Sustainable Social Development 2026, 4(5), 8860.
https://doi.org/10.23812/ssd8860

Article

Integrated environmental communication transformation framework for biodiversity conservation and sustainability: Linking environmental monitoring, strategic communication, behavioral activation, and adaptive governance

Hassan Al-Saify

Mass Media & Communication Department, College of Arts, King Faisal University, Al-Ahsa 31982, Saudi Arabia; habualila@kfu.edu.sa

CITATION

Al-Saify H. Integrated environmental communication transformation framework for biodiversity conservation and sustainability: Linking environmental monitoring, strategic communication, behavioral activation, and adaptive governance. Sustainable Social Development. 2026; 4(5): 8860. https://doi.org/10.23812/ssd8860

ARTICLE INFO

Received: 25 June 2026
Revised: 21 July 2026
Accepted: 18 August 2026
Available online: 18 September 2026

Abstract: Biodiversity loss is one of the main environmental challenges that requires an integrated approach involving environmental monitoring, communication, behavior change and adaptive governance. However, despite recent growth in research in the area, there is a still a lack of comprehensive knowledge about how environmental information is translated into collective action and impacts on policy decisions. This study seeks to create an integrated environmental communication transformation framework to understand the dynamic processes that connect the transformation of environmental data to strategic communication, behavioral processes and adaptive biodiversity governance. This study employed qualitative descriptive design, performing systematic content analysis of academic journal articles, international reports, and policy documents. The findings indicate that biodiversity conservation is governed by a multi-level dynamic system including four interrelated key components: the production of environmental knowledge; strategic communication; the behavioral processes of changing behaviors; and adaptive environmental governance systems. Results reveal that a critical factor in the effectiveness of environmental transformation is the cyclical feedback mechanisms among the flow of data, message Framing, behavior, and policy. It is noted that media and internet based digital systems are sources of data as well as communication amplifiers of messages that lead to increased awareness and participation as well as influenced behavior. Based on findings, this study argues that the use of integrative multi-level communication strategies with an aim to strengthen the information generation, communication and behavioral processes along with adaptation of policy mechanisms, may contribute to improved biodiversity conservation outcomes and sustainability.

Keywords: environmental communication; strategic communication; biodiversity conservation; adaptive governance; sustainability

1. Introduction

The Loss of biological diversity has now become one of the major globally environmental problems and this requires conservation action at all levels from global, national to the local; and even though there is an increased attention of scholars on the ecological importance of biodiversity and human's survival and sustenance, the level of public awareness and concern about this issue vary enormously between countries and societies [1]. In response to escalating environmental problems and complexities, there is a pressing demand for efficient means for increasing public awareness and involvement in the issues of conservation and environmental sustainability, as communication stands out as a vital element in ensuring change, mobilizing society, promoting community-based conservation as well as facilitating sustainability of

natural resources [2]. Therefore, there is an increasing urgency of conservation efforts as not only as an issue for protecting biodiversity, which forms the foundation of a functioning ecosystem and human survival, but as also a profound moral and even an existential responsibility.

In this regards environmental communication is a fundamental function that allows to empower citizens and community groups through communicating information, collaboration and public involvement in decision-making processes by the using of the narratives, stories, digital media and online channels to influence people's views, facilitate pro-environmental behavior and contribute to addressing environmental issues such as climate change and environmental degradation [3]. More broadly, communication plays a critical role in promoting social change, with verbal, visual and sonic elements potentially helping to form meaningful narratives which may help individuals and groups perceive and understand the world in particular ways [4,5]. In this perspective, communication is increasingly becoming the heart of communication strategy of the various political actors, activists, non-profit-organizations and other organizations who attempt to mobilize people and bring about social, and structure transformation needed to achieve sustainability [6]. Communication's narrative is fundamental for frame environmental issue, advocating for practical solutions that promotes the spread of viable alternatives, influencing public attitudes and policies and providing visions shared by the different actors and to make sustainability change happen [7].

Additionally, research, conservation practice and environmental agencies contribute significantly in the domain of biodiversity conservation by producing, vetting and translating into usable format environmental data, scientific literature, research studies, public outreach activities and policy and decision-making outputs. Knowledge creation process enables the society in framing environmental issues, translating into policies and programs that can affect public behavior to conserve biodiversity [8]. Despite this growing body of evidence, the challenge is how to communicate biodiversity conservation to individualsand collective audiences so that it generates and sustains individual and collective action. One factor contributing to this challenge might be the lack of communication or media expertise among many of the people who work in conservation and advocacy [9].

As a result, this research evolves an integrated Environmental Communication Transformation Framework to advance both biodiversity conservation and sustainability. This framework connects, in a transformation sequence, the Environmental monitoring, the strategic communication, the activation of pro-environmental behavior, and the adaptive governance. The study formulated four research questions. Firstly, What is the transformation of environmental communication which can advance the conservation of biodiversity and sustainabilities? Secondly, How the environmental monitoring data, communication approaches and media channels might improve the public cognition, promote the pro-environmental behaviors, and contribute to the biodiversity conservation? Thirdly, what is the content and process of a comprehensive Environmental Communication Transformation Framework? Then, what are the environment concern factors and facilitators that affect the Environmental Communication Transformation Framework?

2. Materials and methods

A qualitative descriptive research design was adopted to develop an integrated conceptual framework describing the interactive effects of environmental monitoring, strategic communication, behavioral activation, and adaptive governance in relation to biodiversity conservation. This research design is considered suitable for conceptual study as it describes an event or a condition in a logical and coherent manner by identifying various dimensions and explaining their relationships and interconnectivities [10]. According to Neuman, qualitative descriptive design is unique in its ability to present detailed and objective accounts of social, organizational and contextual phenomena by specifying the how the different parts interact in different environment [10]. The present research attempts to describe how information derived from monitoring and assessment programs on the environment can be translated into messages in strategic communication and further into the behaviors of individual and groups contributing to biodiversity conservation and by governance which adapts based on the received feedback.

This research is further grounded on qualitative descriptive research design of Lambert and Lambert who argue that in-depth understanding of a phenomenon requires the researchers to analyze the phenomena as they are in their naturally occurring contexts and as a complex interplay of several factors [11]. This approach thus allowed for analyzing communication, behavior and institution-based approaches in the context of biodiversity conservation in a comprehensive, integrated manner without being constrained by experimental analysis or predefined quantitative models thereby facilitating the conceptualization of a new integrated theoretical framework. Qualitative content analysis was used for the study purpose and an extensive literature survey covering academic journals, research reports, books, policy documents on biodiversity conservation, sustainable development, communication and governance was conducted. The analysis of the relevant scholarly literature, international reports, policy documents were carried out with the purpose of identifying and synthesizing key concepts and relationships to develop the integrated conceptual framework. Moreover, A qualitative content analysis framework of Bowen was adapted for this research comprising of three major steps; namely; initial search, analysis in depth and the interpretative synthesis of findings [12].

Content analysis also allowed for ‘dissecting’ complex and lengthy texts into more or less manageable analytical units [13], where several major themes emerged that relate to the interaction between environmental monitoring, strategic communication, behavioral activation and adaptive governance [14]. Using conceptual synthesis with synthesis from diverse literatures, the integrated environmental communication transformation framework for biodiversity conservation was developed, offering a broad theoretical explanation of how data on the environment and related information is converted into strategic messages leading to effective human behavior in terms of both actions and social outcomes for enhanced biodiversity conservation, and adaptive governance and information to enhance environmental decision making for long term sustainable development [15].

3. Results and discussion

3.1. Environmental and strategic communication and their role in enhancing sustainability and biodiversity

There is growing interest in communication strategies in the field of environmental conservation. For example, Kusmanoff et al [4]. present key considerations in message framing, describing strategies to make messages more relevant to audiences, to activate beneficial social norms, and to leverage cognitive biases. As a complementary addition to these strategies, messages that evoke positive emotions in audiences are considered an important yet underappreciated resource in addressing communication challenges related to promoting action to tackle the biodiversity crisis [9].

Therefore, positive communication can enable a practical framing of conservation challenges. This approach combines a clear description of the issue at hand with pathways or actions that can be taken at the individual level, while using language and context appropriate to the audience and avoiding demotivating emotions. In this way, positive communication can lead to the development of fruitful collaborations, relationships, and conversations that may stimulate actions to help address the biodiversity crisis [9]. Consequently, this approach redefines the effectiveness of environmental communication as the ability to sustain long-term public engagement by achieving a delicate balance between acknowledging the reality of the environmental crisis and employing positive emotional motivation that drives action without exaggerating the threat or diluting its seriousness.

3.1.1. Strategic communication and its role in supporting sustainability, biodiversity, and economic growth

Strategic communication is viewed as a collaborative and participatory activity at all levels. It is not only bidirectional but also multidirectional and omnidirectional & diachronic, highlighting the continuous nature of meaning-making, negotiation, and production in both internal and external environments. Accordingly, strategic communication can be seen as a dynamic managerial process that creates environments for strategy formulation and implementation, with continuous evaluation of strategic options through ongoing processes of presentation and discussion [15]. Argenti et al., further explain that strategic communication has a profound influence on the business environment and drives the strategy formulation process .

Although the extent of communication practitioners' involvement in strategy building is not fully determined, their role is considered a fundamental component of this process [16]. Moreover, the term "integrated communications" is sometimes used to refer to "strategic communication," which may include multiple domains within universities such as public relations, political communication, technical communication, administrative communication, marketing communication, and information or social marketing campaigns [17]. Strategic communication can be defined as "purposeful communication practice oriented toward objectives, carried out by a communication actor in the public sphere on behalf of an organizational entity to achieve specific goals" [18].

Accordingly, organizational objectives come first, and strategic communication is used as a tool to achieve these objectives, particularly in external contexts, rather than to reshape or redefine them. Thus, strategic communication is subordinate to strategy and functions as a means to achieve defined goals by shaping public perceptions in alignment with them [15]. Moreover, the media act as an interpreter in the meaning-making process, explaining that media significantly influence the construction of social and cultural realities [19]. They also warn against viewing media as mere transmission channels and audiences as passive recipients. Therefore, strategic communication must take into account how stakeholders construct meaning while interacting with media professionals and how they reinterpret and reshape media information in this process [19]. In contrast, strategic communication is based on expressing and defending organizational objectives rather than formulating or reformulating them; however, it is considered a two-phase flow process in which audiences and media jointly negotiate meaning [15,20].

On the other hand, the importance of strategic communication lies in its role as an effective bridge between biodiversity-related initiatives and various funding sources. It helps increase the visibility of these initiatives to investors and builds trust, thereby attracting diverse forms of financing including venture capital and impact funding. At the same time, hybrid financing models play a key role in combining these diverse sources to bridge existing funding gaps, thereby enhancing the sustainability and long-term growth of environmental efforts [21].

Strategic communication highlights the importance of understanding the psychological, social, and structural barriers that limit public engagement in biodiversity conservation efforts, with these barriers varying according to different levels of awareness and participation among groups. These barriers include lack of knowledge, value conflicts, weak self-efficacy, weak issue attachment, and contextual constraints, all of which are documented in conservation, behavioral, and social change literature. In this context, multiple communication tools such as awareness raising, social norm shaping, value-based messaging, mobilization, and advocacy can be employed to overcome these barriers. This confirms that the effectiveness of biodiversity conservation efforts depends fundamentally on understanding audience behavior and social context in ways that support sustainable social change [22].

Strategic communication also emphasizes that biodiversity issues often go beyond purely scientific solutions, as they typically require addressing social, economic, and political dimensions. This makes communication, education, and engagement with multiple stakeholders' essential elements for understanding and effectively addressing these complex issues in ways that support the sustainability of solutions [23]. Therefore, strategic communication in the context of sustainability and biodiversity is no longer merely a supportive communication function; rather, it has become a governing structure that contributes to shaping strategies themselves through multilevel interactions between institutions, media, audiences, and financial markets. On one hand, it redefines communication as a process of meaning production and negotiation rather than simple information transmission.

On the other hand, it integrates behavioral, social, and economic dimensions into understanding how environmental action is activated .Its analytical strength lies in its

ability to connect "public perception management" with "mobilization of financial and behavioral resources," thereby transforming biodiversity issues from isolated scientific topics into development issues linked to trust, funding, social norms, and multistakeholder governance. However, this conceptual expansion also reveals a fundamental challenge: the success of strategic communication does not depend solely on message accuracy, but on a deep understanding of the psychological, social, and contextual barriers that shape stakeholder responses, making its effectiveness dependent on its ability to adapt to contextual complexity rather than impose a unified narrative upon it.

3.1.2. Environmental communication and its role in supporting biodiversity conservation and shaping sustainable environmental behavior

Environmental communication is a scientific discipline encompassing the "interconnections between communication, media, society and the environment" [24]. It can be defined as a scientific field, as well as a practice, concerned with the design, transmission and use of information through various channels to promote environmental awareness, influence environmental perceptions and behavior and achieve environmental goals [25]. This communication endeavor not only involves the transfer of information about the environment, but goes beyond this function to include raising environmental consciousness, supporting advocacy and prompt behavioral transformation toward sustainability and environmental protection. As an interdisciplinary approach, environmental communication draws from several related scientific disciplines, including communication sciences, environmental sciences, psychology and sociology, to establish a multidisciplinary framework that allows for addressing environmental challenges through a communicative dimension [25].

In an effort to increase the level of environmental consciousness through different means like media, advocacy and participation, environmental communication works as a communication channel that bridges the gap between scientific, policymaking and public knowledge. It is essential for increasing people's knowledge of the issues surrounding the environment, simplifying scientific information and making it easily digestible and understandable, transforming knowledge and perceptions into behavior that support sustainability and conservation policies and procedures, and helping dialogue among the stakeholders to address the environmental challenges they face [26].

Environmental communication can be differentiated by its adaptive ability and suitability to different social, regional and cultural circumstances, thereby ensuring the reception of environmentally relevant messages, as for example messages targeting a rural community can be different from messages targeting a city, or based on different cultural views on nature, thus changing the form of expression of these messages depending on their nature, their recipients and the existing context .As a result, the mission is to move beyond individual awareness toward sustained social behavior by fostering shared environmental responsibility among people in a manner that strengthens a sustainable and flexible society in response to modern challenges [27]. In addition, the development of environmental communication is also regarded as one of the important factors to form individual's attitude and behavior and improve societal sustainability, especially those related to biodiversity. It is reported that

positive emotion experiences (such as hope, satisfaction and collective efficiency from pro-environmental behaviors) could positively influence pro-environmental behaviors, enhance the individual's creativity, cooperation, and resilience, thus play an important role in coping with the challenges in front of environmental issue. However, utilizing the negative emotion to trigger immediate, even rapid, behavior response may lead to temporary effect rather than sustained behavioral changes in long term. Therefore, future efforts should strike a balance between the magnitude of the threats and space of positive and motivating information which will not only boost the engagement of public but also empower the community for the development of the sustained behavioral response and enhance the capacity of sustainability and flexibility in responding to complex environmental problems in 21st Century [9].

In addition to message framing and audience segmentation which were found to have considerable effect on individual's engagement and behavioral change, environmental communication should aim to enhance the audience's participation in biodiversity conservation. Because not only do people hold different awareness, motivations and interest regarding Biodiversity protection at an individual, social or civic level, but they react in different ways to behavior options [28]. Tailored communication approaches tailored for diverse segments with specific attitudes can help increase participation rates and mobilize individuals from passive listeners to proactive and active environmental advocates [28]. Consequently, environmental communication has emerged as a holistic paradigm that combines scientific, cultural, social, behavioral dimensions to facilitate people's understanding, inform public perception and behavior and facilitate a sustained action beyond the simple dissemination of information. Its dynamic framework takes into account varying degrees of individual's environmental awareness, their unique attitudes and motivations, and their willingness to respond and adjust its methods accordingly such as framing with a motivational lens or segments segmentation for optimal targeting and local context adaptability, which seeks for an integration between scientific authority and social encouragement in driving lasting and sustainable community-driven biodiversity actions [28].

Accordingly, it becomes clear that environmental communication has become a multidisciplinary framework which incorporates scientific and technical expertise into societal, behavior and cultural dimension. Communication has already moved on beyond a process for delivering scientific data into the one aimed for influencing the public knowledge and promoting sustainable behavior change. The dynamic of communication in this discipline is such that the audiences must be segmented, with different levels of awareness, motivations; the communication instruments are flexible to use. The motivational messaging, the framing and tailoring strategies with the local condition are example of instruments which can be used in that communication framework. In such context, success is defined by communication which will convert knowledge into the change toward sustainable collective behavior and the appropriate combination between the force of scientific influence, persuasion and the incentive for community mobilization.

3.2. Employing media tools and environmental monitoring in enhancing public awareness and biodiversity protection

It has been identified that the utilization of media programs could enhance monitoring activities that support biodiversity conservation, such as transforming available media resources like documented visual information into scientifically exploitable material as valuable complementary evidence, supporting biodiversity estimation and estimation of distribution patterns, given that significant similarities between data obtained from media programs and actual field data have been identified. It has also been confirmed that the impact of media on biodiversity public awareness and environmental communication is significant; hence, it increases public interest and contribution toward preserving biodiversity [29]. Therefore, it is highly important that the monitoring data from technological devices, such as from a camera trap, can provide scientific evidence that enhances biodiversity knowledge, raise public awareness, and strengthen the sense of environmental responsibility of all, that can also be applied into the design of environmental communication materials used in media and digital campaigns in a way that helps to preserve the Biodiversity and the Sustainability of Ecosystems [30].

For successful biodiversity conservation, public awareness and environmental communications play an extremely significant role .In order to effectively support the conservation of biodiversity, science information is being translated into effective communication message that raise the public awareness about the issue of biodiversity Threats and increase pro-biodiversity behaviors, which contribute the effective design of environmentally educative materials and relevant conservation programs appropriate to a given socio-cultural context that can raise a local and global level of environmental culture [1]. It is concluded that there are a wide variety of methods, including participative communications, social media, stories, immersive technologies etc. Contribute to shaping an environmentally aware and behavior responsive society; nonetheless, an environment with a supporting institutional framework, adequate resources and cultural and social fit of communication programs contributes more to lasting behavioral change, environmental education and public support, rather than the message or content only [2]. Moreover, environmental governance is influenced through the communication system and different communications approaches especially bidirectional and participatory modes would influence the knowledge, value and attitudes, and also the environmental behaviors, and these governance outcomes could further be affected by different external factors like media system, timing, social condition and the challenge of online dis-information [31].

Additionally, modern environmental communication no longer constitutes just the mere transmit of scientific knowledge but has already evolved into an integrated system which transforms environmental data, field monitoring and media contents into instrument to produce public meaning and environmental behavior. The combination of mass media, digital media and environmental data has re-set the relationships between science and publics from mere beneficiaries to partner to co-production of knowledge, which has a better opportunity to transform environmental awareness into concrete practice. Nevertheless, how this system exerts its influence not only depends on the existence of technological tools, but also on the capacity of this system to

respond to social and cultural settings and trusts, and the characteristic of communicative interaction vary between the stage of giving information to participation. In this regard, what truly empowers environmental communication lies in the dynamic transformation from environmental knowledge to environmental behavior, which creates the capacity to shape shared public experience and thereby develop sustained practices on biodiversity conservation.

3.3. The integrated transformation framework of environmental communication for biodiversity conservation

Protecting biodiversity has become dependent on a profound transformation that goes beyond traditional environmental interventions to include reshaping the economic, political, and social systems that influence the relationship between humans and nature. This transformation is based on integrating change at both the individual and structural levels; on the one hand, it requires revisiting individual values, attitudes, and choices, and on the other hand, it calls for developing institutions, standards, and policies capable of supporting and embedding sustainable practices [32,33]. Moreover, effective transformation is not achieved through isolated actions, but through multilevel processes that contribute to the reproduction of social meanings and the formulation of new norms that guide collective behavior. In this context, the importance of individual actions is not limited to their direct environmental impact, but extends to their capacity to influence social systems and public policies and bring about long-term institutional changes. The relationship between individual behavior and social structure is characterized as interactive and reciprocal; institutions and social norms influence individual behavior, while individual and collective behavior in turn contributes to reshaping and developing those institutions and norms [34].

Within the framework of addressing biodiversity loss, community participation emerges as a fundamental pillar for achieving sustainable outcomes, as reducing pressures on ecosystems requires the adoption of more sustainable consumption patterns, supporting field conservation initiatives, and participating in supporting relevant governmental policies and measures. Despite the diversity of efforts aimed at promoting biodiversity-supportive attitudes and behaviors through educational programs, communication campaigns, and awareness initiatives, translating environmental awareness into actual participation and sustainable behavior remains a fundamental challenge for environmental conservation efforts [22].

The success of these efforts is linked to the extent to which environmental communication strategies are able to enhance the psychological and emotional relationship between humans and nature. The more individuals feel connected to the natural environment, strengthen their environmental identity, and increase their ability to envision a more sustainable future, the more likely they are to adopt behaviors that support biodiversity and to support environmental policies and initiatives related to natural resource conservation. Accordingly, strengthening human–nature connection represents a strategic entry point for developing environmental communication programs that are more capable of influencing individual and collective attitudes and behaviors, especially in urban and peri-urban environments [35].

In light of rapid digital transformation, environmental communication has

acquired new dimensions through the employment of digital technologies and interactive platforms that have provided broader opportunities for disseminating environmental knowledge and enhancing public engagement with conservation and sustainability issues [36]. These tools have contributed to raising environmental awareness and learning levels and improving access to information; however, ensuring the long-term sustainability of this impact still requires the development of more integrated communication models that link knowledge, interaction, and actual practice. From this perspective, the importance of building digital communication systems capable of aligning user experience with environmental conservation goals emerges, thereby strengthening the role of scientific communication as a strategic tool for supporting sustainability and stimulating continuous environmental action [36].

At the institutional level, the effectiveness of biodiversity conservation efforts requires adopting environmental communication and education strategies characterized by flexibility and the ability to adapt to the characteristics and changing needs of local communities. The chances of success of environmental policies also increase when they are based on a participatory approach that integrates various stakeholders into planning, implementation, and evaluation processes, thereby enhancing social acceptance and improving the efficiency and effectiveness of environmental interventions in the long term [37].

In this context, environmental communication goes beyond its traditional role as a tool for information transmission to become a central mechanism in building environmental governance and enhancing participation in decision-making [31]. Additionally, communication models based on dialogue, deliberation, and democratic participation enable more effective citizen engagement in environmental issues, contribute to building trust between institutions and local communities, and enhance transparency and the ability to adapt to changing environmental challenges. This approach also supports the development of more inclusive, responsive, and effective governance systems in achieving sustainability goals and biodiversity conservation [31].

Collectively, these findings confirm that achieving an effective transformation in biodiversity conservation requires moving beyond traditional approaches that treat environmental knowledge, communication, behavior, or governance as independent components, and shifting toward an integrative vision that accommodates the dynamic relationships and mutual influences among these dimensions. Through this integration, environmental data can be transformed into usable knowledge, knowledge into influential strategic messages, and then into community practices and behaviors that support sustainability, thereby enhancing the ability of societies and institutions to respond to environmental challenges and achieve long-term biodiversity conservation goals.

Within this context, the integrated transformation framework for environmental communication for biodiversity conservation provides a conceptual contribution that explains how environmental knowledge moves from the stage of its production to the stage of its actual influence on behavior and environmental decision-making, emphasizing that environmental communication is not merely information transmission but a strategic mechanism that links knowledge, action, awareness, practice, and sustainable governance. The framework is based on a fundamental

assumption that biodiversity protection is achieved through dynamic interaction between environmental monitoring, strategic communication, behavioral change, and adaptive governance, within an integrated cycle that begins with data collection and analysis, then transforming it into effective messages that support social and behavioral responses, leading to governance policies and procedures characterized by flexibility and adaptation to environmental changes. The framework, as shown in **Figure 1**, indicated that these stages are not linear but circular and based on feedback and continuous learning, where the outcomes of behaviors and environmental changes feed back into monitoring and planning systems, enabling continuous updating of messages, interventions, and policies, and transforming environmental communication into a strategic system for managing environmental knowledge, enhancing collective action, and supporting the sustainability of ecological and social systems.

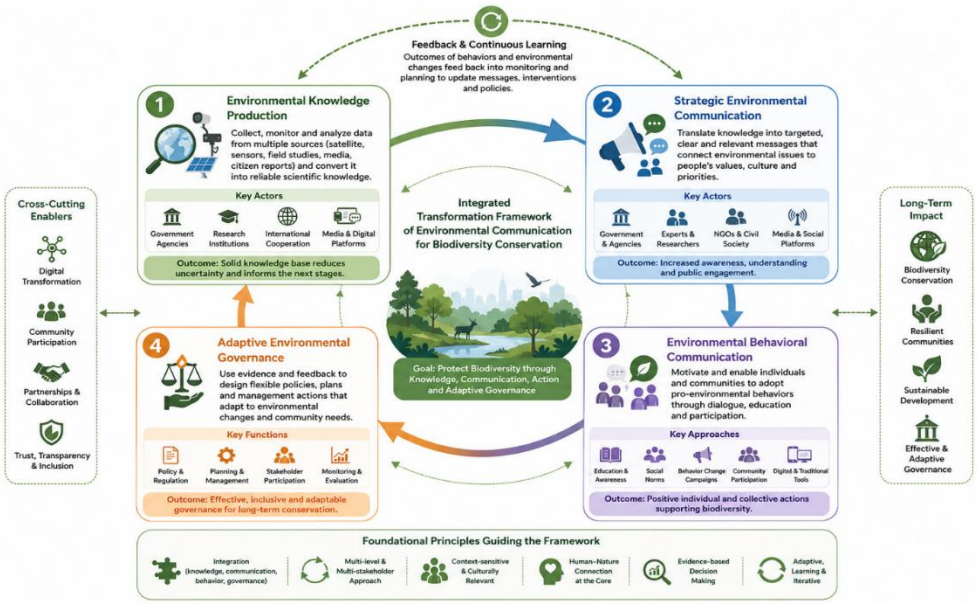

Figure 1. Integrated transformation framework of environmental communication for biodiversity conservation.

Based on this perspective, the integrated transformation framework of environmental communication consists of four interrelated axes that represent the main stages of the transformation process, namely:

- **Environmental knowledge production**

Knowledge Production of the Environment is the first and ground-layer of the integrated frame. It forms the base upon which the communication, Behavioral Change and Adaptation Governance levels are developed. This stage involves collecting of multiple, complementary data from different sources which included both terrestrial and remote based Earth Observation System and technologies, remote sensor, ground sensors devices such as smart cameras, remote controls, field sensor cameras, along with scientific field study and monitoring information, also, information coming from mass and digital media as complementary information to support environmental related public concern information gathering. Through this level, raw and unstructured information is converted into information, which later converts into analytical

knowledge in an organized and logical format.

The organized knowledge is both scientifically informative, logically analyzed and practical enough to form a more integrated and accurate visual picture for eco-systems. It does not mean solely by technical viewpoint. Moreover, it includes the environment itself to redefine in the form of an informative and dynamic complex system which could be interpreted and predict its change and be used for making environmental policy, strategy and plans and for making related environment management process. Duties for this phase cover various levels including; the role of the national level such as governmental institutions for environmental issues such as ministry for environment and agencies such as for the Earth Observation, Role of research & development sector, such as universities & centers which focus on the process of analyzing data into scientific knowledge, and the role of the international and development cooperation level as for providing standard methods, technology exchange and supporting the coordination of the information among monitoring networks and other knowledge providers; Digital & mass media providing support data as to present the interactions between the community and environment issue. Strategic implication "In this phase the uncertainty will be lowered, and the solid knowledge base be formulated" by that providing data for the later levels for setting up exact communicative strategy, design evidence-based policies, and develop effective environmental interventions, which will help system for its adaptation and biodiversity protection response.

- **Strategic environmental communication**

Strategic Environmental Communication acts as the connecting node and core driving link within the Integrated Framework because it is concerned with transmitting environmentally produced knowledge in the production stage into a framework of targeted, specific and impactful narratives. The stage relies on integrated communication and cognitive processes that cover aspects such as framing the communication, the ranking of environmental topics based on priorities and the impact they cause, crafting a focused and coherent strategic discourse on environmental topics, and managing the actors involved so that communications between different groups are aligned. Strategic communication is also about not simply rewording an environmental theme, but reshaping the environmental discourse around a particular subject, and translating the complex outputs of the production stage into effective communication materials, to be used within a decision making process, considering both local and external social, cultural, political, and economic settings to achieve effective communication. Moreover, tasks are divided amongst several environmental governance entities: Governmental and official agencies for environmental concerns ensure the alignment with current policy guidelines and have the supervision function on the setting of the general environmental topics.

The research institutions or the experts' bodies serve to translate science into clear and reliable communication materials. NGOs working in the environmental area act as intermediary between the messages and the public, connecting their work to communities. The media, conventional and on-line, and social media serve to deliver public communications. This stage links environmental issues to cultural and social concerns of a given public. It thus frames environmental issues in order to make them personally relevant to an audience, this will help increase audience involvement on

issues which will subsequently enhance public acceptance and support for environmental and sustainability initiatives, thus indirectly increase the adoption of a behavioral pattern of biodiversity preservation for long-term environmental sustainability.

- **Environmental behavioral communication**

Environmental behavioral communication represents This environmental behavioral communication is the necessary transformation step within the integrated structure, as it is the transformation from strategic environmental messages into real direct impact on individual behaviors and collective actions. The approach of this stage is based on activating a wide array of communication tools and mechanisms which cover traditional and digital environmental media, environmental storytelling, environmental communication and awareness campaigns, digital and interactive media platforms and mechanisms of community engagement for direct communication between individuals and environmental issues. The core function of this component is the promotion of environmental conscience deep consciousness, positive attitudes and attitudes sustained behavior toward environmental protection behaviors for biodiversity. This role is beyond simple transmission of knowledge and information and awareness, it's the transformation of strategic, knowledge and information into practices that ensure the transit between cognitive levels to effective practical behavior levels.

These effective behavioral transformations are perceived by the extent of impact on individual and group behaviors by a set of psychometric drivers such as collective responsibility, the psychological sense of responsibility and capability among groups toward nature, emotional engagement to nature, intellectual relationship to nature, and sense of belongingness towards the environment. Activating such psychological drivers leads to the consolidation of change and sustainability for behavior instead of short-term change. The responsibilities within this component spread across several actors including educational bodies, such as schools or universities, responsible for integrating behavioral and environmental values at early ages, environmental organizations and NGOs to implement direct practices and awareness campaigns to achieve behavioral outcomes, and environmental and digital media and platforms to enhance the reach of behavioral outcomes and disseminates effective models and incentives to adopt positive behavior and also, individuals and local community taking responsibility to translate communication messages into practices contributing to biodiversity. Therefore, this component represents a practical link between communicating awareness about the environment and applying behaviors.

- **Adaptive environmental governance**

Environmental Governance of the highest structural and organizational level in the framework of integration, within this level, the outputs (communicative, behavioral, and knowledge) are translated into public policies and governmental or institutional regulations and institutions that can foster sustainability and the protection of biodiversity. At this stage, the influence on society will transition to structured institutional influence to consolidate change. The policies and tools under this section can include environmental law and regulations, policies on financial aid for environmental projects, systems of economic incentives, government collaboration with the private sector, and civil society, as well as national and international

agreements related to environmental protection and management and evaluation of environmental monitoring that will enable the evaluation of impacts of interventions, the measurement of positive and negative points, and the adjustment and improvement.

In this framework, governance is adaptive, meaning it is not static but dynamic and able to adapt and change according to new data, new behaviors in society and also results stemming from environmental outcomes developed at previous levels. Therefore, governance can be regarded as a mechanism of constant institutional learning that recalibrates policy based on what we learn about how the environment is performing. Moreover, With in the framework, responsibilities associated with this component can be allocated at various levels: governments and legislature will assume policy and the role in making laws, environmental organizations and other international and national agencies will take care of compliance and oversight and other public administrations; think tanks and research centers are called on to produce scientific data to inform decisions; the private sector is to contribute in various ways including the sustainable practices, and; civil society will have an observational role and participation.

Overall, this component reflects the comprehensive vision of the integrated framework, which views biodiversity conservation as an interconnected process that begins with environmental knowledge production, passes through strategic communication and behavioral influence, and culminates in institutional translation via adaptive governance. In this way, a continuous transformation system is formed based on feedback loops between different levels, ensuring the transformation of environmental data into sustainable policies, and community behaviors into effective institutional practices, thereby enhancing the system's overall capacity to achieve long-term sustainability.

3.4. Mechanisms for implementing the integrated transformation framework of environmental communication for biodiversity conservation

The process of implementing the integrated environmental communication transformation framework is carried out through a set of sequential and interconnected procedural mechanisms that ensure the transfer of environmental knowledge across its different levels, ultimately leading to sustainable governance and effective environmental behavior. These mechanisms can be summarized as follows:

- **Environmental data integration mechanism**

This is through combining information sourced from various outlets; environmental monitoring systems, observation equipment in the field, research reports, mass media, and on-line social platforms, where the diverse set of information is harmonized into comprehensive databases amenable to further processing and analysis. This method's benefit is minimizing the environmental information divide, in creating shared data and knowledge to facilitate communication, policy decisions, enhance interpretation of environmental facts and bridging scientific data with community generated knowledge.

- **Strategic framing mechanism**

This mechanism entails framing the environmental information into strategically

framed messages and stories and placing a premium on communication processes and tailoring the environmental discourse towards the predispositions of the target audience, which comprises of stakeholder engagement, identifying the crucial issues, and developing a value-centered and culturally situated narrative. This mechanism is the crucial link connecting scientific knowledge and human behavior, as the process reformats the available knowledge into more easily digestible, comprehensible and compelling formats.

- **Behavioral activation mechanism**

This mechanism focuses on converting communicative messages into tangible environmental practices and behaviors through the use of environmental communication tools such as awareness campaigns, storytelling, digital media, interactive platforms, and community participation. It relies on enhancing psychological and social drivers such as environmental responsibility, environmental identity, and collective efficacy. It also contributes to embedding sustainable behaviors through social learning and continuous interaction with environmental messages.

- **Adaptive governance & feedback mechanism**

This mechanism involves transforming environmental behavioral outcomes and societal responses into direct inputs for developing environmental policies and updating communication strategies. This process includes environmental legislation, funding mechanisms, institutional partnerships, and monitoring and evaluation systems. This mechanism is characterized as non-linear but circular, as it feeds outcomes back into the system to update data, knowledge, and messages. Thus, the framework becomes a continuously evolving dynamic system based on institutional learning and adaptation to environmental changes.

- **Multi-level integration mechanism**

This mechanism provides a framework to weave the four previously addressed levels together into a coherent whole, so that the levels are interdependent instead of acting in isolation. In this sense, the mechanism connects cognitive environmental data collection and knowledge generation into messages designed to facilitate communications that ultimately shape social attitudes and behavior. That in turn influences policy and governance at the institutional level. The continuing interaction and feedback between these dimensions of governance, social attitudes, communication messages and environmental data generation ultimately contributes to better overall environmental conservation and biodiversity management effectiveness, adaptability, and sustainability.

The powerful feature of the integrative mechanism is that it frames environmental communications not as a fragmented effort, but rather as a management system to oversee the transformation of the environment and facilitate sustainability. The framework's implementation mechanisms demonstrate that transforming the environment depends on an integration and interplay between the collection of environmental data, the strategic directedness of that data, its integration into social behavior, and the integration into governance systems, thereby creating a positive feedback loop for better environmental results and sustainability in the long term.

3.5. Constraints on the implementation of the integrated transformation framework for environmental communication for biodiversity conservation

While the integrated environmental communication transformation framework can be described as an ambitious and state-of-the-art framework that combines environmental monitoring, communication strategy and adaptive governance in one holistic system, the implementation of such framework suffers from a range of structural, epistemic and contextual barriers that can affect the effectiveness and sustainability of the outcome. First of all, in terms of structural barriers, problems concerning environmental data, quality and accessibility can arise; the fragmentation of data sources, diversity in standards and heterogeneity between environmental monitoring systems can decrease analytical validity and ability to constitute an accurate and integrated environmental knowledge basis. Institutional and governance-based constraints are also related to a high number of stakeholders, overlapping responsibilities and coordination challenges among different administrative levels as well as conflicting goals at local, regional and international level. Such constraints can hinder the translation of communication activities into concrete and continuously evaluated environmental policies.

On the other hand, communicative and cultural barriers have a significant impact on the functionality of the framework. Indeed, differences in cultural values, level of environmental awareness, engagement with media, can induce significant variation in behavioral reaction towards the messages disseminated, whereas communication and cognitive gaps can exist among scientists and the public, affecting the ability of effectively transmitting the knowledge into simplified forms. Behavioral and psychological obstacles also pose further challenges because the presence of information does not guarantee sustained behavioral changes due to factors such as deeply ingrained habits, cognitive biases, low personal and collective efficacy and limited feelings of responsibilities. Moreover, there are technical and digital barriers to consider since monitoring tools, which can be technically complex, can be conditioned by factors such as country and/or community based digital divides, underdeveloped digital infrastructure or limitations to accessing digital technology which impacts communication effectiveness. Finally, dynamism and adaptive character, that is a strength, also poses methodological challenges because they are based on continuous feedback and learning processes which do not guarantee immediate and obvious results in the short term.

On the other hand, while the integrated environmental communication transformation framework offers a compelling conceptual model of the relationships among environmental monitoring, strategic communication, behavioral activation, and adaptive governance, it is ultimately a constructed theoretical framework that will need to be empirically tested with expert-based methods, such as Delphi processes and focus groups, case studies, and indicator development for operational testing in biolological diversity conservation environments. Conducting longitudinal and comparative studies to test the framework throughout alterations in variables and circumstances could help establish the framework's empirical validity and enable it to be made into decision-support tools to aid natural resource managers in evidence-based decisionmaking.

4. Conclusion

Recently researchers have found that successful sustainability transition relies on integrating more efficient regulation, evidence-based natural resource management and biodiversity preservation to sustain the ecosystem services and enhance long-term environmental resilience [38–40]. Moreover, it is evident, therefore, that biodiversity conservation is not an isolated environmental challenge, but has become a multifaceted process where scientific knowledge connects with strategic communication, behavior, and adaptive governance arrangements. As shown, the integrated framework provided reveals that conservation efforts achieve their true potential, not from separate interventions or linear processes, but from the interlinked, systemic dynamics that starts from generating accurate, multiple-source environmental knowledge and move towards the transformation of that knowledge into strategic communicative messages that produce meaning and provide influence, up to activating both individual and societal environmental behaviors and finally the embedding of the latter in policy and governing structures. Also indicated, that this trajectory is not one-directional, but driven by multiple feedback mechanisms that allow updating knowledge, messages and policy in an adaptive manner as a response to social and environmental changes, which in return improve capacity response to environmental challenges in time.

In this respect, the integrated framework of environmental communication transformation, offers a complete view on science, society and policy, reformulates communication as an environmental change management instrument and not simply as information provision tool, and concludes that for sustainability of biodiversity it is crucial that communication systems are flexibly organized, inclusive and the system integrates media, monitoring, governance and behavior. Thus, conservation ultimately depends on the extent to which this systemic will be able to foster the knowledge-action interaction, and generate a lasting, society-wide and institutionally supported commitment to the long term safeguarding of our ecological systems.

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 No. KFU263468).

Ethical approval: Not applicable

Informed consent statement: Not applicable.

Acknowledgments: The author would like to express his deep appreciation to the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia (Grant No. KFU263468) for the financial support provided to conduct and publish the disclosed research.

Conflict of interest: The author declares no conflict of interest.

References

1. Altamira MB, Koestoer RH. Public awareness on wildlife conservation: A systematic literature review. Environment Education and Conservation. 2024; 1(2): 1–11. doi: 10.61511/educo.v1i2.2024.1652
2. Zainuddin S, Muliawan D, Trihandayani I, Mambang. Participatory communication and digital strategies in environmental

advocacy: A narrative review of frameworks and impacts. Sinergi International Journal of Communication Sciences. 2024; 2(4): 245–259. doi: 10.61194/ijcs.v2i4.679
3. Ong'ong'a DO. Caring for water, plastics, and trees: Community radio and digital media in Kenya's environmental movements. environmental communication. 2024; 18(1–2): 210–215. doi: 10.1080/17524032.2023.2296845
4. Kusmanoff AM, Fidler F, Gordon A, et al. Five lessons to guide more effective biodiversity conservation message framing. Conservation Biology. 2020; 34(5): 1131–1141. doi: 10.1111/cobi.13482
5. Gregg EA, Kusmanoff AM, Garrard GE, et al. Biodiversity conservation cannot afford COVID-19 communication bungles. Trends in Ecology & Evolution. 2021; 36(10): 879–882. doi: 10.1016/j.tree.2021.07.003
6. Kannengießer S. From millennium development goals to sustainable development goals: Transforming development communication to sustainability communication. Studies in Communication Sciences. 2023; 23(1): 121–135. doi: 10.24434/j.scoms.2023.01.3516
7. Neef NE, Fußwinkel S, Roos C, et al. Optimistic narrative future visions: A communication tool for promoting sustainable (plastic) behavior. Frontiers in Psychology. 2023; 14; 1252895. doi: 10.3389/fpsyg.2023.1252895
8. Huber JM, Newig J, Loos J. Participation in protected area governance: A systematic case survey of the evidence on ecological and social outcomes. Journal of Environmental Management. 2023; 336: 117593. doi: 10.1016/j.jenvman.2023.117593
9. de Lange E, Sharkey W, Castelló y Tickell S, et al. Communicating the Biodiversity Crisis: From "Warnings" to Positive Engagement. Tropical Conservation Science. 2022; 15(1): 1–14. doi: 10.1177/19400829221134893
10. Neuman WL. Social research methods: Qualitative and quantitative approaches. Pearson Education Limited. 2014.
11. Lambert VA, Lambert CE. Qualitative descriptive research: An acceptable design. Pacific Rim International Journal of Nursing Research. 2012; 16(4): 255–256.
12. Bowen GA. Document analysis as a qualitative research method. Qualitative Research Journal. 2009; 9(2): 27–40. doi: 10.3316/QRJ0902027
13. Weber RP. Basic content analysis. Sage Publications; 1990.
14. Patton MQ. Qualitative research & evaluation methods. Sage Publications; 2002. doi: 10.1177/1035719X0300300213
15. van Ruler, B. Communication theory: An underrated pillar on which strategic communication rests. International Journal of Strategic Communication. 2018; 12 (4); 367–381. doi: 10.1080/1553118X.2018.1452240
16. Andersson R. Public relations strategizing: A theoretical framework for understanding the doing of strategy in public relations. Journal of Public Relations Research. 2024; 36(2); 91–112. doi: 10.1080/1062726X.2023.2259523
17. Hallahan K, Holtzhausen D, van Ruler B, et al. Defining strategic communication. International Journal of Strategic Communication. 2007; 1(1): 3–35. doi: 10.1080/15531180701285244
18. Holtzhausen DR, Zerfass A. Strategic communication – Pillars and perspectives on an alternate paradigm. Current trends and emerging topics in public relations and communication management. New York, NY: Routledge; 2013. pp. 283–302. doi: 10.4324/9780203079256-17
19. Holtzhausen DR, Zerfass A. The Routledge handbook of strategic communication. New York, NY: Routledge.2015. doi: 10.4324/9780203094440
20. Heide M, von Platen S, Simonsson C, et al. Expanding the Scope of Strategic Communication: Towards a Holistic Understanding of Organizational Complexity. International Journal of Strategic Communication. 2018; 12(4): 452–468. doi: 10.1080/1553118X.2018.1456434
21. Cao SS, Karolyi GA, Xiong WW, Xu H. Biodiversity entrepreneurship. Review of Finance. 2026; 30(1): 43–86. doi: 10.1093/rof/rfaf062
22. Gregg EA, Garrard GE, Sarah A. Bekessy SA, et al. Barriers to public engagement with biodiversity conservation. Conservation Biology. 2025; 39: e70078. doi: 10.1111/cobi.70078
23. Seymour CL, Gillson L, Child MF, et al. Horizon scanning for South African biodiversity: A need for social engagement as well as science. Ambio. 2020; 49: 1211–1221. doi:10.1007/s13280-019-01252-4
24. Takahashi B, Metag J, Thaker J, Comfort SE. Expanding conceptualizations of environmental communication research. The Handbook of International Trends. Routledge; 2022. pp. 3–13.
25. Joosse S, Powell S, Bergeå H, et al. Critical, engaged and change-oriented scholarship in environmental communication. Six methodological dilemmas to think with. Environmental Communication. 2020; 14(6): 758–771. doi: 10.1080/17524032.2020.1725588

26. Kalnbalkite A, Poca P, Laktuka K, et al. The role of environmental communication in advancing sustainability in Fisheries and Aquaculture: A case study of Latvia. Sustainability. 2023; 15(23): 16418. doi: 10.3390/su152316418
27. Ismail IR. Enhancing environmental communication through education: Strategies for promoting sustainability. Proceedings of the 3rd International Conference on Educational Technology and Social Science (ICoETS 2024). Atlantis Press; 2024. pp. 44–61. doi: 10.2991/978-2-38476-331-3_5
28. Champine VM, Tamlyn K, Jones MS, et al. An audience segmentation study of native plant gardening behaviors in the United States. Landscape and Urban Planning. 2024; 256: 1–9. doi: 10.1016/j.landurbplan.2024.105272
29. Yang X, Yang C, Zhang F, et al. Beyond social media: Curated monitoring footage as a biodiversity information source for conservation. Animals. 2026; 16: 1427. doi: 10.3390/ani16101427
30. Bernal Suárez JD, Ortiz-Jaramillo D, Román L. Camera trapping for biodiversity conservation and environmental communication in the ecuadorian amazon. Prisma Social Revista de Ciencias Sociales. 2026; 52: 542–559. doi: 10.65598/rps.5986
31. Erbaugh JT, Chang CH, Masuda YJ, et al. Communication and deliberation for environmental governance. Annual Review of Environment and Resources. 2024; 49: 367–93. doi: 10.1146/annurev-environ-112321-082450
32. Chan KMA, Boyd DR, Gould RK, et al. Levers and leverage points for pathways to sustainability. Nature Sustainability. 2020; 7: 267–279. doi: 10.1002/pan3.10124
33. Westerink J, Nel J, van Dam R, et al. Transformative pathways for social networks to navigate towards a nature-positive society: collaborate, challenge, and disrupt. Current Opinion in Environmental Sustainability. 2026; 79: 101617. doi: 10.1016/j.cosust.2026.101617
34. Naito R, Zhao J, Chan KMA. An integrative framework for transformative social change: A case in global wildlife trade. Sustainability Science. 2022; 17(1): 171–189. doi: 10.1007/s11625-021-01081-z
35. Bosone L, Grandin A, Chevrier M, et al. Fostering urban nature: How identity dynamics and future envisioning drive biodiversity conservation in cities. Biological Conservation. 2025; 311: 1–13. doi: 10.1016/j.biocon.2025.111451
36. Nagy NK. Digital Transformation and sustainable visitor engagement in Zoological Parks: A systematic review and conceptual framework. Sustainability. 2026; 18: 1–20. doi: 10.3390/su18094336
37. Acuña E, Cancino J, Acuña C. Bridging community perceptions and forest management: A BWS assessment of ecosystem service priorities in high-mountain Chile. Small-scale Forestry. 2026; 25: 377–403. doi: 10.1007/s11842-026-09626-9
38. Li MX, Zou SR, Jing PR. Spatial spillover effect of water environment pollution control in basins—based on environmental regulations. Water. 2023; 15: 3745. doi: 10.3390/w15213745
39. Jing PR, Sheng JB, Hu TS, et al. Spatiotemporal evolution of sustainable utilization of water resources in the Yangtze River Economic Belt based on an integrated water ecological footprint model. Journal of Cleaner Production. 2022; 358: 132035. doi: 10.1016/j.jclepro.2022.132035
40. Katumo DM, Liang H, Ochola AC, et al. Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare. Plant Diversity. 2022; 44(5): 429–435. doi: 10.1016/j.pld.2022.01.005