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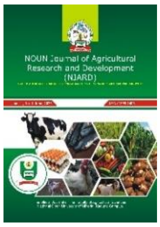

Original Article

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Evolutionary Psychology of Aquaculture Decision Making: An Iceberg Model Perspective

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Abstract

Aquaculture plays an increasingly important role in global food security, livelihood diversification, and economic development. However, decision making within aquaculture systems often deviates from conventional economic assumptions, particularly in developing country contexts where uncertainty, resource limitations, and institutional constraints are prevalent. This review paper presents a conceptual analysis of aquaculture decision making through the integration of evolutionary psychology and the Iceberg Model of systems thinking. Drawing on interdisciplinary literature from aquaculture, behavioural economics, psychology, and systems theory, the study examines how cognitive biases, social dynamics, and structural conditions interact to shape farmer behaviour and production yields. The analysis demonstrates that observable effects such as low adoption of innovations, risk-averse investment behaviour, and uneven productivity are influenced by deeper behavioural patterns, systemic structures, and underlying mental models. Evolutionary drivers including loss aversion, risk perception, heuristic decision making, and social learning are shown to significantly influence aquaculture practices, particularly under conditions of uncertainty. The Iceberg Model also reveals how these behavioural tendencies are reinforced by institutional limitations, cultural norms, and socio-economic realities, creating feedback loops that sustain existing practices. The paper argues that effective aquaculture development requires interventions that move beyond technical and and surface-level solutions to address the behavioural and systemic factors influencing decision making. Integrating evolutionary psychology with systems thinking provides a more holistic framework for understanding aquaculture behaviour and offers practical insights for designing resilient, inclusive and behaviourally informed aquaculture policies and development strategies.

Keywords: Aquaculture decision making, systems thinking, Iceberg Model, behavioural economics, sustainability.

1.0 INTRODUCTION

Aquaculture has emerged as one of the fastest growing food production sectors globally, which contributes significantly to global food security, employment, income generation, and rural development. In Nigeria, the sector plays an important role in bridging the widening gap between domestic fish demand and supply, particularly as capture fisheries continue to decline due to overexploitation and environmental pressures (Food and Agriculture Organization of the United Nations, 2024; Belton et al., 2018). As demand for aquatic foods increases, aquaculture is increasingly recognized as a strategic pathway for sustainable protein production and livelihood diversification.

Despite its growth potential, decision making within aquaculture systems remains complex and often departs from conventional rational economic assumptions. Traditional economic models generally assume that farmers make decisions based on profit maximization, access to information, and resource availability. However, studies have shown that aquaculture decisions are also influenced by social norms, past experiences, perceived risks, trust, and cultural beliefs (Onyekuru & Marchant, 2016; Joffre et al., 2017). Consequently, farmers may fail to adopt profitable innovations, avoid potentially beneficial investments, or persist with familiar production practices despite changing environmental and market conditions.

Behavioural perspectives provide important insight into these patterns. Evolutionary psychology suggests that human decision making is shaped by cognitive mechanisms that evolved to manage uncertainty, resource scarcity, and environmental risks (Buss, 2019; Henrich, 2016). These mechanisms often manifest as behavioural tendencies such as loss aversion, risk sensitivity, preference for familiar practices, and reliance on social learning. In aquaculture systems, such tendencies can influence decisions relating to technology adoption, species selection, investment behaviour, and farm management practices.

Understanding these behavioural dynamics requires moving beyond surface level observations to examine the deeper factors shaping decision making. The Iceberg Model of systems thinking offers a useful framework for this purpose by distinguishing between observable events and the less visible patterns, structures, and mental models that generate them (Meadows, 2008). Within aquaculture systems, visible effects such as low productivity, limited innovation uptake, or recurrent management challenges may reflect deeper institutional constraints, social influences, and cognitive assumptions.

In developing country contexts such as Nigeria, these underlying factors are particularly significant. Access to credit, extension services, infrastructure, and market opportunities remains uneven, while gender norms and social structures continue to influence participation and decision-making power within aquaculture systems (Bennett, 2018; Mangubhai et al., 2021). At the same time, uncertainty associated with climate variability, disease outbreaks, and fluctuating markets further shapes farmer behaviour and risk perception.

Recent scholarship increasingly emphasizes the need to integrate behavioural insights with systems approaches in agricultural and aquaculture development (Brugère et al., 2019; WorldFish, 2022). However, limited attention has been given to how evolutionary psychology and systems thinking can be combined to explain aquaculture decision making. Addressing this gap may provide a more realistic understanding of farmer behaviour and contribute to the design of more effective and sustainable interventions.

This review therefore examines aquaculture decision making through the integrated perspectives of evolutionary psychology and the Iceberg Model of systems thinking. The study seeks to explain how cognitive biases, social dynamics, and systemic structures interact to shape behaviour within aquaculture systems and to highlight the implications for sustainable aquaculture development and policy.

2.0 METHODOLOGICAL APPROACH

This review adopts a conceptual and interdisciplinary analytical approach to examine aquaculture decision making through the combined perspectives of evolutionary psychology and the Iceberg Model of systems thinking. Rather than presenting primary empirical research, the study synthesizes theoretical perspectives and existing scholarly literature to develop a broader understanding of behavioural dynamics within aquaculture systems.

Relevant literature was drawn from aquaculture studies, behavioural economics, evolutionary psychology, systems thinking, rural development, and innovation research. Scholarly materials were identified through searches of academic databases including Google Scholar, Scopus, Web of Science, and Science Direct using combinations of keywords such as “aquaculture decision making,” “evolutionary psychology,” “behavioural economics,” “systems thinking,” “risk perception,” “technology adoption,” “social learning,” and “Iceberg Model.” Emphasis was placed on peer-reviewed journal articles, institutional reports, and foundational theoretical texts published between 2000 and 2025, while seminal earlier works were included where conceptually relevant.

The review employed thematic synthesis in analyzing the literature. Recurring themes relating to cognitive biases, heuristics, social learning, institutional structures, and behavioural patterns in aquaculture systems were identified and interpreted within a systems thinking framework. The Iceberg Model was used as an analytical lens to examine how visible impacts in aquaculture are connected to deeper structural and psychological drivers.

The conceptual approach adopted in this study is particularly appropriate for exploring complex decision-making environments characterized by interacting behavioural, cultural, institutional, and economic factors. By integrating insights from evolutionary psychology with systems thinking, the paper develops a multidimensional framework for understanding aquaculture behaviour and its implications for sustainability and policy development.

3.0 CONCEPTUAL FRAMEWORK: EVOLUTIONARY PSYCHOLOGY AND THE ICEBERG MODEL

The conceptual framework for this review integrates evolutionary psychology with the Iceberg Model of systems thinking to explain decision making within aquaculture systems. The framework recognizes that observable actions and outcomes in aquaculture are influenced by deeper behavioural, institutional, and cognitive processes that often remain hidden beneath the surface.

The Iceberg Model (Figure 1), widely used in systems thinking, distinguishes between four interconnected levels within a system: events, patterns of behaviour, systemic structures, and mental models (Meadows, 2008; Senge, 2006). At the surface level are observable events such as low productivity, disease outbreaks, fluctuating market participation, or limited adoption of improved technologies. These effects are often the primary focus of policy interventions and technical support programmes.

Beneath these observable events are recurring patterns of behaviour that emerge over time. In aquaculture systems, such patterns may include persistent risk aversion, preference for traditional production methods, cautious investment behaviour, and slow adoption of innovations. These behavioural trends are shaped not only by economic conditions but also by social experiences, institutional environments, and individual perceptions of uncertainty.

At a deeper level, systemic structures influence the conditions within which aquaculture decisions are made. These structures include access to credit, extension services, infrastructure, governance systems, market opportunities, and social norms. In many developing countries, structural limitations such as inadequate institutional support and unequal access to resources significantly affect aquaculture participation and productivity.

The deepest level of the framework consists of mental models, which include beliefs, assumptions, values, and cognitive tendencies that shape how individuals interpret risks and opportunities. Evolutionary psychology provides insight into this level by explaining how human cognition evolved to manage uncertainty, scarcity, and environmental risks (Buss, 2019; Henrich, 2016). Cognitive tendencies such as loss aversion, preference for familiarity, social conformity, and heuristic decision making, continue to influence behaviour in modern aquaculture systems.

Integrating evolutionary psychology with the Iceberg Model provides a more comprehensive understanding of aquaculture decision making. It demonstrates that observable outcomes are not isolated events but are connected to deeper behavioural and structural dynamics. The framework therefore emphasizes the importance of addressing both visible challenges and underlying cognitive and institutional drivers when designing aquaculture policies and interventions.

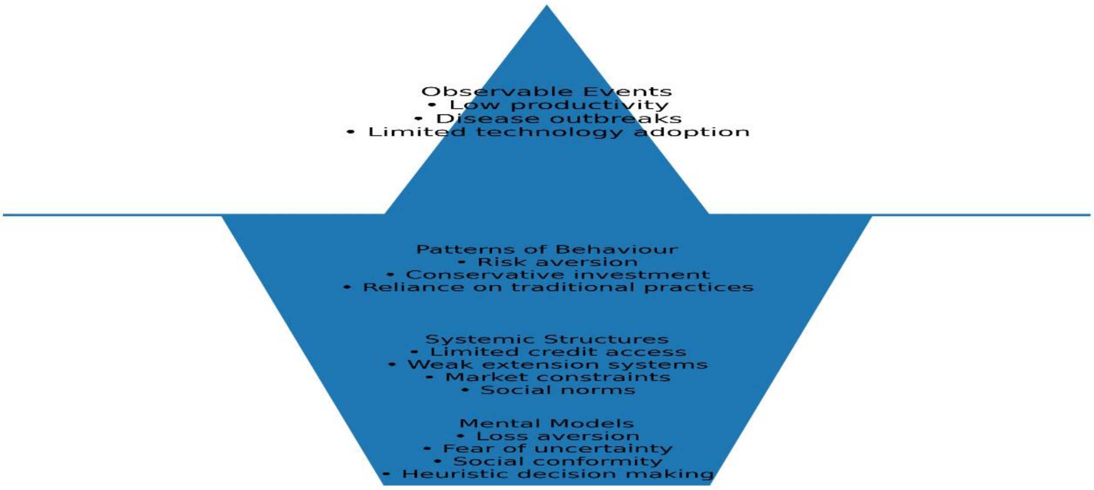

Figure 1: Iceberg Model of Aquaculture Decision Making showing the relationships between observable events, behavioural patterns, systemic structures, and underlying mental models influencing aquaculture systems.

4.0 EVOLUTIONARY DRIVERS OF AQUACULTURE DECISION MAKING

Human decision making in aquaculture systems is shaped not only by economic considerations but also by cognitive mechanisms that evolved to help individuals respond to uncertainty, environmental variability, and resource limitations. Evolutionary psychology explains that many behavioural tendencies observed in modern production systems are rooted in adaptive strategies that historically enhanced survival and decision-making efficiency (Buss, 2019; Tooby & Cosmides, 2015). In aquaculture, these evolutionary drivers influence how farmers perceive risks, evaluate opportunities, and respond to innovation.

4.1 Risk Perception and Uncertainty

Risk perception is a central factor influencing aquaculture decision making, particularly in small-scale production systems where uncertainty relating to disease outbreaks, market instability, environmental variability, and financial losses is common. Evolutionary perspectives suggest that humans are predisposed to avoid potentially harmful results because survival historically depended on minimizing threats and preserving limited resources (Trimmer et al., 2020).

Within aquaculture systems, this tendency often manifests as cautious investment behaviour and reluctance to adopt unfamiliar technologies. Farmers may perceive intensive production systems, improved feeds, or new management practices as risky despite evidence of potential long-term benefits. In many developing country contexts, these perceptions are reinforced by previous experiences of production failure, limited institutional support, and inadequate access to reliable information.

Risk perception therefore extends beyond objective economic calculations and is shaped by subjective experiences, social influences, and cognitive biases. This helps explain why farmers facing similar economic conditions may respond differently to innovation opportunities.

4.2 Loss Aversion and Investment Behaviour

Loss aversion refers to the tendency for individuals to place greater psychological weight on avoiding losses than on acquiring equivalent gains (Kahneman, 2011). In aquaculture systems, this behavioural tendency strongly influences production and investment decisions, particularly where financial resources are limited and the consequences of failure are severe.

Small-scale farmers may hesitate to expand production capacity, adopt new technologies, or invest in improved inputs because the perceived possibility of loss outweighs potential future benefits. This often results in conservative production strategies that prioritize short-term stability over long-term productivity growth.

The influence of loss aversion is particularly significant in environments characterized by weak insurance systems, limited access to credit, and high production uncertainty. In such settings, avoiding loss becomes a rational behavioural response shaped by both economic realities and evolved psychological tendencies.

4.3 Social Learning and Behavioural Influence

Human decision making is strongly influenced by social interactions and collective experiences. Evolutionary theory emphasizes that individuals often rely on social learning as a means of reducing uncertainty and acquiring information efficiently (Henrich, 2016; Boyd & Richerson, 2017). In aquaculture systems, farmers frequently depend on peer networks, local leaders, cooperative groups, and experienced producers when evaluating management practices and innovations.

The adoption of new aquaculture technologies is often influenced by observation of successful peers rather than formal technical recommendations alone. Trust, reputation, and shared experiences play important roles in shaping behavioural responses within farming communities. As a result, social networks can either accelerate innovation diffusion or reinforce resistance to change depending on prevailing community attitudes and experiences.

Recognizing the importance of social learning highlights the need for participatory extension systems and community-based approaches that build trust and encourage knowledge exchange among producers.

4.4 Cognitive Heuristics in Farm Management

Aquaculture decision making frequently occurs under conditions of incomplete information and uncertainty. In such situations, individuals often rely on cognitive heuristics, or mental shortcuts, to simplify complex decisions (Gigerenzer & Todd, 1999). These heuristics enable farmers to make rapid management decisions based on past experiences, observation, and practical judgement.

Examples include estimating feeding rates through visual assessment, determining stocking densities based on previous production cycles, or relying on traditional disease management practices. While these approaches may be efficient under familiar conditions, they can also lead to suboptimal results when environmental, technological, or market conditions change.

Heuristic decision making illustrates how practical experience and local knowledge continue to shape aquaculture management. However, it also underscores the importance of integrating scientific knowledge with experiential learning to improve decision-making quality and adaptive capacity.

4.5 Adaptive Learning and Behavioural Feedback

Aquaculture decision making is dynamic and continuously shaped by feedback from farmers' previous experiences. Farmers often adjust production strategies in response to successes, failures, environmental conditions, and market outcomes. Positive experiences may encourage experimentation and increased investment, while negative effects can reinforce caution and resistance to innovation.

This adaptive learning process reflects the interaction between cognitive tendencies and lived experiences. Behavioural responses are therefore not fixed but evolve over time within specific social and institutional contexts. Understanding these feedback mechanisms is important for designing interventions that strengthen confidence, reduce uncertainty, and encourage sustainable behavioural change.

Collectively, evolutionary drivers such as risk perception, loss aversion, social learning, heuristics, and adaptive learning collectively shape aquaculture decision making. These factors demonstrate that behaviour within aquaculture systems cannot be understood solely through rational economic models but must also account for psychological and social dimensions of decision making.

5.0 THE ICEBERG MODEL IN AQUACULTURE SYSTEMS

The Iceberg Model provides a systems thinking framework for understanding complex problems by examining both visible outcomes and the deeper forces that generate them (Meadows, 2008; Senge, 2006). In aquaculture systems, many observable challenges such as low productivity, limited technology adoption, production losses, and market instability are often symptoms of deeper behavioural and structural dynamics. Applying the Iceberg Model enables a more comprehensive understanding of how cognitive, institutional, and social factors interact to shape decision making within the sector (Brugère et al., 2019).

The model conceptualizes systems across four interconnected levels: events, patterns of behaviour, systemic structures, and mental models. These levels are closely linked, with deeper layers shaping the outcomes observed at the surface.

5.1 Events: Observable Outcomes in Aquaculture

At the surface level are events, which represent the visible and immediate outcomes occurring within aquaculture systems. These include fish mortality, fluctuating market prices, disease outbreaks, low production efficiency, poor feed utilization, and limited adoption of improved technologies. Such issues are commonly highlighted in policy discussions, extension programmes, and technical interventions (Akinrotimi et al., 2018).

In many developing countries, aquaculture challenges are often addressed at this surface level through short-term solutions such as input subsidies, training programmes, or emergency interventions. While these measures may provide temporary relief, they frequently fail to address the underlying factors responsible for recurring problems (World Bank, 2020).

For example, repeated disease outbreaks may be linked not only to technical management failures but also to inadequate institutional support, limited access to information, and behavioural responses shaped by risk perception and resource constraints (Joffre et al., 2017).

5.2 Patterns of Behaviour

Beneath observable events are recurring patterns of behaviour that emerge over time. These patterns reveal how individuals and systems consistently respond to similar conditions and challenges. In aquaculture systems, common behavioural patterns include cautious investment decisions, preference for traditional production practices, low adoption of innovations, and dependence on familiar management strategies (Onyekuru & Marchant, 2016; Kassam & Dorward, 2017).

These recurring behaviours are influenced by previous experiences, social learning processes, economic uncertainty, and perceptions of risk (Henrich, 2016). Farmers who have experienced production losses may become increasingly risk-averse in future production cycles, leading to repeated conservative decision-making patterns (Trimmer et al., 2020).

Recognizing behavioural patterns shifts analysis away from isolated events, and moves toward understanding the long-term trends that shape aquaculture development. This perspective is important for identifying persistent barriers to innovation and sustainability within the sector.

5.3 Systemic Structures

At a deeper level, systemic structures refer to the institutional, economic, social and policy environments that influence behaviour within aquaculture systems. These structures shape access to resources, information, markets, infrastructure, and decision-making opportunities (Meadows, 2008).

In many aquaculture-producing regions, structural constraints such as limited access to credit, inadequate extension services, weak regulatory systems, poor transportation infrastructure, and limited technical support significantly affect productivity and participation (Food and Agriculture Organization of the United Nations, 2022; World Bank, 2020). These structural conditions often reinforce conservative decision-making behaviour and limit farmers' willingness to adopt innovations.

Social and cultural structures also play important roles. Gender norms, for example, may restrict women's participation in production activities or limit their access to resources and decision-making authority (Bennett, 2018; Mangubhai et al., 2021). Similarly, young people may face barriers relating to land access, startup capital, and institutional support despite interest in aquaculture entrepreneurship (Meijer et al., 2015).

Addressing systemic structures requires long-term institutional reforms, investment in infrastructure, improved governance systems, and inclusive policy frameworks that create enabling environments for sustainable aquaculture development.

5.4 Mental Models and Cognitive Drivers

The deepest level of the Iceberg Model consists of mental models, which include beliefs, assumptions, values, perceptions, and cognitive tendencies that shape how individuals interpret situations and make decisions (Senge, 2006). These mental models often operate unconsciously but exert strong influence on behaviour.

In aquaculture systems, mental models influence perceptions of risk, innovation, profitability, and uncertainty. Farmers may perceive unfamiliar technologies as dangerous or financially risky regardless of available scientific evidence (Kahneman, 2011). Cultural beliefs and previous experiences may also reinforce attachment to traditional production systems and resistance to change.

Evolutionary psychology provides insight into the origins of many of these cognitive tendencies. Behavioural traits such as loss aversion, preference for familiarity, and reliance on heuristics evolved as adaptive mechanisms for coping with uncertain environments (Buss, 2019; Tooby & Cosmides, 2015). Although these tendencies historically supported survival, they can limit innovation and flexibility in contemporary aquaculture systems.

Mental models also influence institutional and social structures by shaping collective attitudes, policy priorities, and community norms. Understanding these deeper cognitive drivers is therefore essential for designing interventions capable of producing lasting behavioural and systemic change.

5.5 Implications of the Iceberg Perspective

Applying the Iceberg Model to aquaculture systems highlights the limitations of interventions that focus only on surface-level problems. Addressing observable events without considering behavioural patterns, structural constraints, and mental models may result in temporary improvements without long-term transformation (Meadows, 2008).

The model encourages a shift from reactive problem-solving toward systemic and preventative approaches. Interventions that combine technical support with behavioural insights, institutional strengthening, participatory learning, and social inclusion are more likely to achieve sustainable results (Brugère et al., 2019; WorldFish, 2022).

By linking visible effects to deeper psychological and structural dynamics, the Iceberg Model provides a valuable framework for understanding complexity within aquaculture systems. It also complements evolutionary psychology by demonstrating how cognitive processes interact with broader social and institutional environments to shape behaviour and development outcomes.

6.0 Integrating Evolutionary Psychology with the Iceberg Model in Aquaculture Decision Making

Understanding aquaculture decision making requires a framework that explains both observable production outcomes and the deeper cognitive and systemic processes shaping behaviour. The Iceberg Model provides a systems perspective for examining visible and hidden dimensions of aquaculture systems, while evolutionary psychology explains the cognitive mechanisms influencing how individuals perceive risks, opportunities, and uncertainty (Meadows, 2008; Buss, 2019). Integrating these perspectives provides a more comprehensive understanding of behaviour within aquaculture systems.

The Iceberg Model proposes that observable events are influenced by behavioural patterns, systemic structures, and underlying mental models (Senge, 2006). Evolutionary psychology complements this perspective by explaining how behavioural tendencies such as loss aversion, risk sensitivity, social conformity, and heuristic decision making emerge as adaptive responses to uncertain environments (Kahneman, 2011; Trimmer et al., 2020). Together, these frameworks demonstrate that aquaculture behaviour is shaped not only by economic conditions but also by cognitive and social influences.

At the level of mental models, evolutionary psychology helps explain how farmers interpret uncertainty and make production decisions. Cognitive tendencies that evolved to minimize risk and protect limited resources continue to influence responses to innovation and investment opportunities in aquaculture systems (Henrich, 2016). Consequently, farmers may avoid unfamiliar technologies or intensive production systems when perceived risks outweigh expected benefits, particularly in contexts where institutional support is weak and production uncertainty is high (Joffre et al., 2017).

These mental models also influence systemic structures within aquaculture systems. Perceptions of aquaculture as a high-risk activity may shape access to credit, insurance, extension services, and policy support (World Bank, 2020). Similarly, cultural norms and social expectations influence gender roles, resource access, and participation in aquaculture production (Mangubhai et al., 2021; Bamidele & Adebayo, 2022).

Systemic structures in turn reinforce recurring behavioural patterns such as cautious investment behaviour, low innovation adoption, and continued reliance on traditional management practices (Onyekuru & Marchant, 2016; Kassam & Dorward, 2017). Farmers operating under financial uncertainty and limited institutional support are more likely to exhibit persistent risk-averse behaviours over time.

These interconnected cognitive and structural factors ultimately shape observable outcomes within aquaculture systems, including low productivity, disease vulnerability, market inefficiencies, and uneven technology adoption (Brugère et al., 2019). Such effects should therefore be understood not as isolated events but as manifestations of deeper behavioural and systemic dynamics.

Integrating evolutionary psychology with the Iceberg Model has important implications for aquaculture development. First, it highlights the need for interventions that address both behavioural and structural barriers simultaneously. Technical information alone may be insufficient where farmers remain constrained by fear of loss, distrust, or previous negative experiences. Behaviourally informed strategies such as demonstration farms, participatory learning, peer mentoring, and risk-sharing mechanisms may therefore improve innovation uptake (WorldFish, 2022).

Second, the framework emphasizes the importance of social learning and trust networks in decision making. Farmers often depend on trusted peers and community experiences when evaluating innovations and management practices (Boyd & Richerson, 2017). Extension systems that encourage participation and experiential learning are therefore more likely to build confidence and reduce uncertainty among producers.

Finally, integrating systems thinking with evolutionary psychology encourages a shift from reactive interventions toward long-term systemic transformation. Rather than focusing only on surface-level production challenges, policymakers and development practitioners can address the behavioural and institutional drivers that sustain those challenges (Meadows, 2008).

In summary, combining evolutionary psychology with the Iceberg Model provides a multidimensional framework for understanding aquaculture decision making. The integration demonstrates that behaviour within aquaculture systems is shaped by interconnected cognitive, social, and institutional processes, with important implications for sustainable and resilient aquaculture development.

7.0 Implications for Aquaculture Sustainability and Policy

Integrating evolutionary psychology with systems thinking provides important insights for aquaculture sustainability and policy development. Conventional interventions have largely focused on technical efficiency, production inputs, and market access. However, sustainable aquaculture development also depends on behavioural dynamics, institutional support, and social interactions (Brugère et al., 2019; Joffre et al., 2017).

One important implication is the need to align aquaculture policies with behavioural realities such as risk perception and loss aversion. Aquaculture production involves significant uncertainty arising from disease outbreaks, environmental fluctuations, and market instability. As a result, farmers often adopt cautious investment strategies and may resist unfamiliar technologies when potential losses are perceived to outweigh expected gains (Kahneman, 2011; Trimmer et al., 2020).

Policies aimed at encouraging innovation should therefore focus on reducing uncertainty and building confidence among producers. Measures such as aquaculture insurance schemes, credit guarantees, demonstration farms, and risk-sharing mechanisms can help reduce perceived risks and improve technology adoption (WorldFish, 2022).

The integrated framework also highlights the importance of strengthening institutional and structural support systems. In many regions, inadequate extension services, weak infrastructure, limited access to finance, and inconsistent policy implementation continue to constrain aquaculture productivity (Food and Agriculture Organization of the United Nations, 2022; World Bank, 2020). These structural limitations often reinforce conservative behavioural patterns and reduce adaptive capacity among producers.

Addressing these barriers requires coordinated investments in infrastructure, technical training, extension services, market access, and financial inclusion. Expanding access to affordable credit and youth-focused financing programmes may also encourage entrepreneurship and broader participation within aquaculture systems (Meijer et al., 2015).

The framework further emphasizes the importance of social learning and community-based approaches. Farmers frequently rely on trusted peers and community experiences when evaluating new production practices (Henrich, 2016; Boyd & Richerson, 2017). Participatory extension systems, farmer cooperatives, demonstration farms, and peer mentoring programmes may therefore be more effective than purely information-based interventions.

Gender inclusion and youth participation also remain essential for sustainable aquaculture development. Social norms and institutional inequalities often restrict access to land, finance, training, and decision-making opportunities for women and young people (Mangubhai et al., 2021). Inclusive policies that improve access to productive resources and capacity-building opportunities can strengthen participation and long-term sustainability within aquaculture systems.

From a broader sustainability perspective, integrating behavioural and systems approaches can improve resilience and adaptive capacity within aquaculture systems. Climate change, environmental degradation, and economic uncertainty continue to increase production risks and management complexity. Policies that encourage diversification, climate-resilient production systems, and adaptive learning may therefore strengthen the capacity of aquaculture systems to respond to future challenges (Food and Agriculture Organization of the United Nations, 2024).

Taken together, integrating evolutionary psychology with the Iceberg Model supports a more holistic and interdisciplinary approach to aquaculture policy and development. By addressing behavioural, institutional, and systemic drivers simultaneously, policymakers and practitioners can promote more resilient, inclusive, and sustainable aquaculture systems.

8.0 Conclusion

This review examined aquaculture decision making through the integrated lenses of evolutionary psychology and the Iceberg Model of systems thinking. The analysis demonstrates that decision making within aquaculture systems is influenced not only by economic considerations, but also by cognitive tendencies, social interactions, institutional conditions, and deeply embedded mental models. Observable outcomes such as low technology adoption, conservative investment behaviour, and uneven productivity are therefore manifestations of deeper behavioural and structural dynamics rather than isolated production challenges.

The study highlights how evolutionary attributes including risk aversion, loss sensitivity, preference for familiarity, social conformity, and heuristic decision making continue to shape farmer behaviour in contemporary aquaculture systems. While these behavioural tendencies historically evolved as adaptive responses to uncertainty and resource scarcity, they may constrain innovation, flexibility, and long-term productivity under modern aquaculture conditions characterized by environmental variability, market instability, and institutional limitations.

The Iceberg Model further demonstrates that surface-level interventions alone are insufficient for achieving sustainable transformation within aquaculture systems. Lasting improvement requires attention to the interconnected relationships among behavioural patterns, institutional structures, and underlying mental models that shape production decisions and adaptive capacity. Consequently, sustainable aquaculture development must move beyond purely technical approaches toward more integrated and behaviourally informed strategies.

The review also underscores the importance of social learning, participatory extension systems, trust networks, inclusive governance, and institutional support in promoting innovation and resilience within aquaculture communities. Policies that reduce uncertainty, strengthen access to resources, encourage experiential learning, and improve institutional coordination are more likely to enhance technology adoption and sustainable production outcomes.

Overall, integrating evolutionary psychology with systems thinking provides a holistic and interdisciplinary framework for understanding aquaculture behaviour and development challenges. The framework contributes to emerging discussions on behaviourally informed aquaculture policy and offers a foundation for future empirical research aimed at strengthening sustainability, resilience, and inclusive growth within aquaculture systems.

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