

Managerial Interpretation of Biomathematical Models in Green Management Strategy

Muhammad Awais Bhatti^{1*}, Wael Abdelfattah Mahmoud Alsariera², Jamshid Pardaev³, Tamer Hamdy Ayad⁴

¹Department of Management, School of Business, King Faisal University, Al-Ahsa 31982, Saudi Arabia; ²The World Islamic Sciences and Education University, Jordan; ³Associate Professor of Finance and Tourism Department, Termez University of Economics and Service, Uzbekistan; ⁴Management Department, College of Business Administration, King Faisal University, Al-Ahsa, Saudi Arabia

ABSTRACT

Purpose: This study explores how managers make sense of biomathematical models within green management strategy. Rather than examining model performance, the research focuses on how ecological mathematical constructs such as resilience, carrying capacity, and tipping points are interpreted and translated into strategic sustainability actions. Drawing on Sensemaking Theory, the study seeks to understand how meaning is constructed around nonlinear ecological outputs in organizational contexts. **Method:** A qualitative research design was employed, based on 12 semi-structured interviews with sustainability managers, environmental modeling specialists, and green strategy leaders who directly engage with biomathematical tools. Using a three-step coding process (open, axial, and selective coding), the analysis developed first-order concepts grounded in participants' language, which were then abstracted into second-order themes and aggregate dimensions to explain the interpretive processes linking biomathematical outputs to strategic decisions. **Findings:** The findings indicate that managers engage in structured sensemaking processes by extracting salient ecological cues, framing them within organizational narratives, and enacting green strategic responses. Biomathematical models shape strategy through interpretation and narrative construction rather than technical determinism. **Originality/Implications:** This study contributes by providing a process-oriented understanding of how biomathematical abstraction becomes embedded in green management through managerial sensemaking.

ARTICLE HISTORY

Received September 18, 2025

Accepted February 20, 2026

KEYWORDS

Biomathematics,
Green Management,
Sensemaking Theory,
Ecological Resilience,
Nonlinear Sustainability
Modeling

1. Introduction

Bio-mathematical modeling as an aspect of sustainability practice has been of great importance in changing the way organizations look at green management strategy. Nonlinear population dynamics, resilience equations, regeneration rate models and ecosystem stability simulations are biomathematical representations of ecological processes that go beyond conventional linear forecasting (Rabbi, 2025). More companies in the renewable energy, circular manufacturing, and climate-tech industries are integrating such models into sustainability dashboards and strategic planning systems to model the carbon absorption capacity, biodiversity effects, and resource regeneration levels (Muhammad et al., 2023; Tiwary & Sharma, 2025). These advances indicate the move towards environmental management that is based on compliance to one that is based on a system-focused ecological argument with mathematical abstraction.

The most important part of this change is the concept of resilience thinking that views socio-ecological systems as nonlinear and adaptive (Gennusa, 2025), that is, with thresholds beyond which abrupt regime shifts can be experienced (Basile, 2026). The ideas of tipping points, carrying capacity, and safe operating space have been transferred into the corporate sustainability paradigm (Principe et al., 2023). Decisions on the rate of renewable investment, the intensity of resource extraction, and exposure to financial volatility on the supply chain are now informed by biomathematical simulations (Boh et al., 2025). These models do not simply forecast gradual change; they point to system vulnerability and discontinuity and challenge traditional incremental planning strategies (Otugboyega et al., 2024). Though this has raised technical dependence, the attention of the current study has been on the results of model accuracy, computational robustness and environmental performance (Morales-Morales et al., 2025). The sustainability management literature has also pointed out strategic capabilities, engagement of stakeholder, and environmental performance indicators (Frantz et al., 2023), but has scarcely discussed the interpretation of biomathematical outputs by managers in strategic terms. It seems that the implicit assumption is that ecological modeling, having been implemented into organizational systems, has a direct

informational impact on decision-making (Rukundo & Ariho, 2022). Technical integration however does not always imply cognitive integration.

The yields of biomathematics are complex, probabilistic and nonlinear in nature (Xu et al., 2024). The time when the indices of resilience decline, the models of regeneration can predict the state of overshoot, and the simulations of the tipping point can be used to predict the sudden collapse of the system under the established conditions (Hamdallah, 2025). These results are usually not deterministic and thus they cannot be realized and instead need an interpretation. In this regard, it is important to comprehend the cognitive process of the managers to decode and translate such outputs into green strategic action. The interpretive challenge can be answered using Sensemaking Theory. Sensemaking describes the process of individuals forming meaning out of ambiguous and equivocal information, drawing cues and contextualizing them in the context of organizations, to act (Shokeralla et al., 2025). Nonlinear biomathematical models (that are simulated by environmental simulations) produce equivocal signals, which require interpretive reduction. Guedri et al. (2025) concludes that actors place more emphasis on plausibility than accuracy in managing uncertainty. Therefore, managers who have to deal with resilience measures or tipping likelihoods need to turn abstract ecological equations into storytelling that resonates with strategic concerns (Vishwakarma et al., 2025).

Empirical research proves that the process of managerial identity and organizational culture filters environmental uncertainty (Ahmad et al., 2025; Sijm-Eeken et al., 2022). Indicatively, sustainability decision-making studies also note the manner in which managers redefine long-term ecological risk in terms of short-term performance systems (Mota et al., 2022). Nevertheless, the attention of previous research deals mainly with the general environmental data, including climate change news or the regulatory news (Franzke et al., 2015). Interpretive needs of biomathematical models are unique as they consist of nonlinear structure and abstraction of systems (Saha & Ghosh, 2021). It is necessary to reconcile the scientific abstraction of resilience equations or carrying capacity projections with organizational pragmatism in order to translate them into strategic initiatives (Tyagi et al., 2024). Besides, biomathematical modeling leads to the introduction of ecological logic of boundaries to the strategic discourse. Safe operating space (Parit et al., 2026) is a kind of concept that suggests uncompromising ecological thresholds as opposed to bargaining limits. This boundary logic can be incompatible with traditional managerial cognition which is growth oriented (Pujaru et al., 2024). To explain the resolution of such tensions by managers, it is necessary to have an interpretive lens that describes the cognitive processes of framing and not necessarily a technical assessment.

This paper fills this gap by evaluating the interpretation and application of the outputs of biomathical models in green management strategy by managers. Based on the Sensemaking Theory, the study concentrates on how the ecological mathematical abstractions are translated into the strategic meaning (Ang & Safuan, 2021). In particular, it examines how managers derive relevant information even in complex simulations, how ecological indicators are framed in organizational discourses and how strategic change is implemented to match perceived ecological constraints. This research will help to form a new nexus between biomathematics and green management by shifting out of model performance and into managerial interpretation. It provides a theoretically based work on the pathway of embedding nonlinear ecological reasoning in organizational strategy and how this contributes to the development of knowledge about the influence of advanced mathematical representations of ecological systems on sustainable business.

2. Literature Review

2.1 Biomathematics in Green Management: From Ecological Modeling to Organizational Application

Biomathematics is used to elucidate adaptive, dynamic, nonlinear, and biological systems through applying mathematical structures (Ang & Safuan, 2021). The main biomathematics models are population dynamics equations, resilience modeling, ecosystem stability analysis, regeneration rate modeling and threshold-based tipping point systems (Rai et al., 2024). These frameworks have been very popular in modeling ecological carrying capacity, biodiversity interactions, and system balance in the natural setting. Such models have become more and more a part of sustainability and environmental management settings throughout the past decade as they leave ecological science (Chen et al., 2023). Biomathematical models are applied in green management to simulate the carbon cycles, predict the ecosystem degradation, allocate renewable resources optimally, and design circular material flows. Ecological modeling based on resilience, especially, has impacted sustainability planning highlighting the system stability, adaptability, and threshold sensitivity (Mondal et al., 2020). The issues of ecological tipping points and regeneration rates are currently used as the basis of metrics of sustainability and environmental risk predictors (Song et al., 2015). These tools enable organizations to stop thinking in linear projections and to have dynamic simulations of environmental change (Akman et al., 2024). Nevertheless, the majority of the studies in this interplay are technical in nature. Research is directed towards the model

accuracy, predictability, computational effectiveness and ecological validity (Rabbi, 2025). The focus is also put on the system modeling instead of organizational interpretation, even within the sustainability scholarship (Tiwary & Sharma, 2025). Little is known about the managerial aspect of the problem of how decision-makers will perceive biomathematical outputs and use them as part of green plans.

The classical focus of green management studies has been on adoption of policies, pressure by stakeholders, performance results in terms of environment, and the strategic capabilities (Basile, 2026). Although the quantitative modeling tools are not ignored, the cognitively processed ecological mathematical logic by managers is not given a lot of consideration (Boh et al., 2025). This generates a gap in conceptualization: biomathematics offers advanced ecological modeling, but the organizational implementation of the model to strategic action is not adequately theorized (Morales-Morales et al., 2025). The more sustainability challenges grow to be nonlinear and uncertain, the greater the use of ecological simulation tools to inform decisions by organizations (Rukundo & Ariho, 2022). Such dependency begs some very important questions concerning interpretation: how do managers interpret complex mathematical descriptions of ecological systems? The interpretation of this process is crucial, especially in the light of the fact that biomathematical models do not work on the basis of linear equations, probabilistic thresholds, and dynamic feedback loops that are very different in their logic of operation than that of traditional financial forecasting (Hamdallah, 2025). In order to analyze this intersection, it is necessary to have a theoretical perspective that describes the process of how people make sense of complex, ambiguous information. One such lens is the sensemaking theory.

2.2 Sensemaking Theory as a Lens for Interpreting Biomathematical Outputs

The theory of sensemaking that was developed mainly by Guedri et al. (2025) describes the way in which individuals create meaning when they find themselves in an environment that is ambiguous, uncertain and complex. Sensemaking refers to the process by which actors make sense of cues, organize them in terms of preexisting cognitive schemas and institute responses that influence organizational consequences (Sijm-Eeken et al., 2022). It is backward looking, socially formed and based on identity and situation. The level of environmental uncertainty is high in the contexts of sustainability (Mota et al., 2022). The ecological systems are nonlinear, dynamic and unpredictable. Biological mathematical models are trying to model these complexities mathematically, but their results often concern probabilistic situations, probability warnings and dynamic simulations instead of deterministic predictions (Saha & Ghosh, 2021). These are not outputs that can be accepted at face value. Managers should convert the ecological messages into strategic decisions (Parit et al., 2026). There are three reasons as to why sensemaking theory is of relevance in this particular case. To begin with, biomathematical results are always equivocal. They offer descriptions of system dynamics and not prescriptions as such (Ang & Safuan, 2021). It believes that equivocal information requires cognitive framing. The cues are extracted by managers, including expected decrease in resilience or regeneration imbalance, and incorporated in organizational stories.

Second, disruption or uncertainty is one of the triggers of sensemaking. Examples of such risks as described by environmental modeling include the near-ecological tipping points or the falling carrying capacity. Such signals disrupt the current strategic assumptions and need to be reframed (Song et al., 2015). Managers have to balance the ecological mathematical logic, organizational interests, financial imperatives and stakeholders' expectations. Third, sensemaking is discursive (Muhammad et al., 2023). Meetings, strategy discussion, and sustainability reporting processes are also likely to be the places where the interpretation of biomathematical outputs will occur (Gennusa, 2025). Managers through interaction negotiate the sense of ecological metrics and decide to tell whether they are urgent threats, manageable risks or long term considerations (Principe et al., 2023). Therefore, biomathematical models never dictate strategy directly but have their impact on the strategy by the interpretive processes (Otugboyega et al., 2024). Other qualitative researchers using the sensemaking theory to the sustainability context have found that managers make sense of climate change information (Frantz et al., 2023) and the signals of environmental risks (Xu et al., 2024). These studies have shown that managers are not passive recipients of scientific data but they are proactive in giving meaning on the basis of identity, organizational culture as well as strategic priorities. Nevertheless, these researches concentrate more on the general information about the environment, rather than on the biomathematical modeling systems.

The peculiarities of the biomathematical models complicate the necessity of sensemaking (Shokeralla et al., 2025). These models are based on nonlinear equations, feedback loops and dynamic thresholds in contrast to narrative sustainability reports (Vishwakarma et al., 2025). Managers have to contend the disconnect between mathematical abstraction and strategic action. Such interpretive bridging is the focus of the sensemaking theory, which argues that people are always developing simplified, plausible narratives about complex realities to direct action (Ahmad et al., 2025). Thus, the sensemaking theory offers a consistent theoretical approach to the study of the biomathematical sustainability model interpretation by managers. It enables exploration of the cognitive framing and strategic acting of ecological mathematical constructs, including, but not limited to, resilience, carrying capacity, and tipping points, in green management (Franzke et al., 2015).

2.3 Managerial Sensemaking at the Intersection of Biomathematics and Green Strategy

Although biomathematical models help to improve rational decisions made by the environment, organizational activity seldom corresponds to exclusively technical logic (Tyagi et al., 2024). Formation of strategy entails interpretation, negotiation and correspondence with the larger organizational discourses (Pujaru et al., 2024). This implies that biomathematical models do not directly affect green strategy, but via management sensemaking. Managers who come across biomathematical products have a number of interpretative issues (Rai et al., 2024). To begin with, the nonlinear ecology models do not always agree with linear business planning. In other words, resilience models can imply that there is abrupt collapsing of the system after a certain threshold is reached unlike gradual collapse (Chen et al., 2023). This is because such discontinuities would pose a challenge to incremental strategic planning approaches. Managers need to understand the threat or risk that is being presented by these thresholds or a far-off possibility (Mondal et al., 2020). Second, biomathematical models often act at the system levels which are beyond the organizational boundaries (Rabbi, 2025). Ecosystem simulations bring in interdependences between supply chains, community as well as natural systems (Akman et al., 2024). According to the sensemaking theory, people process such complexity by drawing salient cues (Gennusa, 2025). Managers can choose to be selective in some outputs in the model like estimated carbon accumulation and minimize the others (Boh et al., 2025). These choices determine further green policies.

Third, identity influences sensemaking; the output of biomathematics by sustainability managers might be perceived differently by finance-focused executives (Frantz et al., 2023). The identity-based interpretation determines how outputs of the ecological models are perceived as strategic imperatives or as technical background information (Hamdallah, 2025). According to Shokeralla et al. (2025), identity and context have a strong influence on the way ambiguous information is processed. These dynamics are best addressed using qualitative research (Sijm-Eeken et al., 2022). The processes of sensemaking are internalized, socially constructed and contextually embedded (Franzke et al., 2015). Interviews will enable the researcher to record the explanations that managers give about their understanding of biomathematical outputs, accounts given by managers about strategic deliberations, and justifications made by managers based on ecological modeling (Parit et al., 2026). Although there is a growing use of biomathematical instruments in the field of green management, such interpretive dynamics are hardly studied empirically. The literature that is there focuses on sustainability performance results, environmental competency or on technological uptake (Rai et al., 2024). The processes of cognition between ecological modeling and strategic action have not been well developed into theoretical terms.

This study fills this gap by concentrating on biomathematical models sensemaking by managers. It goes further than the assessment of model performance to the investigation of the way ecological mathematical reasoning becomes entrenched or disputed in the process of green strategy making (Akman et al., 2024). The qualitative approach to the study applies the sensemaking theory as the study aims to discover how managers make sense of resilience metrics, carrying capacity projections, and ecological thresholds and how such understandings influence green management strategy (Muhammad et al., 2023). This theoretical framework gives a logical ground to the following methodological procedure. Since sensemaking is an interpretive, socially constructed process, a qualitative interview-based study design will be suitable in order to collect managerial accounts and cognitive framing system (Basile, 2026). The following section therefore presents the methodological approach that aims at exploring these dynamics in an empirical manner.

3. Methodology

3.1 Research Design

The research design employed in this research study is qualitative research design based on the theory of Sensemaking to find out how managers interpret and use biomathematical models in green management strategy. Since the process of sensemaking is socially constructed, context-dependent, and interpretive, semi-structured interviews were deemed to be suitable to trace the cognitive framing, interpretive processes and strategic rationale of the participants in relation to the products of biomathematical models. The study is limited to the application of biomathematics and green management. Hence, they were sampled according to their first-hand experience with ecological or biologically founded mathematical models (e.g. resilience models, regeneration simulations, ecosystem stability metrics) employed in sustainability strategy or environmental decision-making.

3.2 Sample and Data Collection

Twelve semi-structured interviews were carried out (see table 1). Purposive sampling was employed in the selection

of the participants in order to make sure that every respondent had an actual experience of applying biomathematical models in the context of green management. The respondents were sustainability managers, environmental modeling analysts and leaders of the green strategy in renewable energy, circular economy, environmental consulting, and sustainable manufacturing companies. All interviewees were directly exposed to ecological models that were used in strategic sustainability planning. The interviews took a period of between 30–40 minutes with the highest being 40 minutes. The interviews were held using the online video conferencing platforms and were audio-taped with the consent of the interviewees. Analytical rigor was to be observed in which all the interviews were transcribed verbatim. The interview guide was semi-structured giving some room of probing but keeping in lines with the main research question: *How do managers interpret and apply biomathematical model outputs in formulating green management strategies?*

Table 1: Interview Guideline

Section	Focus Area	Sample Guiding Questions
A	Professional Background	Can you describe your role in sustainability or green strategy? How are biomathematical models used in your organization?
B	Model Exposure	What types of ecological or biomathematical models do you work with (e.g., resilience models, regeneration rate models, ecosystem simulations)?
C	Interpretation of Outputs	How do you interpret outputs such as resilience scores, carrying capacity limits, or threshold warnings?
D	Strategic Translation	How do these biomathematical outputs influence green strategic decisions? Can you describe a recent example?
E	Cognitive Framing	When ecological models indicate risk or instability, how do you make sense of that information?
F	Challenges	What difficulties arise when applying biomathematical model outputs to managerial decisions?
G	Organizational Context	How are these model outputs discussed within strategic meetings or sustainability planning sessions?

3.3 Respondent Profile

The 12 respondents are diverse but relevant positions which are directly related to the Biomathematical sustainability modeling and green management strategy. The professional and demographic features are as summarized below (see table 2).

Table 2: Respondent Demographics

Respondent Code	Position	Industry	Years of Experience	Primary Use of Biomathematical Models
R1	Sustainability Director	Renewable Energy	14 years	Carbon Cycle Simulation
R2	Environmental Systems Analyst	Climate-Tech	9 years	Resilience Modeling
R3	Green Strategy Manager	Circular Manufacturing	11 years	Resource Regeneration Models
R4	ESG Modeling Lead	Environmental Consulting	12 years	Ecosystem Stability Metrics
R5	Sustainability Planning Manager	Smart Agriculture	10 years	Carrying Capacity Modeling
R6	Climate Risk Analyst	Renewable Energy	8 years	Tipping Point Simulations
R7	Environmental Data Manager	Circular Economy	7 years	Regeneration Rate Projections
R8	Head of Green Operations	Sustainable Manufacturing	15 years	System Stability Models
R9	Sustainability Innovation Lead	Bioeconomy Firm	13 years	Ecological Network Modeling
R10	Environmental Modeling Specialist	Climate-Tech	6 years	Nonlinear Ecosystem Simulations
R11	Strategic Sustainability Advisor	Environmental Consulting	16 years	Threshold-Based Modeling
R12	Resource Optimization Manager	Renewable Energy	9 years	Population Dynamics Models

The professional experience of participants was not lower than 6 years and not more than 16 years, which guaranteed practice-based and informed reflections. All the respondents were directly engaged in the interpretation or communication of the biomathematical outputs into the process of green management decision.

3.4 Data Analysis

A coding procedure of three steps was used to analyze the data, which is in line with qualitative interpretive research and compatible with the Sensemaking Theory.

Step 1. Open Coding: The transcripts were reviewed line-by-line to determine first-order codes based on the language of the participants. Codes represented the descriptions given by the managers of the interpretation of biomathematical products, response to ecological signals, and connections between model understandings and strategic responses. They included: translation of resilience to risk, threshold as a warning signal, and balance regeneration and growth goals.

Step 2. Axial Coding: First-order codes were clustered into second-order themes that showed patterns in the managerial sensemaking. The step aimed at determining the common interpretive strategies like ecological framing, strategic simplification of mathematical products, normalization of nonlinear risk, and organizational bargaining of ecological cues.

Step 3. Selective Coding: The last step involved the development of aggregate dimensions which were used to build an integrative account of the role of biomathematical logic in the determination of green management strategy. These dimensions would harmonize themes into the next level of interpretation which aligns with the Sensemaking Theory including the extraction of cues, ecological risk framing and green strategic actions. During the analysis, the constant comparison methods were employed to reveal the similarities and differences between cases. Memos of analysis were kept to record the new knowledge and theoretical thoughts. In order to increase rigor, coding choices were viewed repeatedly and data, themes, and theoretical framing were coherent.

3.5 Methodological Rigor

Verbatim transcription, repeat coding and consistency with a well-defined theoretical backbone were used to assure credibility. The targeted sample of participants who had direct contact with biomathematical tools were used thus improving construct validity. The duration of interviews (not exceeding 40 minutes) at all cases gave depth and comparability at the same time. The methodology has a consistent foundation by the Sensemaking Theory and the focus on the operation of biomathematical modeling in the context of green management, which gives a logical ground to find the interpretation and a strategic implementation of ecological mathematical logic in companies.

4. Results and Analysis

The three-step coding process in the methodology was used in analyzing it. Using open coding, 76 first-order concepts were determined out of 12 interviews. They were then coded into 18 second level themes in the axial coding, which were further reduced into three aggregate dimensions in the selective coding. In line with the Sensemaking Theory, the results indicate that managers did not view biomathematical products as purely technical messages, but instead, they were active in their interpretation, framing, and acting. The findings indicate a systematic sensemaking in which the ecological mathematical logic was converted into the green strategic action.

4.1 Extracting Ecological Cues from Mathematical Abstraction

The former aggregate dimension captures the extraction of meaningful cues of complex biomathematical models by the managers. Contributors referred to ecological simulations as being regularly dense, nonlinear and probabilistic. Nonetheless, instead of entertaining mathematical complexity, they paid attention to specific signals, such as resilience scores, regeneration rates, carrying capacity threshold, and a tipping point probability, as something they could act on. R4 (Head of ESG Modeling):

"The model provides hundreds of variables and in strategic meetings there are two or three indicators of interest-largely resilience index and regeneration time. This is what spurs the conversation."

This trend is consistent with the idea of cue extraction developed by Otugboyega et al. (2024) as the actors reduce the complexity of equivocal information by choosing the salient features. Entire models were not interpreted by managers; they selectively paid attention to the metrics that could be converted into strategic implications. In the same way, R1 (Sustainability Director) remarked:

"The math is complex, though all that we need to know is whether the system is nearing a threshold or not. As soon as we notice the rising probability of a tip, it is a red flag."

Respondents referred to threshold warnings as early alarms (R6), and decider triggers (R11). Mathematical models of tipping points were frequently interpreted as a risk indicator as opposed to a probabilistic forecast. This conclusion resonates with the literature on resilience studies, in which ecological transitions indicate the possibility of a regime change (Rukundo & Ariho, 2022). But in organizational practice these thresholds were turned into managerial signals on precautionary actions. Notably, respondents admitted that they could not comprehend model operation completely. According to R7 (Environmental Data Manager):

"I do not think I know the nonlinear equations. What I depend on is that the model spells out system stability: either we are in a safe operating range or not."

This is an indication of sensemaking in which the plausibility is more important than technical accuracy. Managers desired consistent readings and not mathematical wholeness. Emphasis put on equations was changed to narrative meaning.

Across interviews, cue extraction involved three recurring practices:

1. Translating resilience metrics into risk levels.
2. Framing regeneration rates as sustainability capacity.
3. Interpreting carrying capacity as strategic boundary.

An example is R5 (Sustainability Planning Manager) who explained carrying capacity projections as *"hard limits that*

would be used in our production planning.” The ecological notion of carrying capacity which initially belonged to the area of population biology (Guedri et al., 2025) was redefined as a growth decision boundary condition. Therefore, the first dimension proves the fact that biomathematical models penetrated into the world of managerial cognition with the help of selective cue extraction that made it possible to reduce the complexity and become strategic.

4.2 Framing Ecological Risk Through Organizational Narratives

The second aggregate dimension measures the framing of the extracted ecological cues by the managers into overall organizational stories. According to sensemaking theory, the identity and context influence interpretation (Ahmad et al., 2025). In the present study, managers incorporated biomathematical outputs in sustainability discourse that was in line with organizational purpose and risk management. According to R9 (Sustainability Innovation Lead):

“When the ecosystem stability model displays diminishing resilience, we make internal frames of long-term value protection. It is not only a matter of the environment it is strategic continuity.”

This is the way in which ecological risk signals were repackaged in terms of business continuity issues. Instead of introducing resilience decline as an environmental measure, the managers incorporated it into new strategic language. In the same way, R3 (Green Strategy Manager) was able to elaborate:

“Our material cycle was found to be surpassing renewal rates by the regeneration model. We put it to the executives as a systemic imbalance not a compliance issue but a structural weakness.”

The concept of structural vulnerability is an expression of narrative framing. Deficits in regeneration were construed by managers as challenges to sustainability in operations, which operated according to the ecological logic and the organizational survival. Some of the respondents indicated a conflict between nonlinear ecological models and linear financial planning. R8 (Head of Green Operations) observed:

“Finance anticipates sluggish trends. But thresholds of resilience model collapse abruptly. That's hard to communicate.”

This brings out a formative conclusion: biomathematical reasoning tended to clash with incremental strategic presumptions. The ecological tipping dynamics were a challenge to the classic risk assessment. But instead of the rejection of model outputs, managers took part in reframing model outputs to make them acceptable in the organization. According to R2 (Environmental Systems Analyst) this process was given as follows:

“We reduce the nonlinear curves to scenario narratives- best case, stress case, collapse case. It is how strategy teams internalize it.”

Mathematical complexity was faded through scenario storytelling which converted the mathematical complexity into credible futures. The practice is consistent with previous studies that have revealed that managers use narratives to manage environmental uncertainty (Saha & Ghosh, 2021). Furthermore, it was important with identity. Ecological warnings were incorporated by sustainability-oriented respondents as moral requirements whereas system efficiency was emphasized by operational managers. One example is the R10 (Environmental Modeling Specialist) said:

“In my case, resilience concerns integrity of ecosystems. It concerns system robustness to its operations. Framing the same model differently.”

This observation substantiates the fact that role identity affects sensemaking. The outputs of biomathematics did not look like neutral signals; they were perceived in professional terms. On the whole, this aspect indicates that managers proactively conceptualized the ecological mathematical performance in the organizational discourses that related sustainability indicators to strategic legitimacy, risk reduction, and business survival.

4.3 Enacting Green Strategy Through Ecological Logic

The third aggregate dimension is the outcome of sensemaking in strategic enactment. Pujaru et al. (2024) agrees that sensemaking is interpretive but is enacted, therefore, actors create environments by acting upon them. Some of the areas through which biomathematical outputs affected strategic adjustments as reported by the participants were in three areas:

1. Resource allocation decisions
2. Long-term sustainability planning
3. Operational redesign for resilience

R6 (Climate Risk Analyst) used the following case whereby the tipping point simulations caused the renewable infrastructure investment to quicken:

“The model showed that the carbon absorption capacity would sharply decrease to some point. That made us accelerate the growth of renewables.”

Likewise, R12 (Resource Optimization Manager) had been described as follows:

“A modeling of population dynamics revealed that our ecological biomass sourcing was approaching ecological limits. We decreased the extraction rates in this way.”

These scenarios are the examples of direct implementation of ecological boundaries into strategic decisions. Decision logic implied the ecological concept of safe operating space (Mondal et al., 2020). Nevertheless, it was not automatically enacted. A number of participants mentioned the negotiation processes. According to R11 (Strategic Sustainability Advisor):

“In some instances, the executives ask why it is urgent. We must give reasons why a probabilistic threshold is worthy of immediate action.”

It means that persuasive framing was necessary to be enacted. The ecological probabilities were converted into precautions measures via internal discourse. Surprisingly, biomathematical models were reported to elevate long-term orientation by managers. R1 noted:

“These models make us think not in quarters, but decades. Short-term KPIs are not in line with regeneration timelines.”

This corresponds with sustainability studies that focus on intertemporal tensions (Tiwarly & Sharma, 2025). The use of Biomathematical models broadened time horizons, which promoted long-term alignment of green strategies. Furthermore, the participants reported higher systemic thinking. R9 explained:

“Network modeling assisted us in visualizing interdependencies of supply chains. It transformed the resilience of suppliers in our assessment.”

This awareness is a systemic one, which implies the incorporation of ecological network logic in the management cognition. The model changed the conceptualization of managerial views on the organizational-environment relationships. Although there were these positive effects, the participants admitted implementation issues. The hesitation was occasionally caused by nonlinear uncertainty. R8 stated:

“When the model warns of the potential collapse with a probability of 40 percent, the decision-makers are uncertain.”

Therefore, the implementation required the nature of the interpretation and framing of probability. Sensemaking determined how ecological risk would result in either direct action or cautionary surveillance.

Table 3: Summary of Data Analysis (Three-Step Coding Structure)

First-Order Concepts (Representative Quotes)	Second-Order Themes	Aggregate Dimension	Sensemaking Process (Theoretical Link)
“We Focus Mainly on Resilience Scores.” (R4)	Selective focus on key indicators	Extracting Ecological Cues from Mathematical Abstraction	Cue extraction from equivocal information
“Threshold Probability is Our Red Flag.” (R1)	Threshold-based interpretation		Noticing signals of disruption
“Regeneration Time Tells Us if We’re Overshooting.” (R5)	Translating regeneration metrics into risk signals		Enactment begins with salient cues
“We Don’t Interpret Every Variable.” (R7)	Simplifying complex ecological data		Plausibility over precision
“Carrying Capacity Sets Our Limits.” (R5)	Ecological boundary framing	Framing Ecological Risk Through Organizational Narratives	Framing environmental constraints
“Resilience Decline Means Long-Term Vulnerability.” (R9)	Reframing ecological decline as strategic risk		Meaning construction through framing
“We Turn Nonlinear Curves into Scenarios.” (R2)	Narrative construction of model outputs		Retrospective interpretation
“Executives Understand Risk Better Than Equations.” (R11)	Strategic translation for legitimacy		Social sensemaking
“Same Model, Different Framing.” (R10)	Identity-driven interpretation	Enacting Green Strategy Through Ecological Logic	Identity shaping interpretation
“Collapse Models are Hard to Communicate.” (R8)	Tension between nonlinear ecology and linear planning		Managing ambiguity
“We Reduced Extraction Rates After Seeing Limits.” (R12)	Strategic adjustment to ecological limits		Enactment of interpreted meaning
“The Tipping Model Accelerated Investment.” (R6)	Proactive response to threshold projections		Action based on interpreted cues
“It Forces Long-Term Thinking.” (R1)	Temporal reframing of strategy		Reconstructing time horizons
“We Align Growth with Regeneration Rates.” (R3)	Embedding ecological capacity into planning		Enacting new environmental reality
“Executives Hesitate When Probability isn’t Certain.” (R8)	Negotiation of probabilistic risk		Ongoing iterative sensemaking

4.4 Integrated Interpretation

Across the three aggregate dimensions cue extraction, framing, and enactment a coherent sensemaking process emerged. Managers:

1. Extracted salient ecological indicators from complex models.
2. Framed these indicators within organizational narratives.
3. Enacted green strategies aligned with interpreted ecological logic.

The strategy was not directly determined by biomathematical models, but the effect was mediated by interpretive processes that were consistent with the Sensemaking Theory (Príncipe et al., 2023).

The results are an expansion of previous studies since they indicate that mathematical ecological concepts like resilience and carrying capacity are only strategic when framed cognitively. Although it has been mentioned in earlier research that resilience modeling is technically important (Morales-Morales et al., 2025), this paper demonstrates that the organizational impact of resilience modeling is subject to managerial interpretation. Overall, the findings indicate that biomathematics and green management overlap not simply in the tools that are used in the modeling but also in strategic actions of managerial sensemaking that brings ecological abstraction to strategic action. This interpretative bridge defines the way in which nonlinear ecological logic is installed into green management strategy (Figure 1).

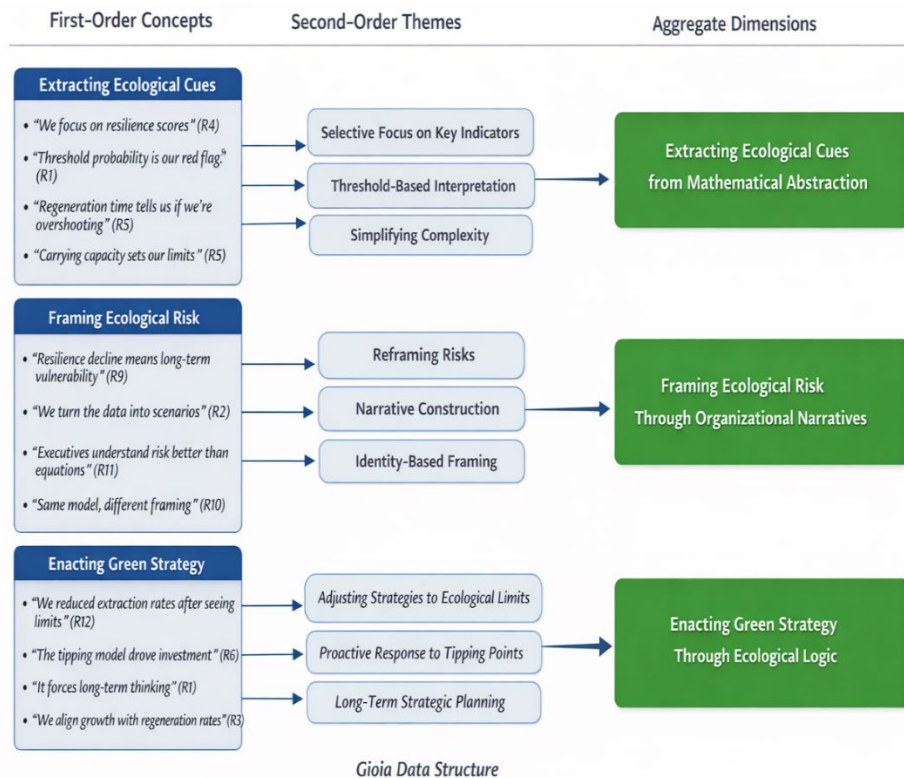


Figure 1: Gioia Data Structure

5. Discussion

This research aimed to explore the interpretation and application of biomathematical model outputs in green management strategy by managers via the prism of Sensemaking Theory (Xu et al., 2024). The results indicate that biomathematical models do not affect the green strategy in terms of technical determinism only. Instead, they mediate their strategic influence by means of organized interpretive activities that entail cue extraction, framing, and enactment. By so doing, the research would change the emphasis on the technical savvy of ecological models to the managerial cognition that makes those models strategically meaningful. This view can be integrated into the literature of sustainability and management since it demonstrates that the ecological mathematical reasoning can only be considered consequential when being socially and cognitively developed within organizational settings.

To begin with, the results put into perspective the resilience-based sustainability research by redefining resilience as a system attribute to a managerial interpretive phenomenon. Although the resilience theory focuses on system adaptability, nonlinearity, and threshold sensitivity, these are taken as objective ecological properties to a large extent in previous studies. The current evidence shows that managers are choosy in deriving particular resilience-associated indicators, including tipping probabilities, regeneration rates and carrying capacity limits, out of complicated models. Such selective attention concurs with the argument by Vishwakarma et al. (2025) that actors minimize equivocality through the extraction of salient cues off the excessive information environments. Biomathematical models usually produce dense results based

on nonlinear equations and probability models. Nonetheless, managers hardly ever deal with such complexity at all. They instead concentrate on few indicators that can be translated into strategic relevance. In this regard, resilience is not only an ecological term of description but a cognitively ecological indicator of organizational action.

The knowledge can be used in sustainability strategy research by signifying the micro-underlying mechanisms that link ecological modeling with strategic choices. Instead of believing that when people are exposed to scientific data, they should be thinking of taking sustainable action, the research indicates that the interpretation is selective and purposeful. Complexity is reduced by managers so as to make it actionable. In this way, managerial plausibility is obtained out of biomathematical abstraction. Second, the results enrich the knowledge on how the uncertainty that surrounds the environment is framed in the organizations. In line with [Mota et al. \(2022\)](#), identity and context had a strong impact on the interpretation. Sustainability-oriented managers defined resilience decline as a long-run weakness that has to be precautionarily managed whereas operations-oriented managers paid a lot of attention to system efficiency and risk containment. These differences of identity help to explain that biomathematical products are not impartial scientific facts; they are understood in terms of professionalism and organizational functions.

This process of framing is further related to the study of intertemporal tensions in sustainability ([Tyagi et al., 2024](#)). Biomath models often model long-term ecological capacity limits or nonlinear collapse limits that go beyond quarterly business cycles. It is thus the role of managers to accomplish narrative translations in place of reconciling ecological timeframes with the organizational planning horizons. As an example, the reduction in resilience was conceptualized as a long-term value protection or strategic continuity. Nonlinear ecological logic is made legitimate at the organizational level through such narratives. In the absence of such work of narration, probabilistic thresholds are in danger of being rejected as technical abstraction. Notably, the research proves that narrative framing is not merely rhetorical but strategic. In turning nonlinear curves into scenario narratives (e.g., stress case, collapse case), managers will facilitate discussion by a group and will lessen ambiguity. This is how the socially constructed process of sensemaking occurs, in which meaning is created in the process of interaction as well as calculation ([Ang & Safuan, 2021](#)). In this manner, the results build upon previous literature by demonstrating how sophisticated biomathematical instruments are tamed in the realm of managerial rhetoric.

Third, enactment dimension verifies that sensemaking is action bound. Managers have said they have adjusted their extraction rates, increased renewable investments, redesigned supply chain sourcing, and introduced regeneration constraints into the processes of planning. Such measures prove to bring ecological limits into green strategy. Nonetheless, it did not happen automatically but was determined by the way probabilistic information was framed. In cases where tipping points were perceived as imminent and a plausible threat, the organizations took the initiative to respond to them. Hesitation and negotiation happened in situations where probabilities were viewed as uncertain or far off. These results are supportive to the thesis that interpretive plausibility determines strategic change, and not necessarily the overwhelming scientific certainty ([Chen et al., 2023](#)). Biomathematical models offer probabilistic prospect, but the action of organizations is based on whether the probabilities are articulated as both credible and urgent. Accordingly, ecological mathematical logic transforms the cognition of managers by bringing in nonlinear risk structures that disrupt the assumption of incremental planning.

On the whole, the paper notes that the interplay of biomathematics and green management is essentially a subjective one. Managerial judgment is not displaced by biomathematical models, but rather reformulated by introducing ecological constraints, logic of resilience, and nonlinear boundaries into the processes of organizational sensemaking. It gives a process explanation of how the ecological mathematical abstraction becomes instilled in green strategic decision-making by uncovering the processes of cue extraction, framing, and enactment.

6. Implications

This paper contributes to the existing theory by directly connecting biomathematics and green management on the basis of Sensemaking Theory. Although the earlier studies have analyzed resilience and sustainability strategy, the question of how mathematical ecological constructs are strategically important in organizations has not been studied previously. The study presents a micro-foundation as it identifies cue extraction, framing, and enactment as a sequential process that generates an effect of ecological modeling on green management. The results also advance sustainability academic literature in pointing out the interpretive nature of the managers in converting nonlinear ecological phenomena into strategic action. This is complemented by the work on the intertemporal tensions along with revealing how the long-term ecological thresholds are narratively repackaged to suit the business decision-making process. More so, the research supports the value of identity and context on interpretation, indicating that the role of the organization plays the role of mediating the understanding of biomathematical outputs.

To practitioners, the results indicate that the usefulness of biomathematical tools cannot be differentiated solely based on technical complexity but interpretative clarity as well. Organizations are advised to make investments in translational

processes, including scenario narratives, visualization dashboards, or cross-functional discussions, to facilitate managerial sensemaking of ecological models. Second, companies must also understand that resilience metrics and carrying capacity projections are more apt to drive strategy when presented as strategic risk indicators as opposed to environment indicators. Integration of ecological thresholds into business continuity or long-term value narratives increases the validity of these narratives. Third, leadership teams ought to be conscious of identity-based variations in interpretation. An intervention between operational executives and the sustainability experts can help decrease the misalignment and enhance the overall understanding of the nonlinear ecological risk. Finally, organizational processes necessary in integrating biomathematical modeling in green management involve facilitating interpretation, dialogue and strategic alignment.

7. Limitations and Future Research

This research has a number of shortcomings. First, the size of the sample (12 interviews) restricts the scope of generalization, but it is suitable to the profound qualitative in-depth exploration. Second, the results are based on self-reported managerial interpretations and might not reflect the true decision processes. Third, the research emphasized the sustainability-focused organizations; interpretation processes might vary in less environmentally developed companies. Future studies might diversify the sample, both in terms of industries and geographical settings in order to establish the transferability of results. Quantitative research might be on whether cue extraction and framing mechanisms have any predictions on green strategic performance. Also, comparative studies would be possible on how different forms of biomathematical models (e.g., resilience versus network models) affect managerial interpretation in different ways.

8. Conclusion

This paper examined the meanings of the outputs of biomathematical models and their related use in green management strategy by managers using the Sensemaking Theory. The results reveal that biomathematical models affect strategy in a systematic interpretive procedure of cues extraction, framing, and acting. The managers selectively pay attention to the resilience scores, regeneration rates, and threshold indicators and place them into the organizational narratives that puts ecological risk on par with strategic priorities. In such a way, the ecological mathematical logic is incorporated into green strategic decisions. The emphasis on managerial sensemaking makes the study go beyond the technical appraisal of biomathematical models and emphasizes the way human cognition interprets ecological abstraction into action. The findings indicate that nonlinear ecological theories, including tipping points, carrying capacity, transform strategic thinking when interpreted as reasonable and valid cues. Finally, biomathematics and green management intersect not so much in terms of technical aspects as in terms of interpretation. Ecological models become relevant in strategy when managers make meaning out of them. This research thus represents a procedural insight into the role played by advanced biomathematical tools in sustainable strategy, which has provided a basis of future theoretical and empirical advancement in this new interdisciplinary frontier.

9. Funding

This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Grant Number KFU261263].

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