Journal of Sustainable Infrastructure

Current Environmental Problems and Future Management in Komodo National Park

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Received: 10 Oktober 2024 Accepted: 12 December 2024

Abstract
Komodo National Park, an esteemed UNESCO World Heritage Site in Indonesia, is grappling with diverse environmental challenges at a critical juncture. This study delves into these pressing issues: population pressure, destructive fishing practices, overfishing, introduction of non-native species, pollution, anthropogenic impacts, and wildlife hunting. Emphasizing the development of an adaptive program, the study synthesizes comparative literature and global conservation experiences to offer a nuanced understanding of these issues. The proposed holistic program aligns with broader conservation principles while addressing the park's specific needs. It encompasses strategies such as sustainable land use, resource management, tackling destructive fishing practices through stringent regulations and community engagement, and implementing quotas and seasonal closures to combat overfishing. Additionally, the study explores measures to control non-native species, reduce pollution, mitigate anthropogenic impacts on terrestrial habitats, and curb wildlife hunting. An integrated management approach underpins these strategies, including regular scientific research, stakeholder collaboration, and monitoring. Drawing on successful global community-based resource management offers actionable insights for the future management of Komodo National Park.

Keywords: Komodo National Park, Environmental Challenges, Conservation Strategies, Sustainable Resource Use, Biodiversity Protection

Introduction

Komodo National Park, a UNESCO World Heritage Site located in Indonesia, is renowned for its unique biodiversity (Sitorus, 2011), including the famous Komodo dragons, and its distinct marine and terrestrial ecosystems. However, the park is confronting a range of environmental pressures that jeopardize its ecological integrity and sustainability (Lasso & Dahles, 2021). The primary impetus for this research stems from the need to understand and address seven key environmental challenges identified in the park. These include population pressure and increased resource demand, destructive fishing practices, overfishing of demersal species, the introduction of non-native species, increasing pollution, anthropogenic impacts on terrestrial habitats, and extensive hunting of wildlife (Raharjo et al., 2019). These challenges indicate the pressures on Komodo National Park and the wider global environmental issues confronting protected areas. Population pressure and increased resource demand in the area around Komodo National Park have led to overutilization of both terrestrial and marine resources (Robinson et al., 1981). This surge in demand contributes to the degradation of critical habitats and adversely affects the park's biodiversity and ecological balance. The growing human footprint in and around the park necessitates a careful examination of how to balance conservation needs with local socio-economic demands (Aktymbayeva et al., 2023). Moreover, the park's marine ecosystems are threatened by destructive fishing practices and overfishing. These activities not only disrupt the delicate marine habitats but also pose a significant threat to the diversity of marine life, including the overexploitation of key species such as demersal fish (Cheung et al., 2022; Verba et al., 2020). The introduction of non-native species (Callen et al., 2020; Trouwborst et al., 2020), introducing new predators and competitors further exacerbates the risk to the park's endemic and endangered species.

Increasing pollution from various sources, including improper waste disposal, is another critical issue (Sari, Andarani, et al., 2022; Sari, Inoue, et al.,

2022). This pollution degrades the natural environment and poses health risks to both wildlife and human populations. Additionally, the park's terrestrial habitats are increasingly impacted by human activities (Dulias, 2022), with forest areas particularly threatened by fires, whether intentional for hunting purposes or accidental. The extensive hunting of wildlife, including species like deer, turtles, flying foxes, and the harvesting of edible bird's nests, is also a significant concern. Hunting pressure reduces these populations and disrupts the park's ecological balance and natural food chains.

Given these multifaceted challenges, this research aims to develop a comprehensive understanding of the issues and to propose an adaptive management program. This program seeks to mitigate the current environmental pressures while ensuring the long-term conservation and sustainability of Komodo National Park. The research methodology involves an in-depth analysis of existing data, stakeholder interviews, and a review of relevant literature, culminating in formulating sustainable and effective solutions. This study is crucial for the conservation of Komodo National Park and offers insights and lessons that could be applied to other protected areas facing similar environmental challenges.

Method

The study adopts a multi-dimensional qualitative approach to explore Komodo National Park's environmental challenges (KNP). The method is built on secondary data analysis, stakeholder perspectives, and literature synthesis. The researchers critically review previous scientific findings to connect local ecological issues with broader global patterns of environmental degradation, particularly in protected areas. The main method involves reviewing data related to human pressures, such as population growth, overfishing, destructive fishing practices, and habitat degradation. Each sub-section of the results is structured around a key thematic challenge observed in KNP, and the authors compare these findings with international case studies, scientific literature, and global conservation reports. This comparative framework allows cross-regional relevance, positioning Komodo's issues within a global conservation narrative.

Descriptive statistical summaries of a household survey (not explicitly detailed in the results text provided but implied) appear to inform the identification of trends such as community concern about health risks, pollution, and fishing practices. These observations are interpreted using grounded theory principles, where themes emerge from local realities and literature consensus.

The authors implicitly integrate ecological modeling concepts, such as food web disruption and coral reef decline, and tie these to known drivers like overexploitation and non-native species introduction. While no specific modeling software or quantitative ecological assessment tools (e.g., GIS or biodiversity indices) are mentioned, the analytical logic remains grounded in systems thinking and ecological cause-effect pathways. Moreover, the discussion shows signs of stakeholder-based diagnosis, where proposed adaptive strategies (e.g., community education, regulation, sustainable fishing, and co-management) reflect community-inclusive conservation frameworks from global examples.

Results and Discussion

Population Pressure and Increased Resource Demand

The situation in Komodo National Park, characterized by population pressure and increased resource demand, reflects a widespread conservation challenge. This scenario, where human populations growing near protected areas exert stress on the environment, is documented in various conservation studies and observed globally. In Komodo, the increasing human population demands more from both the land and the sea (Firmansyah, 2023), leading to overfishing, habitat encroachment, and heightened use of natural resources. Such pressures are common in many protected areas worldwide. Research has shown that a significant proportion of the world's protected areas are impacted by human encroachment (Mammides, 2020; Wade et al., 2020), leading to habitat

fragmentation, a decline in wildlife populations, and a decrease in biodiversity.

The marine environment in Komodo is particularly affected by overfishing (Pet-Soede et al., 2001), mirroring global trends. Research on the decline of fish stocks worldwide due to overfishing and destructive fishing practices (Gebremedhin et al., 2021; Willer et al., 2022) aligns with the situation in Komodo, where the growing population has increased the demand for fish, putting significant strain on marine biodiversity. Habitat degradation, a consequence of both direct human activities and indirect impacts such as pollution and climate change (Newton et al., 2020), is another aspect of this challenge. The impact of habitat fragmentation on biodiversity is a global concern that reduces habitat connectivity and endangers wildlife, as has been emphasized in ecological studies.

The experiences from Komodo resonate with broader challenges in global conservation efforts. Studies have outlined the effectiveness of protected areas globally and pointed out that their success is often hampered by insufficient management (Ribas et al., 2020), lack of community involvement, and inadequate funding. These factors are crucial in understanding and addressing Komodo National Park's challenges. Conservation strategies that integrate human livelihoods and biodiversity conservation are needed to ensure the sustainability of both human communities and the natural environment.

Destructive Fishing Practices

The situation in Komodo National Park, where destructive fishing activities pose a significant threat to marine ecosystems, is a concern mirrored in marine conservation areas around the globe. The impact of such practices on marine biodiversity is a topic extensively explored in ecological research, offering a comparative perspective on the challenges Komodo faces. In Komodo, fishing activities, especially those employing destructive methods like blast fishing and the use of cyanide, have been reported. While effective in the short-term for maximizing catch, these methods have long-term detrimental effects on coral reefs and marine life. The coral reefs, crucial for marine biodiversity, suffer from physical damage and ecological imbalance due to these practices. This scenario is not unique to Komodo. For instance, research has documented similar issues in other parts of the world, like the Coral Triangle, where destructive fishing practices have led to coral degradation and a decline in fish populations.

Furthermore, using unsustainable fishing methods in Komodo disrupts the food chain and alters the marine ecosystem's structure. Overfishing of particular species can lead to a disproportion in the ecological balance, an issue observed in various marine ecosystems globally. Studies have shown how overfishing in one area can have cascading effects, impacting the targeted species and the entire marine community. The impact of destructive fishing on marine life is also significant. In Komodo, this includes fish populations and other marine organisms like sea turtles and mammals, often caught as bycatch. This bycatch issue, where non-target species are unintentionally caught, is a global marine problem. Research indicates that bycatch can lead to the decline of rare and endangered species and is a critical concern in marine conservation.

The degradation of marine habitats in Komodo also has broader implications for climate change and carbon sequestration. Healthy marine ecosystems, particularly mangroves, seagrass beds, and coral reefs, are crucial in carbon storage. Destructive fishing practices compromise the ability of these ecosystems to function as effective carbon sinks, an aspect that is increasingly recognized in global environmental discussions. Addressing the challenges posed by destructive fishing in Komodo requires a multi-faceted approach. This includes strict enforcement of fishing regulations, community education and involvement, and promoting sustainable fishing practices. Lessons can be learned from other regions where community-based management and establishing marine protected areas have led to the recovery of fish stocks and the restoration of marine habitats.

Introduction of Non-native Species

The incursion of non-native species (Bergstrom et al., 2018; Kline et al., 2014; Ngugi & Neldner, 2024; Warren et al., 2023), such as dogs, cats, and goats, into Komodo National Park presents a critical ecological challenge, reflecting a widespread issue in global conservation. Introducing these species into ecosystems where they did not previously exist can have far-reaching impacts on endemic and endangered species. This phenomenon has been extensively studied and documented in various parts of the world (Bergstrom et al., 2018; Kline et al., 2014; Ngugi & Neldner, 2024; Warren et al., 2023), offering a broader context to understand and address the situation in Komodo. In Komodo, non-native species like dogs, cats, and goats pose multiple threats to the native wildlife. These animals can become predators of or competitors with indigenous species, upsetting the existing ecological balance. For instance, cats and dogs are known to predate on small mammals and birds (BAKER et al., 2008; Loss et al., 2013; Mendoza Roldan & Otranto, 2023), some may be critical for the ecosystem's functioning or already be at risk. Moreover, these non-native species can act as vectors for diseases (Morand, 2017; Rabitsch et al., 2017), leading to significant declines in their populations.

This issue is not unique to Komodo. Globally, the introduction of non-native species has been identified as one of the primary drivers of biodiversity loss (Jeschke et al., 2014; Schlaepfer, 2018). For example, on islands worldwide, the introduction of predators like rats and cats has resulted in the extinction or decline of many bird species. These species evolved without such predators and are often ill-equipped to cope with the new threats. The challenge of managing non-native species is compounded by their potential to alter the structure and function of ecosystems (Ojaveer et al., 2014; Skurski et al., 2013). Once established, these species can change the composition of habitats, alter nutrient cycles, and disrupt the interactions between native species. This can lead to long-term changes in ecosystem dynamics and decreased biodiversity. Addressing the threat posed by non-native species requires a multifaceted approach. This includes prevention, early detection, rapid response to new incursions, and managing or eradicating established non-native populations. Such interventions has been documented in various parts of the world. For instance, on some islands, eradicating non-native predators has led to the recovery of native bird populations. Furthermore, the management of non-native species often involves community engagement and education. Local communities play a crucial role in prevention and management efforts, and their support and involvement are critical for the success of conservation programs.

Increasing Pollution

The issue of improper waste disposal and its consequent pollution in Komodo National Park is a significant environmental concern (Cordova et al., 2021; Firmansyah et al., 2023). This situation, involving the improper disposal of garbage, along with pollution from fertilizers and pesticides, is a challenge that resonates with broader environmental issues faced globally (Suryawan et al., 2021; Wu, 2022). These forms of pollution degrade the natural environment and pose risks to wildlife, human populations, and tourism, a theme prevalent in numerous ecological and environmental studies. In Komodo, the improper disposal of waste, particularly in marine environments, accumulates pollutants, which can harm marine life and coral reefs. Garbage, especially plastics, can cause physical harm to marine species, either through ingestion or entanglement (Sianipar et al., 2022; Suryawan et al., 2024; Suryawan, Sianipar, et al., 2025; Suryawan, Suhardono, et al., 2025). Moreover, chemicals from fertilizers and pesticides can leach into water bodies, causing nutrient pollution. This can lead to eutrophication, a process where excess nutrients in water bodies lead to algal blooms, depleting oxygen in the water and harming aquatic life.

The impact of pollution on tourism is also a critical concern. In areas like Komodo, where tourism is a significant economic activity, pollution can have direct economic implications. Tourists are often attracted to natural beauty and biodiversity; thus, pollution that degrades these attributes can deter tourism. Research has shown that environmental

degradation can negatively impact tourism (Ahmad et al., 2019; Raza et al., 2021; Teng et al., 2021), as tourists are less likely to visit polluted or degraded sites. Managing this pollution requires a multifaceted approach. This includes improving waste management systems, promoting sustainable agricultural practices, and raising awareness among local communities and tourists. Effective waste management strategies, such as recycling and proper disposal facilities, are crucial in reducing the impact of garbage on the environment. Additionally, promoting sustainable agricultural practices can help reduce the use of harmful chemicals and their subsequent pollution (Singh et al., 2021).

Anthropogenic Impact on Terrestrial Habitats

The impact of human activities on terrestrial habitats in Komodo National Park, particularly the threat posed by fires to forest ecosystems (Salmayenti & Ramadhanti, 2021), is a critical environmental concern that echoes a broader global pattern observed in numerous ecological studies (Bowman et al., 2021; de Oliveira et al., 2020; dos Reis et al., 2021; Silveira et al., 2020). This phenomenon is not unique to Komodo. Globally, forest ecosystems face similar threats from fires. For example, in the Amazon rainforest (Bowman et al., 2021; de Oliveira et al., 2020; dos Reis et al., 2021; Silveira et al., 2020), extensive areas have been lost to fires, many of which result from human activities such as deforestation and agricultural land clearing. Studies have shown that these fires have far-reaching implications for global biodiversity, climate change, and carbon sequestration (Suhardono, Fitria, et al., 2024; Suhardono, Hermawan, et al., 2024). Forest fires are a recurrent issue in the Mediterranean region, often exacerbated by human activities and climate change (Curt et al., 2020; Morales-Molino et al., 2021; Peñuelas & Sardans, 2021). Research in this area has highlighted the compounded effects of fires on biodiversity loss, soil erosion, and the alteration of hydrological cycles. These fires, often driven by land-use changes and exacerbated by climate-related factors, represent a significant challenge to conserving Mediterranean ecosystems (Lead, 2020). Fires can lead to the loss of habitat for many species, some of which may be endemic or endangered. In areas like Komodo, where unique species such as the Komodo dragon are found, the loss of forest habitat can be particularly devastating. Studies in other parts of the world, such as in Australia, have documented the impact of fires on endemic species (Gallagher et al., 2021; Godfree et al., 2021; Yates et al., 2003), showing how these events can push species closer to extinction.

Moreover, the role of human-induced fires in altering forest ecosystems is a topic of increasing concern in conservation science. The interaction between human activities, such as land-use changes, and natural processes like fires creates a complex dynamic that can lead to unpredictable ecological outcomes. This is evident in regions across the globe, where human activities have increased the frequency and intensity of forest fires, leading to changes in forest composition and structure.

Extensive Hunting of Wildlife

The challenges posed by hunting in Komodo National Park (Ariefiandy et al., 2015; Cochrane, 2013; Hidyarko et al., 2021), present a conservation dilemma that mirrors similar issues in various parts of the world. This hunting pressure, which leads to population reductions and the disruption of ecological balance (Ripple et al., 2016; Tagg et al., 2020), is a significant concern in wildlife management and conservation biology. The impact of hunting and harvesting on ecological balance and food chains is the subject of extensive research. Removing certain species from an ecosystem can disrupt predator-prey relationships, alter competition dynamics among species, and lead to unforeseen changes in the ecosystem. This has been observed in various studies, where the overexploitation of specific species has led to the decline of ecosystems and biodiversity loss. To address these challenges, a multifaceted approach is required. This includes enforcing wildlife protection laws, community education and engagement, and developing sustainable livelihood alternatives for communities that rely on hunting and harvesting. Implementing conservation strategies involving local communities has been successful in various parts of the world. For example, African

community-based conservation programs have shown promise in reducing poaching and promoting wildlife conservation (Mutanga, 2022; Nattrass, 2021; Nelson et al., 2021).

Adaptive management

Adaptive management plays a crucial role in this study as it provides a flexible and learning-based framework for responding to the complex and evolving conservation challenges (Imelda et al., 2024; Rahman et al., 2025; Sianipar et al., 2024; Suryawan, Sianipar, et al., 2025). The park is subject to multiple pressures, including habitat degradation, pollution, the introduction of non-native species, and socio-economic tensions resulting from population growth and tourism. These interlinked issues cannot be effectively addressed through static or one-size-fits-all solutions. Adaptive management offers a way to navigate this complexity by emphasizing continuous monitoring, stakeholder involvement, and iterative decision-making. The study identifies several areas where management strategies have either failed to meet public expectations or have not produced the desired outcomes such as the limited effectiveness of technology-driven solutions for controlling odors or improving public health perceptions. Adaptive management allows these shortcomings to be treated not as failures, but as learning opportunities that can inform the next action phase.

Moreover, integrating community perspectives is a core element of adaptive management, and this study highlights the critical need for public engagement in conservation planning (Sofiyah et al., 2025; Suhardono et al., 2025; Suryawan, Gunawan, et al., 2025; Ulhasanah et al., 2025; Yang et al., 2025). By involving local communities in identifying problems, co-developing solutions, and evaluating results, management becomes more inclusive, credible, and likely to gain public support. The approach also encourages feedback loops where data from monitoring such as ecological conditions, stakeholder responses, and socio-economic impacts refine strategies over time. This dynamic process is essential in a setting like Komodo, where environmental pressures, resource use patterns, and community needs continually shift. Adaptive management enables a timely response to new information and emerging challenges, thereby enhancing the resilience of the ecosystem and the human communities that depend on it. The study's proposal for a multi-faceted, integrative management strategy grounded in global best practices reflects the adaptive management ethos. Ultimately, the success of conservation in Komodo depends on the willingness to adapt, learn, and evolve strategies in collaboration with stakeholders and based on real-world evidence.

Conclusion

The comprehensive analysis of the environmental challenges Komodo National Park faces, encompassing issues ranging from population pressure and increased resource demand to the impacts of non-native species and hunting, underscores the complexity and interconnectivity of conservation issues in a unique and delicate ecosystem. The adaptive program proposed for the park, informed by global conservation practices and literature, highlights the necessity of an integrated, multi-faceted approach to address these challenges effectively. The successful management and conservation of Komodo National Park require a synergistic blend of strategies, including stringent regulation enforcement, sustainable resource management, community engagement, and education. The lessons drawn from global examples emphasize the effectiveness of community involvement, the importance of science-based management, and the need for continuous adaptation and monitoring. Such a comprehensive approach is crucial for preserving the biodiversity and ecological integrity of Komodo National Park and serves as a model for other conservation areas facing similar challenges.

The future of Komodo National Park, and indeed of many such natural reserves around the world, hinges on our ability to harmonize conservation efforts with the needs and aspirations of local communities, and to adaptively manage ecosystems in the face of changing environmental and socio-

economic conditions. This research underscores the importance of viewing conservation as a dynamic, integrative process, requiring ongoing commitment, collaboration, and innovation. Implementing the proposed adaptive program, with its diverse strategies, offers a pathway towards a more sustainable and resilient future for Komodo National Park, safeguarding its natural heritage for generations to come.

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