Comparable patterns exist in capture fisheries. Some regions mandate electronic logbooks and vessel monitoring, while others still rely heavily on rigid paper-based systems. These contrasts highlight how regulatory design shapes technology adoption. For example, the United States emphasizes performance outcomes rather than specific equipment, whereas the United Kingdom continues to debate mandatory remote electronic monitoring. Studies suggest that voluntary systems often yield uneven results, making standardized approaches such as "SMART" mechanisms more effective. Evidence from countries like Indonesia and Pakistan further shows that lasting improvements depend on both reliable data and coordination across governance levels. Where legal, administrative, and technical systems are misaligned, effective governance is difficult to sustain (Suherman et al., 2025; Lina and Butt, 2025).

7.3 Data governance, ethical issues and regulatory challenges

The development of intelligent fisheries requires robust data governance frameworks that balance innovation with confidentiality, fairness, and ethical use. AI systems rely on large volumes of vessel, catch, and image data, yet privacy concerns and legal restrictions often limit data sharing. Even where technology is mature, paper-record requirements and strict confidentiality rules continue to constrain digital applications, while dedicated regulatory standards for fishery AI-such as algorithm transparency and accountability-remain underdeveloped.

As intelligent monitoring becomes more widespread, ethical concerns are increasingly visible. Technologies like remote sensing and drones expand regulatory capacity but also raise questions about privacy and data ownership. Governance research emphasizes that fishers and local communities should be active participants in decisions about how data are collected and used, rather than merely serving as data sources (Montana, 2025). At the operational level, weak coordination among institutions remains a key vulnerability. Inconsistent terminology and unclear standards can create confusion once data flow across agencies. Studies warn that rigid quota rules or poorly designed data systems may generate unintended ecological and social effects, underscoring the need for cautious, preventive policy approaches rather than overreliance on rapid technical fixes (Radi et al., 2025). Ultimately, successful governance depends not only on technology, but also on whether intelligent systems function fairly and effectively in real-world practice.

8 Challenges, Future Trends, and Prospects

The adoption of intelligent technologies in fisheries and aquaculture is constrained by a combination of technical, economic, and operational factors. These barriers slow implementation and may widen existing development gaps within the sector. Technically, intelligent systems depend on reliable sensors, networks, and data transmission, yet many aquaculture sites and small-scale fisheries are located in remote areas with weak infrastructure, making long-term maintenance difficult. Economically, high upfront costs, uncertain returns, and limited financing channels—especially in developing countries-restrict wider uptake. Operationally, limited digital literacy among fishers and managers, along with continued reliance on paper records and the lack of recognition of third-party data, further hinders implementation. As a result, fisheries digitalization cannot be treated as a simple technological upgrade, but must account for the diverse capacities and needs of different actors.

Looking ahead, intelligent fisheries are likely to evolve toward deeper integration between "Fishery 4.0" and AIoT systems. By combining artificial intelligence, the Internet of Things, and edge computing, future systems will increasingly link production, monitoring, processing, and marketing. In aquaculture, intelligent fish farms are expected to become more common, using sensors, computer vision, and digital twins to optimize water quality and feeding in real time, while edge computing helps address connectivity challenges in remote areas. At the same time, advances such as deep-sea intelligent aquaculture will continue to emerge. Successful implementation will depend heavily on cross-disciplinary and cross-institutional cooperation, enabling data sharing, regulatory coordination, and alignment with real production needs. Future research is also expected to move beyond small-scale pilots and focus more on long-term impacts and governance frameworks that support sustained application.