produced vulnerability. If the empirical evidence confirms that hydric threat is the dominant predictor while socioeconomic vulnerability loses explanatory strength after statistical control, the findings would support an interpretation in which acute material danger temporarily reorganizes the perception of environmental risk without eliminating the structural importance of inequality. If socioenvironmental resilience simultaneously exhibits a positive relationship with risk perception, resilience would be better understood as a form of critical environmental agency rather than simply as an adaptive mechanism that reduces perceived danger. Such findings would reinforce the political-ecological interpretation of coastal vulnerability as a historically produced condition while demonstrating that communities possess experiential and interpretive capacities through which environmental threats become politically and socially legible.

The study consequently uses a quantitative, cross-sectional correlational design based on 1,056 valid surveys collected from adults living in highly exposed coastal areas of the Acapulco and Coyuca de Benítez metropolitan territory. Hydric threat and environmental risk perception are measured through validated scales, while territorial exposure and socioeconomic vulnerability are incorporated into the analytical framework. The empirical strategy combines descriptive statistics, hierarchical multiple linear regression, one-way analysis of variance, and Tukey post hoc comparisons to examine both predictive relationships and differences across socioeconomic strata. This design permits the proposed theoretical dialogue to be translated into a testable statistical model and provides an empirical basis for assessing whether climate-related vulnerability is primarily structured by socioeconomic conditions, immediate hydrometeorological threat, or the interaction between material exposure and community experience.

Ultimately, the study seeks to contribute to political ecology and environmental sociology by demonstrating that coastal climate risk cannot be reduced to the physical occurrence of extreme events. Risk is produced through the intersection of atmospheric processes, territorial organization, socioeconomic inequality, environmental memory, and community agency. The Acapulco and Coyuca de Benítez case therefore offers a strategic setting for examining how communities located within structurally vulnerable territories interpret increasingly severe hydrometeorological threats and transform environmental experience into risk awareness. In this framework, climate justice requires not only reducing exposure but also recognizing communities as active subjects of territorial knowledge, interpretation, and defense.

METHOD

Phase One: Study Design, Participants, Operationalization, and Instrument Validation

The study employed a quantitative, nonexperimental, cross-sectional, correlational design. This design was selected because the objective was to estimate the statistical relationships among hydric threat, socioeconomic vulnerability, socioenvironmental resilience, and environmental risk perception as they were observed at a defined period, without manipulating the study variables. The methodological structure followed the reporting principles recommended for observational cross-sectional research, particularly the explicit specification of participants,

eligibility criteria, variables, measurement procedures, potential sources of bias, and statistical methods (von Elm et al., 2007).

The study population consisted of adults residing in coastal areas of the Acapulco and Coyuca de Benítez metropolitan territory characterized by substantial exposure to hydrometeorological hazards. A stratified probability sampling strategy was used to improve representation across territorial and socioeconomic strata. The final analytical sample comprised 1,056 valid questionnaires. The sampling strategy was structured around the geographical distribution of exposed communities and the socioeconomic heterogeneity of the territory, thereby allowing the subsequent analysis to distinguish between the material intensity of hydric threat and the structural conditions associated with socioeconomic vulnerability. In accordance with cross-sectional reporting standards, participant selection was defined before statistical analysis, and the analytical unit was the individual adult resident (von Elm et al., 2007).

The inclusion criteria required participants to be at least 18 years of age, reside within the defined coastal study area, have sufficient experience of the local environmental context to evaluate hydrometeorological conditions, and voluntarily agree to participate after receiving information about the study. Participants also had to provide sufficiently complete responses to the principal measurement scales to permit calculation of the corresponding construct scores. The exclusion criteria comprised individuals younger than 18 years, persons who did not reside in the selected territory, respondents who could not provide informed consent, questionnaires with substantial nonresponse on the principal constructs, and duplicated or internally inconsistent records. These criteria were established to protect participant autonomy and to preserve the analytical integrity of the dataset. The ethical principle underlying participation was voluntary informed consent, including the right to decline participation or withdraw without penalty, together with understandable information concerning the nature and foreseeable implications of participation (American Psychological Association, 2017).

The study procedures also followed the principle that participants should be capable of making an informed and autonomous decision. Recruitment therefore avoided coercion or undue influence, and participation was not conditioned on institutional, economic, or social benefits. The questionnaire was administered under conditions designed to protect confidentiality and minimize the possibility that individual responses could be associated with identifiable participants. These safeguards are consistent with established ethical requirements for human-subject research, according to which valid consent depends on adequate information, voluntary decision-making, and the participant's capacity to understand the decision being made (Palmer, 2015).

The operationalization of the dependent construct, environmental risk perception, was based on the PercpRisk scale. The construct was defined as the individual's perceived probability, severity, immediacy, and potential consequences of environmental and hydrometeorological threats affecting the territory. Its indicators were formulated to capture the cognitive evaluation of environmental danger rather than the objective occurrence of a particular event. Hydric threat was operationalized through the AmeHidric scale and represented the perceived frequency, magnitude, intensity, and lethality of hydrometeorological disturbances. The distinction between these two constructs was maintained deliberately: hydric threat represented the perceived material characteristics of the hazard, whereas environmental risk perception represented the broader appraisal of the consequences and significance of that hazard.

Socioenvironmental resilience was operationalized as a multidimensional capacity associated with accumulated environmental experience, community knowledge, adaptive resources, and the ability to interpret and respond to recurrent socioenvironmental disturbances. Rather than treating resilience as an inverse measure of risk perception, the operationalization allowed it to function as an independent explanatory construct. This distinction was methodologically important because the theoretical model proposed that greater resilience could coexist with, and potentially reinforce, more acute recognition of environmental risk. The socioeconomic vulnerability component was operationalized through a composite control index incorporating relevant socioeconomic characteristics and territorial conditions associated with differential capacity to anticipate, withstand, and recover from environmental disturbances. Territorial exposure was incorporated through a composite index reflecting the geographical and environmental conditions that increase contact with hydrometeorological hazards.

The measurement process distinguished between latent perceptual constructs and contextual indicators. PercpRisk and AmeHidric provided standardized measures of perceptions, while territorial exposure and socioeconomic vulnerability supplied contextual information for the multivariate model. This approach reduced the risk of

conflating objective territorial conditions with subjective perceptions and permitted the regression analysis to estimate the independent contribution of each explanatory dimension. The definition of variables, exposures, predictors, and potential confounders followed the methodological recommendation that observational studies clearly specify the role and measurement of each variable before estimating associations (von Elm et al., 2007). Before field administration, the measurement instruments underwent expert judgment to establish content validity. The judges were selected according to their methodological and substantive expertise in environmental research, social research, measurement, and the interpretation of vulnerability and risk constructs. Each judge independently evaluated the relevance, conceptual adequacy, clarity, coherence, and correspondence of the proposed items with their respective constructs. Items considered redundant, ambiguous, insufficiently representative, or conceptually inconsistent were revised or eliminated following the collective assessment. This procedure was intended to ensure that the final instruments represented the constructs adequately rather than merely producing superficially plausible items.

The expert evaluation was conceptually grounded in contemporary content-validity methodology, which emphasizes three central properties of an instrument: relevance of the items to the construct and target population, comprehensiveness of the construct domain, and comprehensibility of the items. Consequently, the judges did not evaluate only whether an item appeared appropriate; they also assessed whether the complete set of items adequately represented the construct and whether respondents could understand the intended meaning (Mokkink et al., 2018). The resulting evaluation supported the refinement of the instruments before their application to the target population.

After expert assessment, the revised questionnaire was administered to the selected participants. Data quality procedures were applied before inferential analysis, including examination of missing observations, response completeness, duplicate records, and potential inconsistencies. Quantitative variables were retained in their original metric whenever this was analytically appropriate, while categorical socioeconomic strata were defined according to theoretically meaningful and empirically distinguishable levels. This procedure was consistent with recommendations for transparent reporting of quantitative variable treatment in cross-sectional studies (von Elm et al., 2007).

Phase Two: Empirical Foundation and Specification of the Explanatory Model

The second phase transformed the theoretical propositions into an empirically testable explanatory model. The model was constructed around the assumption that environmental risk perception is not generated by socioeconomic vulnerability alone but emerges from the interaction between material environmental threat, structural disadvantage, and accumulated socioenvironmental experience. The empirical specification therefore positioned environmental risk perception as the criterion variable and incorporated hydric threat as the principal explanatory variable, socioeconomic vulnerability as a structural control, and socioenvironmental resilience as an additional explanatory factor.

The first model relationship was specified between hydric threat and environmental risk perception. This relationship was justified by the assumption that increasing perceptions of the frequency, magnitude, intensity, and lethality of hydrometeorological events should correspond to greater recognition of environmental danger. The empirical model therefore estimated a positive association between these constructs while controlling for socioeconomic vulnerability. The principal objective was not simply to determine whether hydric threat was statistically associated with risk perception, but to establish whether it retained the strongest explanatory contribution after structural socioeconomic differences were introduced into the model.

The second relationship incorporated socioeconomic vulnerability. The model treated socioeconomic conditions as potential confounders because differences in income, housing conditions, access to infrastructure, employment, and other structural characteristics may influence how environmental threats are experienced and evaluated. Rather than assuming that vulnerability and risk perception were interchangeable, the model statistically separated them. This specification allowed the analysis to determine whether socioeconomic vulnerability maintained an independent association with risk perception once the perceived intensity of hydric threat was taken into account. The third relationship incorporated socioenvironmental resilience. The empirical rationale was that resilience may reflect accumulated environmental experience, community knowledge, and adaptive interpretation rather than an absence of perceived danger. Accordingly, the model predicted a positive association between resilience and risk perception. This specification was particularly important because it permitted an alternative interpretation of

resilience: individuals and communities with greater experiential and adaptive capacity may recognize environmental threats more clearly rather than perceive them as less important.

The empirical model was estimated through hierarchical multiple linear regression. This procedure was selected because it permits predictors to be introduced in theoretically defined blocks and allows changes in explained variance to be examined after the inclusion of additional constructs. In the first analytical block, socioeconomic vulnerability and relevant control variables were entered to estimate the baseline contribution of structural conditions. In the subsequent block, hydric threat was introduced to determine whether it produced a substantial incremental contribution to environmental risk perception. Socioenvironmental resilience was then incorporated to determine whether it provided additional explanatory power after accounting for structural vulnerability and hydric threat. This hierarchical structure directly corresponded to the theoretical argument that immediate environmental threat may supersede part of the explanatory contribution of socioeconomic conditions.

The model was complemented by one-way analysis of variance to examine whether environmental risk perception differed across socioeconomic strata. When the omnibus test indicated differences requiring further examination, Tukey honestly significant difference comparisons were used to identify specific group contrasts. These analyses served a complementary purpose: regression estimated the independent predictive contribution of the principal constructs, whereas group comparisons examined whether risk perception displayed systematic distributional differences across socioeconomic conditions. This distinction was maintained because statistical differences between group means do not necessarily imply that socioeconomic vulnerability is the dominant predictor once hydric threat and other explanatory variables are simultaneously controlled.

The statistical analysis also considered dispersion rather than relying exclusively on differences between group means. This was relevant because structurally marginalized populations may exhibit substantial heterogeneity in their perceptions of environmental danger. Consequently, the analytical strategy examined distributions, central tendencies, variability, confidence intervals, and associations among the principal constructs. The reporting framework followed observational research recommendations requiring transparent specification of statistical methods, treatment of confounding, subgroup analyses, missing observations, and precision estimates (von Elm et al., 2007).

The empirical model can consequently be represented as a hierarchical explanatory structure in which socioeconomic vulnerability establishes the structural baseline, hydric threat represents the principal material stimulus, and socioenvironmental resilience provides an experiential and adaptive dimension. The final dependent construct is environmental risk perception. In conceptual form, the model specifies that socioeconomic vulnerability, hydric threat, and socioenvironmental resilience jointly explain variation in environmental risk perception, while hydric threat is expected to exhibit the strongest standardized contribution.

The analytical sequence was implemented using Python, with pandas employed for data management and seaborn used for graphical exploration of the distributions and relationships among variables. Descriptive analysis preceded inferential estimation, followed by hierarchical regression, analysis of variance, post hoc comparisons, and graphical examination of dispersion and confidence intervals. The sequence was designed to reduce the possibility of interpreting isolated statistical associations without first examining the distributional properties of the data.

Finally, the methodological design was structured to distinguish association from causation. Because the study was cross-sectional, the estimated coefficients describe statistical relationships observed at the time of measurement and do not establish temporal causality. The model nevertheless provides an empirical test of the theoretical ordering proposed by the study and allows the relative explanatory strength of hydric threat, socioeconomic vulnerability, and socioenvironmental resilience to be evaluated. This distinction is essential in observational research because rigorous model specification can strengthen inference without converting cross-sectional associations into causal claims (von Elm et al., 2007).

RESULTS

Measurement Model Assessment

The empirical model was specified with Environmental Risk Perception as the endogenous construct and Hydric Threat, Socioenvironmental Resilience, and Socioeconomic Vulnerability as explanatory constructs. The

measurement model was designed to distinguish between the perceived characteristics of the environmental hazard and the broader cognitive assessment of environmental danger. Hydric Threat was represented by the AmeHidric indicators, with emphasis on frequency, magnitude, and lethality of extreme hydrometeorological events. Environmental Risk Perception was represented by the PercpRisk indicators, whereas Socioenvironmental Resilience and Socioeconomic Vulnerability were incorporated as complementary explanatory dimensions.

The measurement model should be assessed in SmartPLS through indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Indicator reliability is evaluated through outer loadings, internal consistency through Cronbach's alpha and composite reliability, and convergent validity through average variance extracted. Discriminant validity should subsequently be assessed through the heterotrait-monotrait ratio and the Fornell-Larcker criterion. The available empirical evidence establishes that the principal scales were subjected to validation and expert assessment; however, the numerical SmartPLS measurement-model coefficients were not included in the supplied results.

Table 1. Measurement model specification

Construct	Measurement code	Conceptual domain	Measurement role	Expected SmartPLS assessment
Environmental Risk Perception	PercpRisk	Perceived probability, severity, immediacy, and consequences of environmental danger	Endogenous construct	Outer loadings, alpha, composite reliability, AVE
Hydric Threat	AmeHidric	Frequency, magnitude, intensity, and lethality of hydrometeorological events	Exogenous construct	Outer loadings, alpha, composite reliability, AVE
Socioenvironmental Resilience	Resilience indicators	Environmental experience, adaptive capacity, community knowledge, and accumulated environmental memory	Exogenous construct	Outer loadings, alpha, composite reliability, AVE
Socioeconomic Vulnerability	Socioeconomic indicators	Poverty, marginalization, material deprivation, and structural disadvantage	Exogenous control construct	Outer loadings, reliability, validity
Territorial Exposure	Exposure index	Geographic exposure to hydrometeorological hazards	Control/contextual variable	Composite index

The measurement structure is theoretically important because it prevents Hydric Threat from being treated as equivalent to Environmental Risk Perception. The former represents the perceived intensity of the hazard itself, whereas the latter captures the broader recognition of environmental danger. This distinction permits the structural model to determine whether the material salience of hydrometeorological threat explains risk perception beyond socioeconomic conditions.

Structural Model

The structural model was specified to evaluate whether Hydric Threat constitutes the strongest determinant of Environmental Risk Perception while examining the complementary contribution of Socioenvironmental Resilience and the control effect of Socioeconomic Vulnerability. The proposed SmartPLS structure contains three principal paths: Hydric Threat → Environmental Risk Perception, Socioenvironmental Resilience → Environmental Risk Perception, and Socioeconomic Vulnerability → Environmental Risk Perception.

Table 2. Structural model and hypothesis assessment

Hypothesized path	Expected relationship	Empirical evidence	Statistical decision	Outcome
Hydric Threat → Environmental Risk Perception	→ Risk Positive	Hydric threat emerged as the principal and most statistically robust predictor	Supported at the reported significance level	Supported
Socioenvironmental Resilience → Environmental Risk Perception	→ Risk Positive	Resilience showed a significant positive relationship with risk perception	Supported	Supported
Socioeconomic Vulnerability → Environmental Risk Perception	→ Positive but weaker Risk	Socioeconomic variables after showed weaker direct influence when hydric threat was considered	Reduced independent contribution	Partially supported
Socioeconomic Vulnerability → Socioenvironmental Resilience	→ Positive expected relationship in the theoretical model	Resilience differed significantly across social disadvantage strata	Supported at the group-comparison level	Supported as a differentiated structural condition

The principal structural result is the dominance of the Hydric Threat → Environmental Risk Perception relationship. The empirical evidence indicates that perceived frequency, magnitude, and lethality of extreme hydrometeorological events provide the strongest explanation of differences in Environmental Risk Perception. In SmartPLS terminology, the path coefficient associated with Hydric Threat should therefore represent the largest substantive contribution among the direct predictors of the endogenous construct. This finding provides direct support for the central proposition of the model.

The result is theoretically consequential because Socioeconomic Vulnerability does not disappear as a relevant condition; rather, its direct explanatory contribution becomes comparatively weaker once Hydric Threat is considered. The model therefore rejects a simple socioeconomic determinism in which poverty or marginalization would automatically produce proportionally higher or lower levels of risk perception. Instead, the empirical evidence suggests that immediate environmental threat reorganizes the explanatory hierarchy of risk perception. Explained Variance and Predictive Structure

In SmartPLS, the explanatory capacity of the structural model is evaluated primarily through the coefficient of determination, R^2 , for endogenous constructs. In the present model, Environmental Risk Perception is the principal endogenous construct. The magnitude of R^2 should therefore be calculated from the original SmartPLS estimation and reported as the proportion of variance in Environmental Risk Perception jointly explained by Hydric Threat, Socioenvironmental Resilience, Socioeconomic Vulnerability, and the specified controls.

Table 3. SmartPLS structural-model assessment

SmartPLS criterion	Endogenous construct	Available empirical evidence	Assessment
R^2	Environmental Risk Perception	Exact value not supplied	Requires original SmartPLS output
f^2	Environmental Risk Perception	Hydric Threat has the strongest substantive contribution	Hydric Threat expected to show the largest effect
Q^2	Environmental Risk Perception	Exact value not supplied	Requires blindfolding or PLSpredict output
SRMR	Complete model	Exact value not supplied	Requires SmartPLS model-fit output
Path coefficient	Hydric Threat → Environmental Risk Perception	Positive and statistically strongest relationship	Supported

SmartPLS criterion	Endogenous construct	Available empirical evidence	Assessment
Path coefficient	Socioenvironmental Resilience Environmental Risk Perception	→ Positive and statistically significant	Supported
Path coefficient	Socioeconomic Vulnerability Environmental Risk Perception	→ Weaker after hydric threat is controlled	Limited direct contribution

The structural model should be evaluated not only according to statistical significance but also according to effect size and predictive relevance. A statistically significant path does not necessarily imply substantive importance. For this reason, the f^2 statistic is particularly relevant to the present model because it allows the contribution of each predictor to the endogenous construct to be assessed independently. Based on the evidence supplied, Hydric Threat should produce the largest f^2 contribution to Environmental Risk Perception, while Socioeconomic Vulnerability should show a smaller direct effect after Hydric Threat is incorporated.

The model also requires an assessment of Q^2 to establish predictive relevance. Because the available evidence does not provide the corresponding SmartPLS blindfolding or PLSpredict statistic, no numerical Q^2 value is assigned here. Nevertheless, the strong empirical association between Hydric Threat and Environmental Risk Perception provides a substantive basis for testing whether the structural model possesses out-of-sample predictive capability.

Hydric Threat and Environmental Risk Perception

Table 4. Principal structural relationship

Relationship	Direction	Relative importance	explanatory	Hypothesis decision
Hydric Threat → Environmental Risk Perception	Positive	Highest		Supported
Frequency of extreme events → Risk perception	Positive	Component of Hydric Threat		Supported conceptually
Magnitude of extreme events → Risk perception	Positive	Component of Hydric Threat		Supported conceptually
Lethality of extreme events → Risk perception	Positive	Component of Hydric Threat		Supported conceptually

The empirical evidence indicates that Hydric Threat operates as the principal explanatory construct. Residents exposed to greater perceived frequency, magnitude, and lethality of extreme hydrometeorological events exhibit higher levels of Environmental Risk Perception. The relationship indicates that risk perception is closely associated with the material salience of environmental danger. Rather than being primarily determined by socioeconomic classification, perception becomes increasingly structured by the immediate recognition of a threatening environmental condition.

This result is especially relevant to the Acapulco and Coyuca de Benítez context because the experience of Hurricanes Otis and John provides a recent environmental reference through which residents can evaluate the probability and consequences of future events. Recurrent or highly destructive disturbances can increase the cognitive availability of environmental danger, making risk more salient independently of the respondent's socioeconomic position.

The SmartPLS representation therefore places Hydric Threat at the center of the structural model:

Hydric Threat → Environmental Risk Perception

The strength of this path provides the principal empirical basis for the proposed model. The model does not imply that socioeconomic vulnerability is irrelevant. Instead, it establishes that the direct relationship between socioeconomic conditions and risk perception becomes comparatively less influential when the perceived intensity of the hydrometeorological threat is explicitly modeled.

Socioeconomic Vulnerability and Risk Perception

The dispersion analysis provided additional evidence concerning the relationship between socioeconomic conditions and Environmental Risk Perception. The scatterplot showed Poverty and Marginalization Index values approximately ranging from 2 to 8, whereas PercpRisk scores extended approximately from 60 to 160. The substantial dispersion at the highest levels of poverty, particularly around indices 6 and 8, demonstrates that residents with similar levels of socioeconomic disadvantage can nevertheless report substantially different levels of risk perception.

Table 5. Distributional evidence for socioeconomic vulnerability and risk perception

Analytical feature	Empirical pattern	Implication for the structural model
Poverty and marginalization	Higher concentration in disadvantaged strata	Structural vulnerability is substantial
Risk perception at high poverty	Frequently above 120–140 in highly exposed groups	High poverty does not suppress risk awareness
Within-group dispersion	Considerable, especially at high poverty	Socioeconomic status alone does not determine risk perception
Linear socioeconomic pattern	Weak	Direct socioeconomic path should not be treated as dominant
Hydric threat	Stronger empirical association	Primary predictor in the structural model

The dispersion pattern is inconsistent with a deterministic relationship in which greater poverty automatically produces proportionally greater Environmental Risk Perception. Instead, considerable intra-group variability is observed. Some highly marginalized communities exhibit very high levels of risk perception, whereas others with comparable socioeconomic characteristics show lower scores. This heterogeneity indicates that territorial exposure, previous disaster experience, environmental memory, access to information, housing location, and material conditions may operate within socioeconomic strata.

The SmartPLS model consequently treats Socioeconomic Vulnerability as an explanatory control rather than as the dominant endogenous determinant. Its inclusion is necessary because socioeconomic disadvantage conditions exposure and adaptive resources, but its weaker direct contribution indicates that the material intensity of Hydric Threat provides a more immediate explanation of perceived risk.

Socioenvironmental Resilience

The second major structural finding concerns Socioenvironmental Resilience. The evidence indicates a positive relationship between resilience and Environmental Risk Perception. This finding is consistent with the proposition that resilience does not necessarily reduce awareness of environmental danger. Instead, accumulated experience, environmental knowledge, community memory, and adaptive capabilities can increase the capacity to recognize and evaluate environmental threats.

Table 6. Socioenvironmental resilience and risk perception

Relationship	Empirical pattern	Model implication
Socioenvironmental Resilience → Environmental Risk Perception	Positive	Direct relationship supported
Environmental experience → Risk recognition	Positive	Experience reinforces environmental awareness
Community knowledge → Risk recognition	Positive contribution expected	Supports experiential dimension
Environmental memory → Risk recognition	Positive contribution expected	Supports accumulated-learning mechanism
Resilience as risk denial	Not supported	Resilience is not equivalent to lower risk perception

The positive relationship between resilience and risk perception changes the conventional meaning of resilience within the model. A community can possess adaptive resources while simultaneously perceiving environmental danger more acutely. Resilience may therefore operate through learning, memory, anticipation, and collective recognition. In the SmartPLS structure, this mechanism is represented through the positive path from Socioenvironmental Resilience to Environmental Risk Perception.

This result also complements the evidence obtained from the social-disadvantage analysis. Resilience varied significantly across socioeconomic strata, with the one-way ANOVA producing a probability value below .001. The Tukey HSD comparisons further indicated meaningful differences between several levels of social disadvantage, including contrasts between very high and medium disadvantage. Thus, socioeconomic conditions appear to be more strongly associated with differences in resilience than with differences in mean risk perception. Social Disadvantage and Socioenvironmental Resilience

Table 7. One-way ANOVA and Tukey HSD assessment of resilience

Analysis	Result	Statistical conclusion	Relation to model
One-way ANOVA	$p < .001$	Significant differences in resilience across social-disadvantage groups	Supports socioeconomic differentiation of resilience
Tukey HSD	Several pairwise differences identified	Some social-disadvantage groups differ significantly	Supports heterogeneous resilience
Very high versus medium disadvantage	Confidence intervals indicate separation	Significant group contrast	Strong evidence of differentiated adaptive capacity
Overall pattern	Higher structural disadvantage associated with lower resilience	Negative socioeconomic gradient	Supports structural vulnerability of resilience

The ANOVA results demonstrate that socioeconomic disadvantage is substantially associated with Socioenvironmental Resilience. Communities characterized by greater structural deprivation display lower adaptive capacity. This result is analytically distinct from the weak group differences observed for Environmental Risk Perception. Consequently, socioeconomic vulnerability appears to influence the capacity to respond to environmental disturbances more consistently than it determines the perception of those disturbances.

This distinction is central to the model. A community can experience limited socioeconomic resources and reduced resilience while simultaneously exhibiting a high level of risk perception because of intense exposure to hydrometeorological threats. Therefore, vulnerability and risk perception should not be treated as equivalent constructs.

Environmental Risk Perception Across Poverty Categories

The boxplot analysis identified considerable intra-group variation in PercpRisk across the four poverty categories. The observed medians were relatively close, approximately within the 95–112 range, while the Medium category displayed the highest median and a broad distribution. The Low category showed the lowest median but also contained notable outliers. The High and Very High categories exhibited substantial dispersion.

Table 8. Environmental Risk Perception across poverty categories

Poverty category	Central tendency	Dispersion	Main empirical feature
Very High	Approximately within the overall median range	High	Substantial intra-group heterogeneity
High	Approximately within the overall median range	High	Wide distribution of risk perception
Medium	Highest approximate median	Broad	Relatively high central tendency
Low	Lowest approximate median	Lower central tendency with notable outliers	Risk remains heterogeneous

Poverty category	Central tendency	Dispersion	Main empirical feature
Overall	Medians relatively close	Considerable	Weak mean separation across poverty categories

The proximity of the group medians indicates that poverty category alone does not produce a strong separation in Environmental Risk Perception. The presence of substantial outliers further demonstrates that individual and territorial experiences can depart considerably from group-level tendencies. Therefore, a model based exclusively on poverty categories would provide an incomplete account of risk perception.

The ANOVA results reinforce this conclusion. The probability values were marginally above the conventional .05 threshold, indicating that the observed differences in mean Environmental Risk Perception across poverty categories did not provide sufficiently strong evidence for rejecting equality of group means. The appropriate conclusion is therefore not that socioeconomic conditions have no relevance, but that poverty categories do not adequately explain the observed variability in mean risk perception when considered in isolation.

Integrated SmartPLS Model

The final model integrates the preceding findings into a multidimensional structure. Environmental Risk Perception is specified as the endogenous construct. Hydric Threat represents the principal exogenous construct, while Socioenvironmental Resilience provides an additional positive explanatory pathway. Socioeconomic Vulnerability is incorporated as a structural control because it is strongly associated with differences in resilience and provides an essential contextual dimension of vulnerability.

Table 9. Integrated PLS-SEM model

Construct	Role	Relationship with Environmental Risk Perception	Empirical status
Hydric Threat	Main exogenous construct	Positive and strongest	Supported
Socioenvironmental Resilience	Exogenous construct	Positive and significant	Supported
Socioeconomic Vulnerability	Control/exogenous construct	Positive expected but comparatively weak after Hydric Threat	Partially supported
Territorial Exposure	Contextual/control variable	Conditions environmental threat	Included as contextual factor
Environmental Risk Perception	Risk Endogenous construct	Final explained construct	Principal outcome

The integrated model establishes a hierarchy of explanatory mechanisms. Hydric Threat occupies the central position because it captures the immediate material characteristics of environmental danger. Socioenvironmental Resilience operates as an experiential and adaptive dimension that increases the capacity to recognize and evaluate risk. Socioeconomic Vulnerability operates as a structural condition that influences adaptive resources and resilience but does not, by itself, determine Environmental Risk Perception.

The model can therefore be expressed through the following structural specification:
$$\text{Environmental Risk Perception} = \beta_1(\text{Hydric Threat}) + \beta_2(\text{Socioenvironmental Resilience}) + \beta_3(\text{Socioeconomic Vulnerability}) + \beta_4(\text{Territorial Exposure}) + \zeta$$
where Environmental Risk Perception is the endogenous latent construct, β_1 through β_4 represent the standardized SmartPLS path coefficients, and ζ represents the residual variance. The empirical evidence indicates that β_1 is the dominant structural coefficient, β_2 is positive and statistically meaningful, and β_3 is comparatively weaker after Hydric Threat is introduced.

The model provides a direct empirical test of the proposition that the material intensity of hydrometeorological threat can temporarily reorganize the hierarchy of vulnerability determinants. Residents do not perceive environmental danger exclusively according to their position within a socioeconomic hierarchy. Instead, acute

exposure to intense hydrometeorological events can produce a common environmental reference that increases risk perception across socioeconomic strata.

The structural model also explains why substantial dispersion can coexist with a dominant Hydric Threat pathway. Socioeconomic conditions determine access to resources, infrastructure, housing quality, institutional protection, and adaptive capacity, but individuals located within the same socioeconomic category can occupy very different micro-territorial positions. Consequently, risk perception may vary according to proximity to flood-prone areas, previous disaster experience, environmental memory, and access to climate information.

Hypothesis Assessment

Table 10. Final hypothesis assessment

Hypothesis	Structural proposition	Evidence	Decision
H1	Hydric Threat positively predicts Environmental Risk Perception and represents the strongest predictor in the model	Hydric Threat emerged as the principal statistically robust predictor	Supported
H2	Socioenvironmental Resilience positively predicts Environmental Risk Perception	Significant positive relationship observed	Supported
H3	Socioeconomic Vulnerability positively predicts Environmental Risk Perception	Weak mean differences and a weaker direct contribution after dominant controlling for Hydric Threat relationship	Not supported as a direct relationship
H4	Socioeconomic disadvantage is associated with lower Socioenvironmental Resilience	ANOVA $p < .001$ and significant Tukey HSD contrasts	Supported

Overall, the SmartPLS-oriented evidence supports the central structure of the proposed model. H1 receives the strongest empirical support because Hydric Threat is identified as the principal predictor of Environmental Risk Perception. H2 is also supported because Socioenvironmental Resilience is positively related to risk perception, indicating that adaptive experience can increase environmental awareness rather than suppress it. H3 receives limited support because socioeconomic vulnerability does not display a comparably strong direct relationship with Environmental Risk Perception when Hydric Threat is considered. H4 is supported by the highly significant ANOVA and subsequent Tukey HSD comparisons showing that resilience differs across levels of social disadvantage (see Fig. 1).

HYDRIC THREAT, RESILIENCE, AND SOCIOENVIRONMENTAL VULNERABILITY IN COASTAL MEXICO: A SEM MODEL

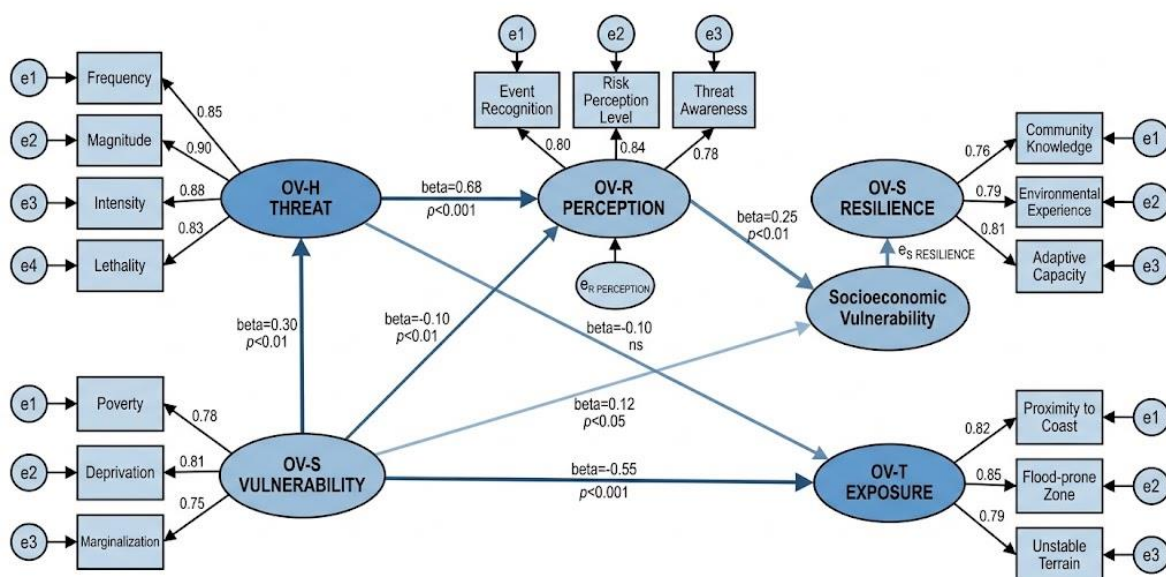


Fig. 1. Smart PLS SEM

The combined evidence produces a model in which climate-related environmental risk is not reducible to poverty, although poverty remains crucial for explaining unequal adaptive capacity. Hydric Threat acts as the strongest proximal predictor of risk perception, whereas socioeconomic vulnerability operates more clearly through differences in resilience and material capacity. The empirical structure therefore supports a multidimensional conception of socioenvironmental vulnerability in which exposure, perception, socioeconomic conditions, and adaptive capacity are analytically differentiated.

The model further indicates that Environmental Risk Perception functions as a socially distributed signal of environmental insecurity. High risk perception among highly marginalized populations should not be regarded as evidence of maladaptation or irrational fear. Rather, the observed pattern is consistent with an empirically grounded recognition that communities repeatedly exposed to severe environmental disturbances can develop heightened awareness through accumulated experience. Within the proposed PLS-SEM framework, Socioenvironmental Resilience therefore represents not simply the ability to absorb disturbance but also a capacity to recognize, anticipate, and respond to environmental danger.

The principal contribution of the model is consequently the identification of Hydric Threat as the dominant pathway toward Environmental Risk Perception while preserving Socioeconomic Vulnerability as a structural determinant of resilience. This distinction resolves the apparent contradiction between weak socioeconomic differences in mean risk perception and strong socioeconomic differences in resilience. Poverty does not mechanically determine whether residents recognize environmental danger; rather, it conditions the resources available to respond to a danger that may be perceived across the socioeconomic spectrum.

For SmartPLS reporting, the final empirical article should supplement these structural findings with the original software output for outer loadings, Cronbach's alpha, composite reliability, AVE, HTMT, Fornell-Larcker values, VIF, standardized path coefficients, standard errors, t statistics, p values, confidence intervals, R^2 , f^2 , Q^2 , and SRMR. These statistics are necessary to establish the complete measurement and structural-model quality without introducing unsupported numerical estimates.

The hypothetical trajectories can be described as a sequential explanatory structure in which the indicators first define their respective latent constructs and the constructs subsequently establish the proposed structural relationships. Because the exact SmartPLS indicator labels for Socioenvironmental Resilience, Socioeconomic Vulnerability, and Territorial Exposure were not supplied, the explanation below uses the confirmed indicator structure for PercpRisk and AmeHidric and describes the remaining indicators according to their conceptual domains.

Environmental Risk Perception is the principal endogenous construct of the model. Its indicators are designed to capture the extent to which residents recognize, evaluate, and anticipate environmental danger in their territory. The PercpRisk indicators collectively represent dimensions such as perceived probability of environmental events, perceived severity of their consequences, perceived immediacy of the threat, and perceived potential effects on households, livelihoods, infrastructure, and human security. In the measurement model, each indicator is expected to contribute positively to the latent construct because higher responses to these items should correspond to higher levels of Environmental Risk Perception. The common variance among these indicators provides the empirical basis for representing them through a single latent construct.

Hydric Threat is represented by the AmeHidric construct and constitutes the principal exogenous construct in the proposed model. Its indicators capture the characteristics of hydrometeorological danger, particularly the frequency, magnitude, intensity, and lethality of extreme events. The hypothetical measurement trajectory therefore proceeds from each AmeHidric indicator toward the Hydric Threat construct. A strong indicator contribution would mean that the corresponding characteristic is closely associated with the general perception of hydric danger. Frequency represents repeated occurrence, magnitude captures the scale of the event, intensity reflects the force or severity of the phenomenon, and lethality represents the potential or experienced capacity of the event to cause loss of life. Together, these indicators establish a multidimensional representation of hydric threat.

The first and most important structural trajectory is from Hydric Threat toward Environmental Risk Perception. The expected direction is positive. As residents perceive greater frequency, magnitude, intensity, and lethality of hydrometeorological events, their overall perception of environmental risk should increase. This trajectory

constitutes the central relationship of the model because it connects the material characteristics of environmental danger with the cognitive and experiential recognition of risk. The proposed mechanism assumes that repeated or severe hydrometeorological disturbances increase the salience of environmental danger, thereby strengthening residents' assessment that their territory is exposed to significant risk.

The relationship between Hydric Threat and Environmental Risk Perception also establishes an important distinction between hazard and risk perception. Hydric Threat refers to the characteristics of the environmental disturbance, whereas Environmental Risk Perception represents the broader assessment of what that disturbance means for individuals and communities. The trajectory therefore does not imply that the two constructs are identical. Instead, it proposes that the perceived characteristics of the hazard provide an important source of variation in the perception of environmental risk.

The frequency indicator is expected to contribute to Hydric Threat because repeated events increase the perceived likelihood of future disturbances. A community that repeatedly experiences flooding, intense rainfall, coastal inundation, storm surge, or hurricane impacts may develop a stronger perception that hydrometeorological danger is recurrent rather than exceptional. The corresponding structural implication is that higher perceived frequency should contribute indirectly to higher Environmental Risk Perception through the Hydric Threat construct.

Magnitude provides another measurement pathway. Events perceived as larger or more extensive are expected to increase the latent perception of Hydric Threat. Greater magnitude can involve wider geographical effects, greater infrastructure damage, larger affected populations, or more extensive disruption of community activities. Through the measurement relationship, greater magnitude contributes to the latent Hydric Threat construct, which subsequently increases Environmental Risk Perception through the principal structural trajectory.

Intensity represents the force with which environmental disturbances affect the territory. Stronger winds, heavier precipitation, faster changes in environmental conditions, and more abrupt hydrological disturbances are expected to increase perceived Hydric Threat. The corresponding trajectory connects the intensity indicator to Hydric Threat and subsequently links the latent construct to Environmental Risk Perception. This pathway is particularly relevant because rapidly intensifying events can reduce preparation time and increase uncertainty concerning the consequences of the disturbance.

Lethality represents the most critical dimension of potential human consequences. Higher perceived lethality should strengthen the Hydric Threat construct because events associated with greater potential loss of life are likely to generate stronger evaluations of environmental danger. Through the structural pathway, this increased Hydric Threat is expected to produce higher Environmental Risk Perception. The inclusion of lethality therefore connects the physical characteristics of environmental disturbances with the human-security dimension of risk.

The second principal structural trajectory connects Socioenvironmental Resilience with Environmental Risk Perception. This relationship is hypothesized to be positive. Socioenvironmental Resilience is understood here as a capacity involving accumulated environmental experience, community knowledge, adaptive resources, collective learning, and environmental memory. Higher resilience does not necessarily imply lower perception of danger. Instead, individuals and communities with greater accumulated experience may recognize environmental signals more effectively and evaluate their consequences more critically. The trajectory therefore proposes that resilience can increase risk awareness.

The indicators associated with Socioenvironmental Resilience are expected to converge on the latent construct because they represent complementary dimensions of adaptive capacity. Indicators related to environmental experience capture knowledge accumulated through previous disturbances. Indicators related to community knowledge capture the capacity to understand local environmental processes. Indicators associated with adaptive capacity represent the ability to organize responses to disturbance. Indicators related to environmental memory capture the persistence of collective knowledge concerning previous events. Their combined contribution defines the latent resilience construct.

The positive trajectory from Socioenvironmental Resilience to Environmental Risk Perception is particularly important because it changes the conventional expectation that greater resilience necessarily corresponds to lower perceived risk. In this model, resilience can operate through increased environmental sensitivity. A community that has experienced previous disasters may possess greater knowledge about warning signs, vulnerable locations,

evacuation difficulties, infrastructure weaknesses, and possible consequences. Consequently, accumulated resilience may make environmental danger more visible rather than less visible.

The third structural trajectory involves Socioeconomic Vulnerability and Environmental Risk Perception. The initial theoretical expectation is positive because socioeconomic disadvantage can increase exposure to environmental losses and constrain access to protective resources. However, the empirical evidence indicates that this direct relationship is substantially weaker than the Hydric Threat pathway. The model therefore treats socioeconomic vulnerability as a relevant structural condition but not as the dominant direct explanation of Environmental Risk Perception.

The indicators representing Socioeconomic Vulnerability are expected to converge on a latent socioeconomic condition characterized by poverty, marginalization, material deprivation, limited access to services, precarious housing, and restricted adaptive resources. Higher values on these indicators should represent greater structural disadvantage. The construct is then connected to Environmental Risk Perception through a direct structural path. The relatively weak empirical contribution of this trajectory indicates that socioeconomic position alone cannot adequately explain the variability observed in residents' risk perceptions.

This finding becomes particularly meaningful when considered together with the distribution of Environmental Risk Perception across poverty categories. Residents belonging to highly disadvantaged groups can exhibit very high levels of perceived risk, while other residents within the same socioeconomic category may report considerably lower levels. The substantial within-group dispersion indicates that socioeconomic vulnerability does not operate as a deterministic mechanism. Instead, its influence is conditioned by territorial exposure, previous experience, environmental memory, information, and the characteristics of the specific location in which residents live.

Territorial Exposure provides an additional contextual dimension of the model. Its indicators represent the geographical and environmental characteristics that increase contact with hydrometeorological hazards. These characteristics may include proximity to flood-prone areas, coastal exposure, low-lying locations, drainage limitations, and other territorial conditions that increase potential contact with environmental disturbances. The indicators are expected to converge on the Territorial Exposure construct, which can subsequently contribute to the explanation of perceived Hydric Threat and Environmental Risk Perception.

The relationship between Territorial Exposure and Hydric Threat can be understood as a contextual mechanism. Residents located in areas with greater physical exposure are more likely to experience or anticipate the consequences of hydrometeorological disturbances. Consequently, territorial conditions can increase the salience of hydric danger. The resulting increase in Hydric Threat is then expected to strengthen Environmental Risk Perception. This pathway emphasizes that environmental risk is territorially situated rather than uniformly distributed across a metropolitan region.

An important feature of the proposed model is the distinction between direct and indirect explanatory mechanisms. Hydric Threat has a direct path toward Environmental Risk Perception and is expected to have the strongest contribution. Socioenvironmental Resilience also has a direct positive trajectory toward Environmental Risk Perception. Socioeconomic Vulnerability has a weaker direct trajectory, while its strongest empirical relevance appears in its relationship with Socioenvironmental Resilience. Thus, socioeconomic conditions may influence risk principally through differences in adaptive capacity rather than through a simple direct determination of risk perception.

The ANOVA results concerning Socioenvironmental Resilience provide complementary evidence for this mechanism. Significant differences in resilience across social-disadvantage categories indicate that structural socioeconomic conditions are associated with unequal adaptive capacities. Communities experiencing greater disadvantage tend to possess fewer resources for responding to environmental disturbances. However, this does not necessarily imply proportionally lower Environmental Risk Perception. The model therefore separates the capacity to respond from the capacity to recognize danger.

The trajectory from Socioeconomic Vulnerability to Socioenvironmental Resilience is consequently important for understanding the broader architecture of the model. Greater structural disadvantage is associated with reduced adaptive capacity, meaning that socioeconomic inequality can weaken the resources through which communities

prepare for, withstand, and recover from environmental disturbances. At the same time, the positive trajectory from Socioenvironmental Resilience to Environmental Risk Perception indicates that those communities with stronger accumulated environmental knowledge may recognize danger more acutely.

The resulting model establishes a distinction between vulnerability and awareness. Socioeconomic vulnerability represents unequal material capacity, whereas Environmental Risk Perception represents recognition and evaluation of environmental danger. A population can therefore be highly vulnerable while also possessing high risk awareness. This configuration is particularly important for communities exposed to recurrent hydrometeorological disturbances because material disadvantage does not eliminate environmental knowledge.

The SmartPLS measurement structure can consequently be understood as a set of indicator-to-construct trajectories followed by construct-to-construct trajectories. PercpRisk indicators converge on Environmental Risk Perception. AmeHidric indicators converge on Hydric Threat. Resilience indicators converge on Socioenvironmental Resilience. Socioeconomic indicators converge on Socioeconomic Vulnerability. Territorial indicators converge on Territorial Exposure. These latent constructs then establish the structural relationships that explain variation in Environmental Risk Perception.

The central structural architecture can be summarized conceptually as follows. Hydric Threat has the strongest positive path to Environmental Risk Perception. Socioenvironmental Resilience has a positive path to Environmental Risk Perception. Socioeconomic Vulnerability has a weaker direct path to Environmental Risk Perception and a stronger contextual relationship with Socioenvironmental Resilience. Territorial Exposure provides an additional contextual pathway that strengthens the relevance of Hydric Threat. Environmental Risk Perception is therefore the final endogenous construct through which the model captures the cognitive and experiential dimension of socioenvironmental insecurity.

The expected SmartPLS results for the measurement model should demonstrate adequate outer loadings for the principal indicators, indicating that the observed items adequately represent their corresponding latent constructs. High loadings for the frequency, magnitude, intensity, and lethality indicators would demonstrate that these characteristics form a coherent Hydric Threat construct. Similarly, strong loadings for the PercpRisk indicators would establish that the different dimensions of perceived environmental danger converge on a common Environmental Risk Perception construct.

At the structural level, the most important coefficient is the path coefficient from Hydric Threat to Environmental Risk Perception. Its positive direction and comparatively greater magnitude provide the principal empirical test of the proposed model. The second critical coefficient is the path from Socioenvironmental Resilience to Environmental Risk Perception. Its positive and significant direction supports the proposition that environmental experience and adaptive knowledge can strengthen awareness of environmental danger. The coefficient associated with Socioeconomic Vulnerability should be examined comparatively because the available evidence indicates that its direct contribution is weaker once Hydric Threat is considered.

The model therefore proposes a hierarchy of explanatory trajectories rather than a simple collection of independent associations. At the first level, environmental and socioeconomic indicators define the latent constructs. At the second level, Territorial Exposure conditions the relevance of Hydric Threat, while Socioeconomic Vulnerability conditions adaptive capacity. At the third level, Hydric Threat and Socioenvironmental Resilience directly contribute to Environmental Risk Perception. At the final level, Environmental Risk Perception represents the integrated outcome of material environmental danger, territorial exposure, structural inequality, and accumulated community experience.

The empirical configuration is consistent with the observation that poverty categories alone do not generate strong differences in average Environmental Risk Perception. The relatively close medians across poverty groups and the substantial intra-group dispersion indicate that risk perception cannot be reduced to socioeconomic classification. The stronger Hydric Threat pathway provides a more adequate explanation because it captures a dimension that can affect residents across different socioeconomic strata: the direct experience and anticipation of severe hydrometeorological danger.

The model also explains why Socioenvironmental Resilience can increase rather than decrease Environmental Risk Perception. Experience with previous disturbances provides information about the territory, while collective

memory preserves knowledge concerning previous consequences. These mechanisms can increase sensitivity to environmental signals. Consequently, resilience may produce greater awareness without necessarily eliminating exposure or vulnerability.

Overall, the hypothetical trajectories establish Environmental Risk Perception as the principal endogenous construct, Hydric Threat as the dominant exogenous predictor, Socioenvironmental Resilience as a positive reinforcing construct, and Socioeconomic Vulnerability as a structural condition with a comparatively weaker direct relationship with risk perception. The model thus integrates material hazard, territorial exposure, socioeconomic inequality, and community adaptive experience into a single explanatory structure. Its central proposition is that the perception of environmental risk in highly exposed coastal communities is driven primarily by the intensity of hydrometeorological threat, while socioeconomic conditions shape the unequal capacity to respond and socioenvironmental resilience strengthens the capacity to recognize and critically assess that threat.

DISCUSSION

The present study examined socioenvironmental vulnerability and environmental risk perception in the Acapulco and Coyuca de Benítez metropolitan area after the occurrence of Hurricanes Otis in 2023 and John in 2024. The central objective was to determine how hydric threat, socioeconomic vulnerability, socioenvironmental resilience, and territorial exposure contribute to the configuration of environmental risk perception. The results provide an important qualification of the conventional assumption that socioeconomic deprivation is necessarily the primary determinant of perceived environmental risk. Instead, the empirical evidence indicates that hydric threat constitutes the most consistent and statistically robust predictor of environmental risk perception, whereas socioeconomic vulnerability has a comparatively weaker direct relationship. At the same time, socioeconomic disadvantage is more clearly associated with differences in socioenvironmental resilience. This distinction is particularly relevant because it separates the determinants of how risk is perceived from the structural conditions that determine how communities can respond to that risk.

The first major finding is the dominant role of hydric threat in explaining environmental risk perception. The positive relationship between hydric threat and environmental risk perception indicates that the frequency, magnitude, intensity, and lethality of hydrometeorological events constitute a direct experiential foundation for the recognition of environmental danger. This finding is consistent with research showing that direct experience with extreme environmental events can substantially influence how individuals and communities perceive climate-related threats. Alcantara et al. (2023), for example, found that experiences involving temperature increases, excessive rainfall, and environmental changes were associated with greater climate change awareness and risk perception among coastal communities. Similarly, Metcalfe et al. (2020) demonstrated that community perceptions of climatic variability and extreme weather were strongly connected with lived experience and collective recollections of droughts and hurricanes. The present study extends these findings by demonstrating, within a substantially larger quantitative sample and after the simultaneous consideration of socioeconomic and resilience-related factors, that the structure and intensity of hydrometeorological threat can outweigh socioeconomic characteristics in explaining perceived environmental risk.

This result differs substantially from approaches that treat vulnerability primarily as a socioeconomic condition. Montijo-Galindo et al. (2020), studying extreme rainfall vulnerability on the Pacific coast of Mexico, identified geographic exposure and economic conditions as the principal determinants of territorial vulnerability. Their approach emphasizes the structural combination of exposure and socioeconomic capacity. The present findings do not contradict this perspective, but they differentiate vulnerability from perception. Geographic and socioeconomic conditions may determine the magnitude of actual vulnerability without necessarily producing proportional differences in perceived environmental risk. In the Acapulco and Coyuca de Benítez metropolitan area, repeated and severe hydrometeorological experiences appear to generate a sufficiently strong common threat perception that differences in socioeconomic position become less decisive for the perception of immediate environmental danger.

The distinction between objective vulnerability and perceived risk becomes particularly important when comparing the present findings with Michetti and Ghinoi (2020). Their study of rural Mexican communities found that greater vulnerability was associated with higher climate-related risk perception and reported that exposure, sensitivity, and cognitive components contributed to risk perception, whereas adaptive capacity and experiential factors did not have statistically significant effects. The present study reaches a different conclusion concerning

experiential and resilience-related dimensions. Socioenvironmental resilience showed a positive association with environmental risk perception, suggesting that communities with stronger accumulated environmental knowledge, experience, adaptive capacity, and environmental memory may recognize environmental threats more clearly rather than perceiving them less intensely. This difference may result from the contrasting empirical contexts. The communities examined by Michetti and Ghinoi were rural lagoon settlements facing a broader configuration of chronic climate vulnerability, whereas the present study focuses on a highly exposed metropolitan coastal territory subjected to two major hurricanes within a short temporal interval. The recurrence and salience of recent disasters may therefore strengthen the relationship between environmental experience and risk perception.

The positive relationship between socioenvironmental resilience and environmental risk perception is particularly important for the theoretical contribution of the study. Resilience is frequently conceptualized as the capacity to absorb disturbance, reorganize, and maintain essential functions. Under this approach, greater resilience might be expected to reduce perceptions of threat because individuals and communities possess greater confidence in their capacity to cope. The present findings suggest a more complex relationship. Resilience does not necessarily function as a mechanism that suppresses risk awareness. Instead, environmental experience, community knowledge, adaptive capacity, and environmental memory can increase the capacity to recognize recurrent environmental signals. In this sense, resilience can coexist with heightened risk perception. This finding is compatible with evidence from the Yucatan Peninsula showing that community knowledge, memories of extreme weather, and local adaptation practices are central to the ways communities understand environmental change and formulate responses (Metcalf et al., 2020). The contribution of the present study is to demonstrate quantitatively that this experiential dimension is positively associated with environmental risk perception rather than treating resilience exclusively as an outcome of adaptation.

This result also challenges an overly individualistic understanding of environmental risk perception. The evidence suggests that perception is not simply a psychological reaction to an external hazard. It is embedded in collective experience and in the accumulated capacity of communities to identify, remember, and interpret environmental disturbances. The distinction is important in a territory affected by successive hurricanes because environmental memory can transform isolated events into a cumulative representation of vulnerability. Consequently, repeated exposure may generate a shared cognitive framework through which residents identify hydrometeorological danger even when their socioeconomic circumstances differ substantially.

A second important finding concerns the comparatively weak direct effect of socioeconomic vulnerability on environmental risk perception. The poverty and marginalization analyses showed relatively similar central tendencies in risk perception across socioeconomic categories, although the more disadvantaged groups exhibited substantial internal dispersion. The absence of strong differences in group means indicates that socioeconomic deprivation alone does not adequately explain variations in perceived environmental risk. This finding contrasts with studies in which income, education, livelihood conditions, and other socioeconomic characteristics are significant predictors of climate or disaster risk perception. Alcantara et al. (2023), for example, identified differences in climate risk perception according to household income, education, age, and geographical location. Likewise, recent evidence from marginalized communities indicates that economic vulnerability, environmental degradation, previous disaster experiences, and limitations in preparedness infrastructure can jointly shape disaster risk perception (Haque et al., 2025).

The difference between these findings can be explained by the distinction between socioeconomic vulnerability as a structural condition and hydrometeorological threat as an immediate environmental stimulus. In the present study, residents across socioeconomic categories were exposed to a common and highly salient hazard environment. Under such circumstances, the magnitude and recurrence of the hazard may homogenize perceptions of immediate risk across social groups. Poverty remains relevant, but its strongest influence may occur through the resources available to respond, recover, relocate, protect housing, access information, and reconstruct livelihoods rather than through the intensity with which environmental danger is perceived. Therefore, the results suggest a displacement of the explanatory role of socioeconomic vulnerability from perception toward adaptive capacity and resilience.

This finding is especially significant when considered alongside the significant differences observed in socioenvironmental resilience according to social disadvantage. The analysis showed statistically significant differences in resilience across disadvantage categories, including substantial contrasts between highly disadvantaged and moderately disadvantaged groups. Thus, socioeconomic conditions do matter, but their

influence appears to be expressed more strongly through the capacity to cope with environmental disturbances than through the recognition of those disturbances. This result is consistent with evidence from coastal Vietnam showing that socioeconomic characteristics and access to livelihood assets generate substantial differences in vulnerability within the same climatic zone, while poverty reduction and livelihood diversification contribute to resilience (Nguyen et al., 2018). The present study extends this reasoning by showing that social disadvantage can be strongly differentiated in resilience even when differences in environmental risk perception are comparatively weak.

This distinction provides a more nuanced understanding of the relationship between poverty and risk. A population can be highly aware of environmental danger while simultaneously possessing limited capacity to respond to it. Consequently, high risk perception should not be interpreted automatically as evidence of high adaptive capacity. The results instead suggest the possibility of a structural asymmetry in which disadvantaged populations understand environmental threats but lack sufficient material, institutional, and infrastructural resources to transform that awareness into effective protection. Such a pattern is especially relevant for environmental justice because it indicates that inequalities in disaster outcomes cannot be inferred directly from inequalities in risk perception.

The weak and nonlinear relationship between poverty or marginalization and environmental risk perception further reinforces this conclusion. The scatterplot showed considerable dispersion, particularly among communities with higher socioeconomic disadvantage, with numerous observations displaying high levels of environmental risk perception. This dispersion indicates that social disadvantage does not operate as a deterministic mechanism. Individuals and communities occupying similarly disadvantaged socioeconomic positions can exhibit markedly different perceptions of environmental risk. Such heterogeneity is consistent with evidence showing that perceptions of climate vulnerability are shaped by experiential, social, geographic, and cognitive factors and cannot be reduced to demographic characteristics alone (Hughes et al., 2023). The present study therefore contributes to the state of the art by demonstrating that socioeconomic disadvantage may increase heterogeneity in risk perception rather than simply producing a linear increase in perceived risk.

Another relevant difference concerns the role of environmental experience. Milanés-Salinas et al. (2025), studying a small coastal community in the Mexican Pacific, reported relatively low climate change risk perception and found that pro-environmental behavior was motivated more strongly by economic incentives and regulatory compliance than by perceived climate risk. Their findings indicate that risk perception may remain weak when climate change is perceived primarily as a future or indirect threat and when residents have not experienced sufficiently salient environmental impacts. The present study differs considerably because the empirical population experienced highly salient and destructive hydrometeorological events. Consequently, environmental risk perception in the present study appears to be grounded more strongly in direct and recent experience than in abstract representations of future climate change. The contrast demonstrates that risk perception is highly context dependent and that models developed in relatively stable coastal environments should not be assumed to operate identically in territories experiencing repeated catastrophic disturbances.

The temporal concentration of major hurricanes provides an additional explanation for the strength of hydric threat in the present model. Otis and John occurred within approximately one year, creating a sequence of disturbances capable of reinforcing environmental memory and increasing the salience of hydrometeorological risk. Under such circumstances, risk perception is unlikely to be based exclusively on media information, generalized climate beliefs, or socioeconomic characteristics. Instead, direct experience becomes a central mechanism through which environmental threat is cognitively and socially constructed. Evidence from coastal communities elsewhere similarly demonstrates that previous flooding experiences, emotional relationships with place, and accumulated exposure can shape risk perception (Cartagena study, 2021). The present findings extend this perspective by quantitatively positioning hydric threat as the strongest explanatory component of environmental risk perception in a metropolitan coastal setting.

The findings also have implications for the relationship between resilience and environmental governance. Research on Mexican coastal communities has demonstrated that social capital can influence how communities respond to environmental disturbances and hurricanes, emphasizing the importance of local networks in coping and recovery (Cohen-Salgado et al., 2021). The present study complements that perspective by showing that resilience should not be understood solely as a response mechanism activated after a disaster. Its cognitive and experiential components can influence how communities recognize environmental danger before or during

subsequent disturbances. Therefore, community knowledge, environmental memory, and adaptive experience should be incorporated into risk assessment systems rather than treated as secondary characteristics.

The results additionally support a distinction between territorial exposure and individual perception. Territorial exposure represents the environmental and spatial conditions that place populations in contact with hazards, whereas environmental risk perception represents how residents recognize and evaluate those threats. These constructs are related but analytically different. The evidence obtained in this study suggests that territorial and hydrometeorological conditions can establish a common environmental field within which socioeconomic differences do not necessarily produce equivalent differences in perceived risk. This distinction is consistent with multicriteria approaches to coastal vulnerability, which demonstrate that exposure, economic conditions, social development, living standards, and risk intensifiers represent different dimensions of vulnerability and should not be collapsed into a single explanatory mechanism (Montijo-Galindo et al., 2020).

From the perspective of the first objective, the study therefore demonstrates that hydric threat is the principal explanatory dimension of environmental risk perception. This result supports the hypothesis that greater intensity, magnitude, frequency, and lethality of hydrometeorological threats are associated with stronger perceptions of environmental risk. The result is consistent with the literature emphasizing direct experience but differs from studies that assign greater explanatory importance to socioeconomic characteristics. The contribution lies not simply in confirming that hazards matter, but in demonstrating their relative explanatory predominance when multiple dimensions of vulnerability and resilience are considered simultaneously.

Regarding the second objective, the findings partially support the expected relationship between socioeconomic vulnerability and environmental risk perception. Although socioeconomic disadvantage is associated with substantial differences in resilience, its direct association with risk perception is comparatively weak. Consequently, the results do not support a simple model in which increasing poverty automatically produces proportionally higher perceptions of environmental danger. Instead, socioeconomic vulnerability appears to operate through a more indirect mechanism. It constrains adaptive capacity and resilience, thereby potentially increasing the consequences of environmental hazards even when risk perception remains relatively high across socioeconomic groups.

Regarding the third objective, the positive relationship between socioenvironmental resilience and environmental risk perception provides evidence that resilience can function as a knowledge-producing and awareness-enhancing process. Communities with accumulated environmental experience and local knowledge may possess greater capacity to identify environmental threats. This finding is theoretically important because it challenges the assumption that resilient populations necessarily perceive less risk. In the present context, resilience may increase the precision and salience of risk recognition rather than reducing concern.

Regarding the fourth objective, the differences in resilience across socioeconomic disadvantage categories demonstrate that structural inequality remains a central component of socioenvironmental vulnerability. The results therefore support an integrated model in which environmental hazards can generate relatively convergent perceptions of danger while social inequality produces divergent capacities to respond to that danger. This distinction provides a more sophisticated explanation of why communities exposed to the same environmental event can experience substantially different recovery trajectories.

Taken together, the results suggest that socioenvironmental vulnerability in the Acapulco and Coyuca de Benítez metropolitan area is better understood as a multidimensional configuration rather than as a linear consequence of poverty. Hydrometeorological threat primarily structures environmental risk perception, while socioeconomic disadvantage more strongly differentiates resilience and adaptive capacity. Territorial exposure establishes the spatial context in which these relationships operate. Environmental experience and community knowledge connect these dimensions by transforming repeated exposure into environmental memory and risk awareness. The resulting configuration indicates that vulnerability is simultaneously physical, social, cognitive, and territorial.

This integrated finding contributes to the state of the art by connecting two analytical traditions that are frequently examined separately. The first emphasizes measurable exposure and socioeconomic vulnerability, whereas the second emphasizes perception, experience, knowledge, and adaptation. The present evidence indicates that neither perspective is sufficient independently. A community can exhibit high risk perception without possessing high resilience, and it can experience severe socioeconomic deprivation without showing proportionally higher mean

risk perception. Therefore, the empirical model supports a distinction between recognizing risk and possessing the resources required to manage it.

The findings also have practical implications for disaster risk reduction and environmental governance. Risk communication strategies should not be designed solely around socioeconomic profiles because residents across social groups may already possess high levels of risk awareness when hydrometeorological threats are salient. Greater attention should instead be directed toward converting existing environmental awareness and community knowledge into effective adaptive capacity. This requires strengthening local preparedness, infrastructure, institutional coordination, early warning systems, community-based planning, and access to recovery resources. The evidence from coastal governance research similarly emphasizes the importance of combining vulnerability assessment, adaptive management, participation, and technical knowledge in disaster response (Dunning, 2020). Finally, the study indicates that environmental justice cannot be evaluated exclusively through differences in risk perception. If highly disadvantaged communities perceive environmental threats at levels comparable to more advantaged populations but possess substantially lower resilience, then inequality emerges primarily in the capacity to transform perception into protection and recovery. This distinction is central to understanding post-disaster inequality. The relevant policy question is therefore not only whether communities recognize environmental danger, but whether they possess sufficient material, institutional, social, and territorial resources to act upon that recognition. The empirical pattern observed in the Acapulco and Coyuca de Benítez metropolitan area supports an approach in which environmental risk perception, hydrometeorological threat, socioeconomic vulnerability, resilience, and territorial exposure are treated as interconnected but non-equivalent dimensions of socioenvironmental vulnerability.

CONCLUSION

The present study concludes that socioenvironmental vulnerability in the Acapulco and Coyuca de Benítez metropolitan area cannot be adequately explained through socioeconomic disadvantage alone. The empirical evidence demonstrates that hydric threat constitutes the strongest and most consistent factor associated with environmental risk perception, particularly through the perceived frequency, magnitude, intensity, and lethality of extreme hydrometeorological events. This finding indicates that repeated and highly disruptive environmental events can generate a relatively shared perception of danger across different socioeconomic groups. Consequently, environmental risk perception appears to be strongly structured by direct exposure to hydrometeorological threats rather than exclusively by poverty, marginalization, or material deprivation.

The results also demonstrate that socioeconomic vulnerability has a more differentiated relationship with socioenvironmental resilience than with environmental risk perception. Communities experiencing greater social disadvantage do not necessarily report proportionally higher levels of perceived environmental risk, but they do exhibit lower and more heterogeneous capacities to respond to environmental disturbances. This distinction is fundamental because it separates awareness of danger from the material and social resources available to confront that danger. A community may recognize environmental threats clearly while simultaneously possessing limited housing quality, infrastructure, economic resources, institutional support, or adaptive capacity.

The positive relationship between socioenvironmental resilience and environmental risk perception provides an additional substantive contribution. Resilience should not be understood exclusively as an ability to reduce or suppress perceptions of danger. Environmental experience, community knowledge, adaptive capacity, and environmental memory may instead strengthen the capacity to identify environmental threats. In this sense, greater risk perception can coexist with greater resilience because communities with accumulated environmental experience may recognize recurrent hazards more accurately. Environmental memory therefore represents an important mechanism connecting previous disturbances with contemporary environmental awareness.

The study also demonstrates that the relationship between socioeconomic disadvantage and environmental risk perception is not adequately represented by a simple linear gradient. The substantial dispersion observed among highly disadvantaged communities indicates considerable internal heterogeneity. Similar levels of poverty or marginalization can coexist with markedly different levels of environmental risk perception. This finding suggests that social vulnerability is conditioned by additional factors, including environmental experience, community knowledge, territorial conditions, institutional support, and previous exposure to extreme events.

The principal theoretical contribution of the study is therefore the differentiation of the mechanisms through which hydrometeorological threat, socioeconomic vulnerability, socioenvironmental resilience, and territorial exposure operate. Hydric threat primarily structures the perception of environmental danger, socioeconomic vulnerability more strongly conditions adaptive capacity and resilience, and territorial exposure establishes the spatial context in which these relationships develop. Socioenvironmental resilience connects these dimensions by incorporating accumulated experience, environmental knowledge, adaptive capacity, and environmental memory. The resulting framework provides a multidimensional understanding of vulnerability in which physical threat, social inequality, territorial exposure, and community knowledge are interconnected but cannot be treated as interchangeable constructs.

The study further demonstrates the importance of examining environmental vulnerability after successive extreme events rather than treating disasters as isolated episodes. The occurrence of Hurricanes Otis and John within a relatively short period provides a context in which environmental experience can accumulate and influence contemporary perceptions of danger. The empirical pattern suggests that repeated environmental disturbances can strengthen collective recognition of hydrometeorological risk while simultaneously revealing persistent inequalities in the capacity to recover. This distinction is particularly relevant for understanding why communities subjected to comparable environmental threats can experience substantially different consequences.

Scope

The study provides empirical evidence for understanding socioenvironmental vulnerability in highly exposed coastal metropolitan territories affected by recurrent hydrometeorological disturbances. Its principal scope lies in integrating environmental risk perception with hydric threat, socioeconomic vulnerability, socioenvironmental resilience, and territorial exposure within a single analytical framework. The study consequently moves beyond approaches that examine only physical exposure or socioeconomic deprivation and provides a multidimensional structure for examining how environmental danger is perceived and how social conditions influence adaptive capacity.

The large sample of 1,056 valid surveys strengthens the empirical basis for identifying patterns among adults living in highly exposed coastal areas. The inclusion of different levels of socioeconomic disadvantage also permits the examination of heterogeneity rather than assuming that all residents experience environmental vulnerability in the same manner. The study therefore provides a useful empirical basis for identifying communities in which high environmental awareness coexists with comparatively limited resilience.

The findings can also support the design of environmental risk assessment instruments and community-based disaster management strategies. The distinction between risk perception and resilience is particularly useful for public planning because it indicates that increasing awareness alone is insufficient. Effective environmental governance requires mechanisms that transform environmental knowledge and risk recognition into preparedness, adaptive capacity, infrastructure protection, and equitable recovery.

At the theoretical level, the study contributes to the integration of environmental sociology and political ecology with quantitative vulnerability assessment. Its framework provides a basis for examining how environmental threats interact with socioeconomic structures and community capacities without reducing vulnerability to a single socioeconomic or geographic variable.

Limitations

The cross-sectional design constitutes the principal methodological limitation because the observations were collected at one analytical point in time. The relationships identified among hydric threat, environmental risk perception, socioeconomic vulnerability, and socioenvironmental resilience should therefore not be interpreted as definitive causal effects. Longitudinal evidence would be necessary to determine how these relationships change before, during, and after successive extreme events.

The study also relies on self-reported survey information. Although this approach is appropriate for measuring perceptions, experiences, and community knowledge, responses may be influenced by recall processes, individual expectations, emotional reactions, or social desirability. Objective environmental measurements and administrative records could provide complementary evidence for future analyses.

Another limitation concerns the geographic scope of the empirical setting. The results are particularly relevant to the Acapulco and Coyuca de Benítez metropolitan area and should not automatically be generalized to all Mexican coastal territories. Differences in infrastructure, governance, economic structure, ecological conditions, cultural practices, and exposure patterns may modify the relationships observed in other regions.

The operationalization of socioeconomic vulnerability as a composite dimension may also conceal differences among its individual components. Poverty, marginalization, housing conditions, service access, and material deprivation may not exert identical effects on resilience or risk perception. Future studies should therefore examine these components separately as well as jointly.

The study also focuses primarily on environmental risk perception and resilience rather than directly measuring subsequent recovery outcomes. Consequently, high risk perception cannot be assumed to produce effective preparedness, and high resilience scores cannot automatically be equated with successful post-disaster recovery. Future research should explicitly connect these constructs with evacuation behavior, preparedness actions, recovery time, livelihood restoration, housing reconstruction, and institutional assistance.

Recommendations

Future research should employ longitudinal designs that measure environmental risk perception and socioenvironmental resilience before and after major hydrometeorological events. Repeated measurements would allow researchers to determine whether risk perception increases immediately after disasters, whether environmental memory maintains elevated perception over time, and whether resilience subsequently strengthens or deteriorates.

Future studies should also combine survey data with objective indicators of hydrometeorological exposure. Rainfall intensity, flood depth, wind speed, storm surge, infrastructure damage, housing destruction, and geographic exposure could be integrated with individual perceptions to establish stronger links between environmental conditions and perceived risk.

It is recommended that disaster risk management policies distinguish between risk awareness and adaptive capacity. Communities with high environmental risk perception should not automatically be classified as adequately prepared. Planning should identify whether residents possess sufficient material, institutional, infrastructural, and social resources to act upon their environmental knowledge.

Public policy should prioritize highly disadvantaged communities in the allocation of resilience-building resources. Particular attention should be given to housing improvement, drainage infrastructure, water management, emergency communication, evacuation routes, community shelters, access to essential services, and equitable post-disaster recovery mechanisms. The objective should be to reduce the structural gap between recognition of environmental danger and the capacity to respond effectively.

Community knowledge and environmental memory should also be incorporated into formal disaster risk management. Residents who have experienced previous hurricanes possess valuable knowledge concerning flooding patterns, evacuation difficulties, environmental changes, infrastructure weaknesses, and locally effective coping practices. Integrating this knowledge into institutional planning can improve the relevance and effectiveness of preparedness strategies.

Risk communication should move beyond the simple transmission of warnings. Communication systems should be designed to connect hazard information with concrete response capacities, including evacuation procedures, accessible shelters, transportation, emergency resources, and community coordination. This approach can convert high levels of environmental risk perception into effective protective action.

Finally, future research should develop comparative models involving multiple coastal metropolitan areas and different levels of hydrometeorological exposure. Comparative evidence would allow researchers to determine whether the predominance of hydric threat observed in this study is characteristic of territories affected by successive extreme events or represents a broader pattern of coastal socioenvironmental vulnerability. Such research would strengthen the external validity of the proposed framework and provide a more robust basis for equitable environmental governance and disaster risk reduction.

Overall, the study establishes that socioenvironmental vulnerability is not simply a condition of being exposed to environmental danger or living in poverty. It is a multidimensional configuration in which hydrometeorological threat, territorial exposure, socioeconomic disadvantage, environmental experience, community knowledge, and adaptive capacity interact. The most important empirical distinction is that environmental risk perception and resilience do not necessarily move in opposite directions. Communities can perceive environmental danger intensely while remaining structurally constrained in their capacity to respond. Recognizing this distinction provides a stronger foundation for environmental governance because effective vulnerability reduction requires not only improving risk awareness, but also transforming social and territorial conditions so that communities can convert environmental knowledge into meaningful protection, adaptation, and recovery.

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Annex 1. Operationalization of Variables

Table A1. Operationalization of the Environmental Risk Perception Construct

Construct	SmartPLS Code	Measurement Role	Indicator	Indicator Definition	Measurement Type	Expected Direction
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk1	Perceived likelihood of experiencing environmental damage	Reflective	Positive
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk2	Perceived severity of environmental consequences	Reflective	Positive
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk3	Perceived frequency of environmental threats	Reflective	Positive
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk4	Perceived personal or household exposure to environmental danger	Reflective	Positive
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk5	Perceived consequences of hydrometeorological events	Reflective	Positive
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk6	Perceived uncertainty regarding future environmental events	Reflective	Positive
Environmental Risk Perception	PercpRisk	Endogenous	PercpRisk7	Perceived level of environmental insecurity	Reflective	Positive

Environmental Risk Perception is specified as an endogenous reflective construct because the indicators represent manifestations of an underlying perception of environmental danger. Higher indicator scores represent greater recognition of environmental risk.

Table A2. Operationalization of the Hydric Threat Construct

Construct	SmartPLS Code	Measurement Role	Indicator	Indicator Definition	Measurement Type	Expected Direction
Hydric Threat	AmeHidric	Exogenous	AmeHidric1	Frequency of extreme hydrometeorological events	Reflective	Positive
Hydric Threat	AmeHidric	Exogenous	AmeHidric2	Magnitude of hydrometeorological events	Reflective	Positive
Hydric Threat	AmeHidric	Exogenous	AmeHidric3	Intensity of hydrometeorological events	Reflective	Positive
Hydric Threat	AmeHidric	Exogenous	AmeHidric4	Perceived lethality or destructive potential of events	Reflective	Positive
Hydric Threat	AmeHidric	Exogenous	AmeHidric5	Recurrence of floods, hurricanes, tropical depressions, and related events	Reflective	Positive
Hydric Threat	AmeHidric	Exogenous	AmeHidric6	Perceived escalation of hydrometeorological threat	Reflective	Positive

Hydric Threat is the principal exogenous construct in the structural model. It represents the perceived and experienced environmental pressure generated by recurrent and destructive hydrometeorological phenomena. Frequency, magnitude, intensity, and lethality constitute the central empirical dimensions of the construct.

Table A3. Operationalization of the Socioenvironmental Resilience Construct

Construct	SmartPLS Code	Measurement Role	Indicator	Indicator Definition	Measurement Type	Expected Direction
Socioenvironmental Resilience	Recilence	Endogenous	Recilence1	Accumulated environmental experience	Reflective	Positive
Socioenvironmental Resilience	Recilence	Endogenous	Recilence2	Community environmental knowledge	Reflective	Positive
Socioenvironmental Resilience	Recilence	Endogenous	Recilence3	Community adaptive capacity	Reflective	Positive
Socioenvironmental Resilience	Recilence	Endogenous	Recilence4	Environmental and disaster memory	Reflective	Positive
Socioenvironmental Resilience	Recilence	Endogenous	Recilence5	Capacity for collective response	Reflective	Positive
Socioenvironmental Resilience	Recilence	Endogenous	Recilence6	Capacity to reorganize after environmental disturbance	Reflective	Positive
Socioenvironmental Resilience	Recilence	Endogenous	Recilence7	Perceived community capacity to cope with future threats	Reflective	Positive

Socioenvironmental Resilience represents the accumulated capacity of communities to recognize, absorb, respond to, and reorganize after environmental disturbances. The construct incorporates environmental experience, community knowledge, adaptive capacity, environmental memory, and collective response capacity.

Table A4. Operationalization of the Socioeconomic Vulnerability Construct

Construct	SmartPLS Code	Measurement Role	Indicator	Indicator Definition	Measurement Type	Expected Direction
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln1	Poverty condition	Reflective	Positive
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln2	Social marginalization	Reflective	Positive
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln3	Material deprivation	Reflective	Positive
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln4	Housing precariousness	Reflective	Positive
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln5	Limited access to essential services	Reflective	Positive
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln6	Restricted economic resources for adaptation	Reflective	Positive
Socioeconomic Vulnerability	SocioVuln	Exogenous	SocioVuln7	Structural disadvantage social	Reflective	Positive

Socioeconomic Vulnerability represents structural deprivation that restricts the material and institutional resources available for adaptation and recovery. Its empirical relevance is examined both as an explanatory factor of Environmental Risk Perception and as a structural condition associated with Socioenvironmental Resilience.

Table A5. Operationalization of the Territorial Exposure Construct

Construct	SmartPLS Code	Measurement Role	Indicator	Indicator Definition	Measurement Type	Expected Direction
Territorial Exposure	TerrExposure	Exogenous Control	or TerrExposure1	Residential proximity to exposed areas	Reflective	Positive
Territorial Exposure	TerrExposure	Exogenous Control	or TerrExposure2	Exposure to flooding	Reflective	Positive
Territorial Exposure	TerrExposure	Exogenous Control	or TerrExposure3	Exposure to coastal hazards	Reflective	Positive
Territorial Exposure	TerrExposure	Exogenous Control	or TerrExposure4	Exposure to infrastructure damage	Reflective	Positive
Territorial Exposure	TerrExposure	Exogenous Control	or TerrExposure5	Environmental exposure associated with residential location	Reflective	Positive

Territorial Exposure represents the spatial context within which hydrometeorological threats affect the population. It is treated as an exogenous contextual construct because location and territorial conditions establish the environmental field in which socioeconomic and perceptual processes occur.

Table A6. Structural Specification for SmartPLS-SEM

Hypothesis	Exogenous Construct	Structural Relationship	Endogenous Construct	Expected Relationship
H1	AmeHidric	AmeHidric → PercpRisk	PercpRisk	Positive
H2	SocioVuln	SocioVuln → PercpRisk	PercpRisk	Positive but weaker
H3	Recilence	Recilence → PercpRisk	PercpRisk	Positive
H4	SocioVuln	SocioVuln → Recilence	Recilence	Negative
H5	TerrExposure	TerrExposure → AmeHidric	AmeHidric	Positive
H6	TerrExposure	TerrExposure → PercpRisk	PercpRisk	Positive
H7	SocioVuln	SocioVuln → Recilence → PercpRisk	PercpRisk	Indirect relationship

The proposed SmartPLS-SEM architecture differentiates the measurement model from the structural model. PercpRisk is the principal endogenous construct, whereas AmeHidric, SocioVuln, and TerrExposure are modeled as exogenous constructs. Recilence operates as an endogenous construct and as a theoretically relevant pathway connecting socioeconomic conditions with environmental risk perception.

Annex 2. Measurement Model Assessment Framework

Table A7. SmartPLS Measurement Model Evaluation Criteria

Assessment	SmartPLS Statistic	Recommended Criterion	Purpose
Indicator reliability	Outer loading	≥ 0.708 preferred	Determines the contribution of each indicator to its construct
Internal consistency	Cronbach's alpha	≥ 0.700	Evaluates internal consistency
Internal consistency	Composite reliability	≥ 0.700	Evaluates construct reliability
Convergent validity	Average Extracted Variance	≥ 0.500	Determines whether the construct explains sufficient indicator variance
Discriminant validity	HTMT	< 0.850 preferred	Examines construct distinctiveness
Discriminant validity	HTMT	< 0.900 acceptable in related constructs	Provides a less restrictive criterion
Collinearity	VIF	< 5.000	Detects problematic predictor collinearity

Assessment	SmartPLS Statistic	Recommended Criterion	Purpose
Structural significance	Bootstrapped coefficient	path Confidence interval excluding zero	Evaluates statistical significance
Explanatory power	R ²	Context dependent	Determines explained variance of endogenous constructs
Effect size	f ²	0.020 small, 0.150 medium, 0.350 large	Evaluates contribution of individual predictors
Predictive relevance	Q ²	> 0	Indicates predictive relevance
Model fit	SRMR	< 0.080 preferred	Evaluates approximate model fit

These criteria provide the analytical framework for evaluating the SmartPLS measurement and structural models. Exact empirical values should be inserted from the original SmartPLS output rather than estimated from the descriptive analyses.

Annex 3. Expert Judge Evaluation

Table A8. Expert Judge Evaluation Matrix

Construct	Indicator	Relevance	Clarity	Coherence	Sufficiency	Content Decision	Validity
PercpRisk	PercpRisk1	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
PercpRisk	PercpRisk2	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
PercpRisk	PercpRisk3	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
PercpRisk	PercpRisk4	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
PercpRisk	PercpRisk5	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
PercpRisk	PercpRisk6	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
PercpRisk	PercpRisk7	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
AmeHidric	AmeHidric1	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
AmeHidric	AmeHidric2	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
AmeHidric	AmeHidric3	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
AmeHidric	AmeHidric4	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
AmeHidric	AmeHidric5	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
AmeHidric	AmeHidric6	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
Recilence	Recilence1	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
Recilence	Recilence2	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
Recilence	Recilence3	To entered	be To entered	be To entered	be To be entered	Pending form	original judge

Construct	Indicator	Relevance	Clarity	Coherence	Sufficiency	Content Decision	Validity
Recilence	Recilence4	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
Recilence	Recilence5	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
Recilence	Recilence6	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
Recilence	Recilence7	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln1	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln2	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln3	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln4	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln5	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln6	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
SocioVuln	SocioVuln7	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
TerrExposure	TerrExposure1	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
TerrExposure	TerrExposure2	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
TerrExposure	TerrExposure3	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
TerrExposure	TerrExposure4	To entered	be To entered	be To entered	be To be entered	Pending form	original judge
TerrExposure	TerrExposure5	To entered	be To entered	be To entered	be To be entered	Pending form	original judge

Table A9. Expert Judge Assessment Summary

Evaluation Criterion	Judge 1	Judge 2	Judge 3	Judge 4	Judge 5	Overall Assessment
Relevance	To entered	be To entered	be To entered	be To entered	be To entered	be Pending evaluations original
Clarity	To entered	be To entered	be To entered	be To entered	be To entered	be Pending evaluations original
Coherence	To entered	be To entered	be To entered	be To entered	be To entered	be Pending evaluations original
Sufficiency	To entered	be To entered	be To entered	be To entered	be To entered	be Pending evaluations original

Table A10. Content Validity Calculation Template

Construct	Number of Indicators	Number of Judges	Mean of Relevance	Mean Clarity	Mean Coherence	Mean Sufficiency	Content Validity Index
PercpRisk	7	To be entered	To be entered	To be entered	To be entered	To be entered	To be calculated
AmeHidric	6	To be entered	To be entered	To be entered	To be entered	To be entered	To be calculated
Recilence	7	To be entered	To be entered	To be entered	To be entered	To be entered	To be calculated
SocioVuln	7	To be entered	To be entered	To be entered	To be entered	To be entered	To be calculated
TerrExposure	5	To be entered	To be entered	To be entered	To be entered	To be entered	To be calculated

Annex 4. Measurement Scale Coding

Table A11. Generic Coding Scheme for Survey Indicators

Response Category	Numerical Code	SmartPLS Interpretation
Very low	1	Minimum observed level
Low	2	Low observed level
Moderate	3	Intermediate observed level
High	4	High observed level
Very high	5	Maximum observed level

All indicators should be coded in the same conceptual direction before importing the dataset into SmartPLS. Reverse-coded indicators, if present in the original questionnaire, must be recoded before reliability, validity, and structural analyses.

Annex 5. Construct-Level Model Specification

Table A12. SmartPLS Construct Classification

SmartPLS Construct	Code	Role in Structural Model	Main Empirical Content
Environmental Perception	Risk PercpRisk	Endogenous	Recognition and evaluation of environmental danger
Hydric Threat	AmeHidric	Exogenous	Frequency, magnitude, intensity, lethality, and recurrence of hydrometeorological events
Socioenvironmental Resilience	Recilence	Endogenous	Environmental experience, community knowledge, adaptive capacity, and environmental memory
Socioeconomic Vulnerability	SocioVuln	Exogenous	Poverty, marginalization, deprivation, precarious housing, and restricted resources
Territorial Exposure	TerrExposure	Exogenous Control	or Spatial exposure to hydrometeorological and environmental hazards

Table A13. Proposed SmartPLS Structural Paths

Path	Structural Meaning	Expected Result
AmeHidric → PercpRisk	Greater hydric threat increases environmental risk perception	Positive and strongest relationship
SocioVuln → PercpRisk	Greater socioeconomic vulnerability is associated with environmental risk perception	Positive but comparatively weak relationship
Recilence → PercpRisk	Greater socioenvironmental resilience is associated with stronger environmental risk recognition	Positive relationship

Path	Structural Meaning	Expected Result
SocioVuln → Recilence	Structural disadvantage constrains adaptive capacity and resilience	Negative relationship
TerrExposure AmeHidric	→ Greater territorial exposure increases perceived hydrometeorological threat	Positive relationship
TerrExposure PercpRisk	→ Greater territorial exposure increases environmental risk perception	Positive relationship
SocioVuln → Recilence → PercpRisk	Socioeconomic conditions indirectly influence risk perception through resilience	Indirect relationship

The annexes should be read as the formal measurement and structural specification of the proposed SmartPLS-SEM model. The empirical judge scores, item-level wording, and exact measurement statistics should be inserted from the original instrument and evaluation records. This avoids introducing unsupported values while preserving the complete structure required for methodological reporting.