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Human–Wildlife Coexistence in Japan: Adapting Social–Ecological Systems for Culturally Informed Management

Fangzhou Gu and Kenta Sakanashi *

Graduate School of Agriculture, Kyoto University, Kyoto 6068502, Japan; gu.fangzhou.82w@st.kyoto-u.ac.jp
* Correspondence: sakanashi.kenta.6h@kyoto-u.ac.jp

Abstract

Human–wildlife conflict (HWC) is intensifying in Japan, driven by complex socio-ecological changes. While the Social–Ecological Systems (SES) framework offers a valuable analytical tool, standard applications often fail to capture the crucial cultural specificities, demographic pressures, and institutional dynamics that define the Japanese context. This paper addresses these limitations by conducting a scoping review of academic and policy literature in order to synthesize the evidence needed to develop a culturally and institutionally attuned adaptation of the SES framework. The review's findings confirm that profound demographic change (*kaso* and *kōreika*), unique institutional arrangements (the *Ryōyūkai* crisis), deep-seated cultural values, and asymmetric power relations are core systemic drivers of HWC, not external factors. Building on this evidence, we propose a theoretically grounded adapted framework that internalizes these factors as endogenous variables. The resulting framework serves as a more robust diagnostic tool for understanding and navigating HWC in Japan. It facilitates the identification of context-specific leverage points and offers a transferable methodological model for adapting SES analysis to other culturally distinct and rapidly changing societies.

Keywords: human–wildlife conflict; SES framework; framework adaptation; scoping review; Japan; cultural values; rural depopulation; conservation governance; *Ryōyūkai*; *satoyama*

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1. Introduction

Human–wildlife conflict (HWC) represents a significant and escalating global challenge that demands integrated, transdisciplinary approaches transcending simplistic ecological or economic analyses [1,2]. This challenge is particularly acute and complex in Japan, a nation often characterized by perceptions of harmonious human–nature relationships [3]. Across the archipelago, interactions between human communities and burgeoning wildlife populations—notably sika deer (*Cervus nippon*), wild boar (*Sus scrofa*), Asiatic black bears (*Ursus thibetanus*), and Japanese macaques (*Macaca fuscata*)—have intensified [4]. The conflict manifests in substantial economic losses, with agricultural damage reaching ¥15.6 billion in Fiscal Year 2022 [5], and extends to damages in forestry, biodiversity, and human safety. Crucially, HWC extends beyond material costs to erode the social fabric and psychological wellbeing of rural communities, a dimension often overlooked in conventional analyses [6–8].

Although these impacts are experienced locally, they are propelled by systemic, national-level drivers. It is for this reason that this study adopts a national-level perspective

to develop a broadly applicable analytical framework, focusing on the rural and peri-urban landscapes where these interactions are most intense.

The intensification of HWC in Japan is deeply rooted in a confluence of profound socio-ecological transformations. Foremost among these are severe *kaso* (過疎, rural depopulation) and *kōreika* (高齢化, societal aging) [9,10]. These demographic pressures have spurred widespread abandonment of agricultural land—reportedly reaching 253,000 hectares by 2023 [5]—and the degradation of traditional *satoyama* (里山, traditional social-ecological rural landscape). The erosion of these historical mosaics of managed forests and farmlands has undermined their critical function as buffer zones, blurring the boundaries between human and wildlife domains [11–13]. Concurrently, successful conservation efforts have contributed to the recovery and significant range expansion of wildlife populations; the distribution of sika deer and wild boar, for example, expanded by approximately 170% and 130%, respectively, between 1978 and 2003 [14,15]. Compounding these ecological shifts is a dramatic decline in human capacity for management. The number of registered hunters, who have historically played a key role in population control, plummeted from over 500,000 in the 1970s to below 200,000 in recent years, with the remaining cohort aging significantly [16–18]. This crisis not only strains traditional management but also threatens the vital intergenerational transmission of local ecological knowledge [19,20].

Addressing such multifaceted problems, where human societies and ecological systems are inextricably linked, demands a robust analytical framework [21]. The Social–Ecological Systems (SES) framework, pioneered by Elinor Ostrom and her colleagues, offers a powerful, structured approach for diagnosing these complex, linked systems [22]. However, despite its global utility, the direct application of standard SES models reveals significant limitations in capturing the unique context of Japan [23]. Standard applications, often developed from studies in different cultural settings [24], can fail to adequately incorporate Japan's unique cultural values, such as *kyōsei* (共生, coexistence) and relational ethics [25,26]; overlook the specific institutional arrangements and demographic crisis facing *Ryōyūkai* (猟友会, local hunters association) [17,27,28]; neglect the profound impacts of demographic pressures on community capacity for collective action; and often lack an explicit analysis of power, which shapes stakeholder interactions and determines whose knowledge is valued in management decisions [29–31]. Collectively, these shortcomings indicate that applying the SES framework without significant contextual adaptation risks producing an incomplete and potentially misleading analysis of HWC in Japan.

Therefore, to address these analytical gaps, this paper undertakes a scoping review of the literature to develop and demonstrate a culturally and institutionally attuned adaptation of the SES framework for analyzing HWC in contemporary Japan. By explicitly incorporating these critical contextual factors, this tailored framework can provide a more robust and nuanced tool for research and management.

The central argument of this paper is thus structured as a logical progression: we first posit that standard SES applications are insufficient for the Japanese context. We then argue that a comprehensive synthesis of the existing literature—the core function of a scoping review—is required to diagnose the specific reasons for this insufficiency. Finally, we demonstrate how the evidence gathered from this review is used to construct a more robust, context-specific adapted framework. The primary contribution of this work is therefore twofold: it provides a detailed diagnosis of the systemic challenges of HWC in Japan and offers a transferable methodological model for adapting the SES framework to other culturally distinct and rapidly changing societies. To achieve this aim, this paper addresses the following central research questions:

(1) How can the standard SES framework be critically adapted to more effectively analyze HWC within Japan's specific socio-ecological context, considering its cultural, demographic, and institutional particularities?

(2) What specific theoretical modifications to the SES framework's components and variables are necessary to explicitly integrate Japanese cultural values (e.g., relational ethics, *kyōsei*), unique institutional arrangements (e.g., the role of *Ryōyūkai*), profound demographic shifts (e.g., *kaso*, *kōreika*), and underlying power relations relevant to HWC?

(3) How does applying this adapted SES framework enhance the understanding of Japanese HWC dynamics and inform the development of more effective, equitable, culturally appropriate, and sustainable management strategies and policy implications?

The subsequent sections elaborate on this argument. Section 2 introduces the standard SES framework and critically examines its limitations when applied to the Japanese HWC context. Section 3 details the scoping review methodology employed to develop the adapted framework. Section 4 provides a rich overview of the Japanese HWC context, highlighting key drivers and stakeholder characteristics. Section 5 presents the proposed adapted SES framework tailored for Japan, detailing its specific modifications and their rationale. Finally, Section 6 demonstrates the conceptual utility of this adapted framework, discusses the broader theoretical and policy implications, and outlines future research directions.

2. Theoretical Foundation: The SES Framework and Its Limitations in Japan

2.1. Introduction: The Need for an Integrated Framework

Addressing the multifaceted challenges of human–wildlife conflict (HWC) in Japan necessitates a robust theoretical framework capable of integrating complex ecological dynamics with the intricate social, cultural, institutional, economic, and demographic dimensions defining this issue. HWC is fundamentally situated at the "intersection of human social systems and natural ecological systems" [2], demanding analytical tools that capture the intricate dynamics and feedback loops between these domains. The escalating complexity of HWC in Japan—driven by a confluence of socio-demographic shifts such as rural depopulation and aging, landscape transformations including agricultural abandonment, recovering wildlife populations, changing human capacities like the declining hunter population, and nuanced cultural perspectives on nature—starkly underscores the inadequacy of single-discipline approaches. An integrated analytical approach is therefore essential to dissect these interconnected challenges and pave the way for sustainable human–wildlife coexistence, or *kyōsei* (共生).

2.2. The Social–Ecological Systems (SES) Framework: Rationale and Core Components

The Social–Ecological Systems (SES) framework, developed primarily through the work of Elinor Ostrom and her colleagues, offers a powerful and widely adopted approach for such analyses [21,24,32–34]. This section first outlines the core tenets and analytical strengths of the standard SES framework. It then critically examines the framework's significant limitations when applied directly to the unique socio-cultural, demographic, and institutional landscape of HWC in contemporary Japan. This critique establishes the theoretical rationale for adapting the framework, arguing that such modification is essential for accurate diagnosis and the development of effective, culturally informed management strategies.

The selection of the SES framework as this study's foundational theoretical lens, despite subsequent critiques, is a deliberate and strategic choice. Its established utility as a diagnostic tool for complex human-environment interactions provides a robust, widely

understood analytical architecture [22,35]. More importantly, the SES framework was envisioned by Ostrom not as a rigid, predictive model but as an adaptable diagnostic tool intended to be tailored to specific empirical realities [34]. This inherent flexibility means the framework can and should be refined to incorporate unique variables pertinent to diverse socio-ecological contexts. This paper thus undertakes such a critical adaptation, leveraging the SES framework's organizational power while enhancing its capacity to capture Japan's nuanced HWC complexities.

The framework provides a multi-tiered, nested structure that decomposes complex systems into core, interacting subsystems to facilitate systematic analysis. As conceptualized by Ostrom [22], these include the Resource System (RS), representing the biophysical environment (e.g., forest ecosystems); the Resource Units (RU), which are the specific entities utilized or affected (e.g., individual deer); the Governance System (GS), comprising the formal and informal rules that shape human interactions; and the Actors (A), the individuals and groups who participate in the system. These subsystems interact (Interactions, I) within focal Action Situations, generating patterns (e.g., harvesting, conflict, cooperation) that lead to Outcomes (O) (e.g., resource sustainability, social equity). This entire dynamic is embedded within and influenced by broader Social, Economic, and Political Settings (S) and related Ecosystems (ECO) [22]. The framework's diagnostic power stems from its systems-thinking approach, which acknowledges feedback loops, institutional diversity, polycentric governance, and unintended consequences, making it well-suited for the nonlinear challenges of HWC [34,36,37].

2.3. Diagnosing the Gaps: Limitations of the Standard SES Framework in the Japanese HWC Context

A critical first step in our scoping review methodology is to diagnose the specific analytical gaps that arise when applying the standard SES framework to the Japanese context. Despite its strengths, a standard SES framework—often derived from studies of different common-pool resources or cultural settings—presents significant limitations in contemporary Japan without careful attunement [23]. These limitations arise because such applications may not adequately capture or prioritize crucial Japanese cultural nuances, unique institutional arrangements, pressing demographic challenges, and underlying power dynamics that fundamentally shape the conflict landscape [29]. The following subsections detail these critical gaps, which form the basis for the targeted adaptations developed in this paper.

2.3.1. Inadequate Capture of Cultural Specificity, Relational Values, and Traditional Ecological Knowledge

A primary limitation is the difficulty of standard SES applications in operationalizing Japan's deep cultural outlooks on nature. Often rooted in rational choice assumptions [24], these applications may fail to fully accommodate Japanese views influenced by syncretic Shinto and Buddhist traditions, which foster worldviews emphasizing interconnectedness and respect for life [3,38,39]. This leads to nuanced, sometimes ambivalent, attitudes towards wildlife that transcend purely utilitarian calculations [40]. Concepts like *kyōsei* and "relational values"—which prioritize stewardship, responsibility, and place-based connections over simple utility [26,41,42]—are central in Japan but difficult to capture with standard variables. These values are embodied in concepts like *satoyama* (里山), which signifies not just a landscape type (RS) but a historically and culturally embedded human-ecosystem relationship [11,25]. Failing to integrate these cultural layers risks profoundly misinterpreting stakeholder motivations and the social acceptability of management outcomes.

2.3.2. Overlooking Profound Demographic Change and Community Dynamics

The SES framework's concept of "community" requires careful examination to avoid romanticized assumptions of homogeneity, especially amid the intense demographic pressures facing rural Japan [29,43]. Japan is experiencing severe rural depopulation (*kaso*) and societal aging (*kōreika*) [9]. In 2023, 885 municipalities were designated as depopulated, covering 63.2% of Japan's land but holding only 9.3% of its population [10]. This demographic crisis is not merely an external "setting" (S); it is a fundamental, endogenous driver that reshapes the entire SES. It directly alters the Actors (A) subsystem by eroding a community's capacity for collective action, monitoring, and knowledge transmission [18]. These pressures contribute to the abandonment of agricultural land—reaching 253,000 hectares by 2023 [5]—and the degradation of *satoyama* landscapes, altering wildlife habitats [44]. Critically, the decline in registered hunters—plummeting from over 500,000 in the mid-1970s to around 190,000 by 2010, with over 60% aged 60 or older by the mid-2010s [17,45]—strains the ability to manage wildlife and transmit local ecological knowledge [19,46]. A standard SES analysis risks treating these profound forces as background conditions rather than as core systemic drivers.

2.3.3. Insufficient Attention to Institutional Specificity: The Role of the *Ryōyūkai*

While the Governance System (GS) is a core SES component, unadapted applications may fail to capture the unique traits of key Japanese institutions. A prime example is the *Ryōyūkai*. This socio-institutional hybrid acts not merely as a "user group" (A) but as a quasi-governmental entity contracted by local governments for wildlife control [28,47]. This association operates under a complex blend of formal national regulations and powerful, localized informal norms like *nawabari* (縄張り, hunting territoriality) [48]. Analyzing the *Ryōyūkai* with generic variables overlooks its unique intermediary role and, critically, its extreme vulnerability to the demographic crisis described above, which directly threatens its operational capacity and knowledge transmission [18,20].

2.3.4. Lack of Explicit Focus on Power Dynamics and Conflict

A significant critique of many SES applications is the insufficient attention paid to power dynamics, politics, and conflict among actors [31,49]. HWC situations are fundamentally conflict arenas with unequal power among diverse stakeholders like farmers, hunters, government agencies, and urban and rural residents [2,3,50]. Power determines who defines the "problem", who shapes the rules (GS), whose knowledge is considered legitimate (e.g., scientific data vs. local experience), and ultimately, who benefits or loses from management outcomes [30,51,52]. Overlooking how power operates can lead to management approaches that appear rational on paper but are socially unjust, politically unfeasible, or exacerbate underlying tensions [53,54].

2.3.5. Potential Overemphasis on Material Outcomes

Finally, many SES applications can prioritize readily quantifiable material outcomes, such as the economic costs of agricultural damage (which reached ¥15.6 billion in FY2022) or wildlife population targets [5]. This focus can neglect crucial "hidden" social, cultural, and psychological impacts [6,37]. The psychological stress on farmers, residents' fear and anxiety due to wildlife presence, and the erosion of cultural practices tied to landscapes are critical components of the socio-ecological reality that profoundly influence tolerance levels and actor behavior [55,56]. An overemphasis on material metrics leads to an incomplete diagnosis and to strategies that fail to address the full spectrum of human impacts.

2.4. The Imperative of Contextual Adaptation and This Paper's Contribution

The limitations identified above are part of a broader scholarly conversation confirming that the SES framework's analytical power is contingent upon its careful adaptation to specific contexts. Researchers consistently find that one-size-fits-all applications risk generating flawed analyses and falling into "panacea traps". For instance, Dressel et al. [57] used SES mapping for moose management in Sweden to reveal significant spatial heterogeneity, arguing that uniform national policies are ill-suited to such varied local realities. Stephenson et al. [58], in developing a fisheries framework, highlighted that most generic frameworks are disproportionately focused on ecological and economic pillars, necessitating purpose-built adaptation to properly integrate social and institutional dimensions. Furthermore, Elmqvist et al. [59], in a deep case study of an urban park in Stockholm, illustrated how SES analysis can uncover critical mismatches between ecological and governance scales, which can undermine resilience. This paper, therefore, builds upon this established tradition of SES adaptation. While the aforementioned studies either demonstrate the need for adaptation or apply it to a specific case, our study's primary contribution is to propose a systematic, transferable methodology for adaptation at a national scale. By focusing on the unique and powerful drivers of deep-seated cultural values and profound demographic change in Japan, we develop a tailored framework that not only provides a more accurate diagnosis of HWC but also serves as a model for how the SES framework can be adapted to other culturally distinct and rapidly changing societies. The following section details the scoping review methodology employed to construct this adapted framework.

3. Methodology: A Scoping Review Approach to Framework Adaptation

This study employs a scoping review methodology to systematically synthesize the diverse body of evidence required to develop a Social–Ecological Systems (SES) framework specifically adapted for analyzing human–wildlife coexistence in Japan. A scoping review was chosen over a systematic review as it is the ideal methodology for mapping a broad and complex field of literature, clarifying conceptual boundaries, and synthesizing existing knowledge to inform the development of a new conceptual model [60]. The process was structured following the five-stage framework established by Arksey and O'Malley [60], informed by the PRISMA extension for Scoping Reviews (PRISMA-ScR) guidelines [61,62].

3.1. Stage 1: Identifying the Research Questions and the Relevant Literature

The review was guided by the three central research questions outlined in the Introduction, which defined the scope of the inquiry. To address these questions, a comprehensive search strategy was implemented across both academic and grey literature. Systematic searches were conducted in major scholarly databases, including Google Scholar, Scopus, PubMed, and the Japanese-language databases CiNii and J-STAGE. Search queries combined keywords in English and Japanese, such as "human-wildlife conflict", "social-ecological systems", "wildlife management", "Japan", "*satoyama*" (里山), "*kaso*" (過疎), "*kōreika*" (高齢化), and "*Ryōyūkai*" (猟友会). This was supplemented by a review of grey literature, including policy documents and reports from the Ministry of the Environment (MoE) and the Ministry of Agriculture, Forestry and Fisheries (MAFF). A "snowballing" technique, scanning reference lists of key articles, was used to capture additional sources.

3.2. Stage 2: Selecting Relevant Studies

Following the search, studies were selected for inclusion through a two-stage screening process (title/abstract, then full-text review). The primary criteria required sources

to directly address: (a) the theory or application of the SES framework; (b) the empirical realities of human–wildlife conflict in Japan, including its social, cultural, and institutional dimensions; or (c) scholarly critiques and adaptations of the SES framework. This process ensured that the included literature was directly relevant to diagnosing the limitations of the standard framework and gathering the evidence needed for its adaptation. This scoping review was conducted and reported in accordance with the PRISMA guidelines. A PRISMA flow diagram summarizing the search and screening process is presented in Figure 1.

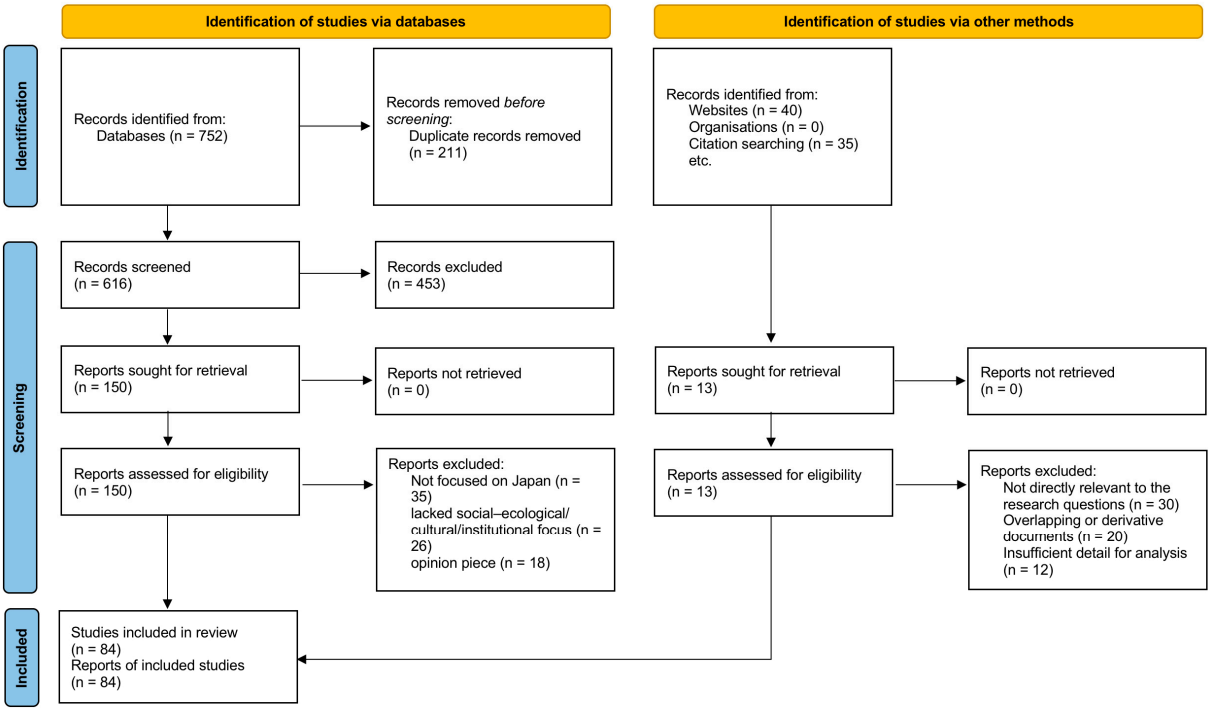


Figure 1. PRISMA-2020 flow diagram summarising the literature search and study selection process for this scoping review. The diagram shows the number of records identified in each database and grey-literature source, the number of duplicates removed, the number of records screened and excluded at the title/abstract stage, and the number of reports assessed at full-text level. Reasons for full-text exclusions are provided in parentheses. Boxes for registers and automation-tool screening were omitted because no trial registries were searched and all screening was performed manually.

3.3. Stage 3: Charting the Data

Data from the selected literature were then charted by systematically extracting key information. This charting process was structured according to the primary subsystems of the standard SES framework (i.e., Resource System, Resource Units, Governance System, Actors, etc.). This theory-driven approach ensured that the extracted data could be systematically organized and later synthesized to both critique the standard framework and inform the construction of the new, adapted variables.

3.4. Stage 4: Collating, Synthesizing, and Developing the Adapted Framework

The final stage involved collating and synthesizing the charted data. This synthesis served a dual purpose, forming the core intellectual work of this study. First, it enabled a critical evaluation to identify the limitations of the standard framework in the Japanese context (the findings of which are presented in Section 2.3). Second, it provided the rich, context-specific evidence needed to develop the adapted SES framework. This was a theoretically grounded process, drawing on concepts from political ecology, institutional analysis, and cultural studies to inform the creation of refined variables. The adapted framework

was then iteratively refined by conceptually applying it to representative HWC scenarios derived from the literature—a "thinking through" process that ensured the new variables were coherent, robust, and capable of generating nuanced insights.

3.5. Stage 5: The Methodology Structure of the Paper

The structure of this manuscript is a direct reflection of this methodological process. Section 2 establishes the theoretical foundation that informed the scoping review. Section 4 presents the synthesized contextual findings from the review (the output of Stages 1–3). Section 5 details the construction of the final adapted framework (the output of Stage 4). Finally, Section 6 demonstrates the framework's conceptual utility and discusses its broader implications, fulfilling the final stage of conceptual refinement and analysis.

4. Japanese Context: Socio-Ecological Landscape of HWC

This section presents the synthesized findings from the scoping review detailed in Section 3. Our analysis of the academic and policy literature reveals that HWC in Japan is not a simple problem of animal overabundance but a complex socio-ecological phenomenon driven by deep historical, cultural, and demographic forces. The review confirmed that while HWC impacts are experienced locally, the most powerful drivers are systemic and national in scale, justifying the national-level perspective of this study. The findings are organized thematically below, focusing on the rural and peri-urban landscapes where HWC is most acute and drawing examples from the key species at the center of the conflict: sika deer (*Cervus nippon*), wild boar (*Sus scrofa*), Asiatic black bears (*Ursus thibetanus*), and Japanese macaques (*Macaca fuscata*).

4.1. Historical Roots: Shifting Landscapes and Human-Nature Relations

The current HWC situation in Japan is not a sudden crisis but the culmination of long-term socio-economic and ecological transformations that have fundamentally reshaped the relationship between people and nature. Historically, Japanese society maintained a close, interactive relationship with its environment, often mediated through *satoyama* landscapes—the traditional mosaics of secondary forests, farmlands, grasslands, and settlements managed for subsistence and resource use [11]. These managed socio-ecological systems, maintained through intensive human activities like coppicing for charcoal and mowing for fertilizer [63], served not only as sources of livelihood but also acted as crucial buffer zones. They maintained a degree of ecological separation and a healthy "tension" between human settlements and the deeper mountain habitats of large mammals [12,44,64–66]. The cyclical use of resources embedded within *satoyama* management reflected an integrated system where wildlife was viewed as both a resource and a potential source of conflict, actively managed within a resilient socio-ecological structure [7].

However, the post-World War II era of rapid modernization and economic growth, driven by a national policy of industrialization, dramatically altered this dynamic. An energy revolution from fossil fuels diminished the necessity of managing *satoyama* forests for firewood and charcoal, while agricultural modernization reduced the reliance on communal labor and resources [11,63]. This shift was compounded by large-scale national afforestation programs that favored monocultures of commercial conifers like *sugi* (Japanese cedar, *Cryptomeria japonica*) and *hinoki* (Japanese cypress, *Chamaecyparis obtusa*). As these plantations matured, often with reduced thinning and management, many transformed into what ecologists term "green deserts": vast tracts of dense, dark forest with minimal

undergrowth and reduced biodiversity, fundamentally altering the traditional forest mosaic and offering poor habitat for many native species [15,64].

Compounding these land-use changes were the fundamental population shifts of widespread rural depopulation (*kaso*) and societal aging (*kōreika*) that accelerated from the mid-20th century [9,16]. The resulting abandonment of vast tracts of agricultural land—reaching 253,000 hectares by 2023 [5]—and the under-management of *satoyama* blurred the once-clear boundaries between wildlife habitat and human areas [44,67]. This confluence of landscape and demographic change created highly favorable ecological conditions for adaptable generalist species. With reduced human pressure and newly available habitat, populations of sika deer and wild boar recovered and expanded their ranges dramatically. Notably, their respective distributions expanded by approximately 170% and 130% between 1978 and 2003 [14,15]. The dramatic nature of this spatial expansion is visually demonstrated in Figure 2, which maps the progressive colonization of new areas by both species over four decades. This historical trajectory established the ecological stage for the intensified HWC observed today and vividly demonstrates how broad Social, Economic, and Political Settings (S) dynamically shape core SES components. This deep historical legacy highlights the inadequacy of static analyses and reinforces the need for variables like S-HIST (Historical Land Use Legacies) and RS-LC (Landscape Transformation Dynamics) in our adapted framework.

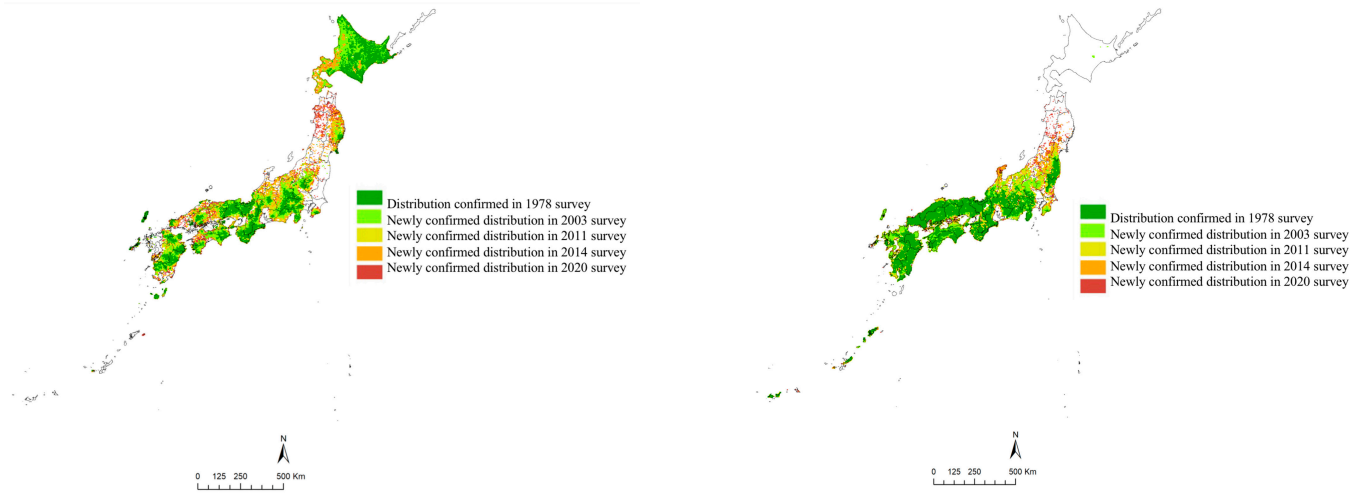


Figure 2. Maps illustrating the spatial range expansion of (**a**) Sika Deer and (**b**) Wild Boar in Japan based on national surveys. Colors indicate the survey year in which distribution was newly confirmed in an area, showing a progressive expansion from 1978 to 2020. Source: Adapted from the Ministry of the Environment [68].

4.2. Cultural Dimensions: Values, Perceptions, and Ambivalence

Understanding HWC in Japan requires grappling with complex cultural outlooks that shape perceptions and responses—a dimension often inadequately captured by standard SES models. Japanese views on nature are deeply interwoven with syncretic Shinto and Buddhist traditions that emphasize interconnectedness and respect for life [3,38,39]. Buddhist influences, in particular, which discourage the taking of life, can create profound ethical dilemmas surrounding the lethal control of wildlife, sometimes fostering a higher tolerance for damage that transcends purely economic calculations [3,69].

These traditional values, however, often clash with the pragmatic realities of HWC, resulting in complex and contradictory standpoints [37,40]. The idealized "love of nature" often associated with Japan masks a wide spectrum of views, from deep spiritual rever-

ence to pragmatic concerns about damage and fear. This cultural ambivalence is vividly illustrated in prefectures like Nagano and Gifu, where Asiatic black bears are simultaneously revered in some contexts as mountain deities (*yama no kami*) and targeted for lethal control due to safety concerns, embodying a deep-seated cultural tension [7].

This ambivalence is reflected not only in management actions but also in the very language used to discuss human–wildlife relations. The concept of *kyōsei* (coexistence), for example, is frequently invoked in policy and public discourse but remains a contested term, with interpretations ranging from passive tolerance to active, interventionist management [25,48]. Kito [25] further critiques a modern tendency towards a *kirimi* ("sliced view") of nature, where a "problem animal" is perceived as detached from its ecological context, thereby complicating integrated management.

The framework of "relational values"—emphasizing relationships, responsibilities, and stewardship connections to place [26,41]—resonates strongly in this context. The *satoyama* ideal, for instance, embodies a relationship of active stewardship that is now threatened [11]. This ethic is evident in community-led initiatives, such as those on the Kii Peninsula where local efforts to restore traditional charcoal production are framed not just as economic activities, but as attempts to reinvigorate a place-based cultural identity and responsibility toward the landscape [70]. Attitudes towards specific animals are also multifaceted; a bear can be viewed simultaneously as a destructive pest, a subject of conservation, and a bearer of cultural significance, akin to a "cultural keystone species" [71]. This intricate value landscape complicates consensus on management and requires an analytical framework with variables like A-CVR (Cultural Values & Relationality) and RU-CSV (Species-Specific Cultural Significance) to be adequately understood.

4.3. Manifestations of HWC: Damage, Impacts, and Bottlenecks

The confluence of these historical, ecological, and cultural factors manifests as tangible and multifaceted conflicts. The most prominent economic impact is agricultural damage, which totaled ¥15.6 billion in FY2022 [5]. Forestry also suffers significant damage, primarily from sika deer overgrazing and bark-stripping that hinders timber production and degrades fragile alpine and subalpine ecosystems [15,72].

Beyond direct economic losses, HWC incurs considerable "hidden costs" [7], including damage to infrastructure like fences and railways, risks to human safety from collisions and encounters, and significant social and psychological burdens on rural residents [73]. Population control through capture is a primary mitigation strategy—with approximately 720,000 deer and 590,000 boar captured in FY2022 [5]—but efforts to utilize this resource as *gibier* (wild game meat) face significant bottlenecks. Despite being a national policy goal to add value to culling activities, only 2085 tons of venison and boar meat were processed for commercial use in FY2022 due to persistent challenges in infrastructure, processing capacity, distribution, and market development [74,75].

Crucially, the impacts of HWC extend to significant social and psychological burdens. The constant stress of potential crop loss, the fear and anxiety from wildlife encounters, and a perceived loss of environmental control impose considerable stress and diminish the quality of life and well-being of community members [8,19,55]. These intangible costs are critical components of the conflict reality and often influence local attitudes and policy preferences more profoundly than monetary losses alone [56]. This reality strongly justifies the inclusion of variables like O-PSY (Psycho-Social Well-being) and A-PSY (Psychological Factors) not as secondary considerations, but as core components of any framework seeking to holistically assess HWC in Japan.

4.4. Stakeholder Deep Dive: Actors, Institutions, and Power Dynamics

The capacity to manage HWC is intrinsically linked to the actors involved and the institutional and demographic context they operate within.

4.4.1. Hunters and the *Ryōyūkai*: A System Under Strain

Registered hunters and their local association (*Ryōyūkai*) play a pivotal but increasingly strained role in HWC management. The *Ryōyūkai* are not simply user groups; they represent a unique institutional hybrid, acting as quasi-governmental bodies contracted by municipalities for pest control while also operating under strong informal norms like territoriality (*nawabari*) [47,48]. This system faces an existential crisis due to a dramatic decline and aging of the hunter cohort. Registered hunter numbers plummeted from over 500,000 in the 1970s to under 200,000 in recent years, with over 60% of the remaining hunters being aged 60 or older [4,17,72].

This demographic implosion severely strains the *Ryōyūkai*'s operational capacity. A 2022 report from Kyoto Prefecture, for instance, explicitly highlighted the increasing difficulty in fulfilling nuisance culling requests due to the advanced age and declining number of active hunters, a situation mirrored in many rural prefectures [76]. This crisis not only hinders their ability to meet culling targets but also threatens the intergenerational transmission of Traditional Ecological Knowledge (TEK) related to hunting techniques and animal behavior, weakening the informal institutions that have historically governed hunter communities [18,19].

4.4.2. Local Communities: Facing Impacts with Diminished Capacity

Rural communities are on the frontline of HWC, yet they are simultaneously undergoing the profound demographic transformations of *kaso* and *kōreika*. This diminishes their capacity for collective action, such as the physically demanding work of installing and maintaining community fences [9,19,55]. Defining the relevant "community" for collective action has itself become complex, as declining social cohesion and an influx of new residents, such as urban-to-rural migrants, can challenge assumptions of shared perspectives and values regarding wildlife management [29,43]. Consequently, tolerance for wildlife damage and support for management strategies can vary significantly, influenced by a mix of local economic, cultural, and social factors [77,78].

4.4.3. Government Actors: Multi-Level Governance and Coordination Challenges

HWC governance in Japan involves a complex, polycentric structure of national, prefectural, and municipal governments with differing, sometimes conflicting, mandates [23]. At the national level, the Ministry of the Environment (MoE) focuses on conservation and species protection under the Wildlife Protection and Proper Hunting Act (WPPHA), while the Ministry of Agriculture, Forestry and Fisheries (MAFF) prioritizes damage mitigation and supports agriculture [16,79]. This division can lead to coordination challenges. For example, the promotion of *gibier* utilization is led by MAFF to address agricultural damage, while the MoE simultaneously manages species protection plans, sometimes creating implementation dilemmas for prefectural governments tasked with balancing both objectives. This intricate multi-level system, with its flow of authority and key points of institutional stress, faces significant hurdles in ensuring effective coordination and addressing the limited capacity for implementation at the municipal level, which is the frontline for HWC response [18,80]. This structure is visualized in Figure 3.

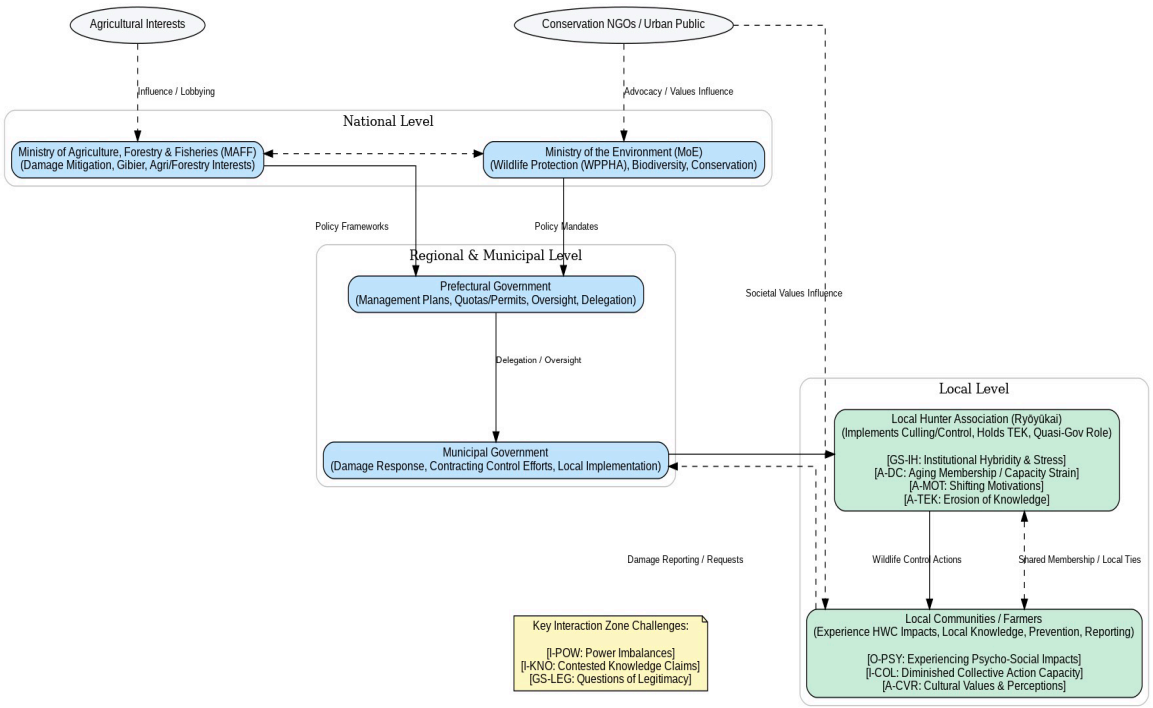


Figure 3. A conceptual model of the multi-level governance structure and key actors in Japanese Human–Wildlife Conflict (HWC) management. The diagram illustrates the flow of policy mandates, delegation, and reporting, as well as key interactions and feedback loops. Annotations in brackets refer to specific adapted variables from the SES framework proposed in this paper (see Table 1), highlighting key points of stress and conflict within the system. Solid lines indicate formal lines of authority and delegation, while dashed lines represent flows of influence, reporting, and feedback.

Table 1. An Adapted Social–Ecological Systems (SES) Framework for HWC Analysis in Japan.

Core Sub-System (Ostrom, 2009 [22])	Key Variables (Standard SES—Examples)	Proposed Adaptations/Refinements for Japanese HWC Context	Rationale/Relevance & Link to Limitations (Problem -> Solution)
Social, Economic & Political Settings (S)	S1 Econ. Development, S2 Demo. Trends, S3 Political Stability	S-DEM: Fundamental Demographic Trends (*kaso*, *kōreika*) S-CUL: Overarching Cultural Context & Narratives (*kyōsei*, Shinto-Buddhism) S-HIST: Historical Land-Use Legacies (afforestation)	Problem: Standard SES often treats deep demographic and cultural trends as external "settings", failing to capture their role as core system drivers. Solution: These variables internalize *kaso*, *kōreika*, and historical land-use legacies as fundamental endogenous forces, providing the foundational context for analyzing system-wide dynamics.
Resource System (RS)	RS3 System Boundaries, RS5 Productivity, RS8 Habitat Heterogeneity	RS-LC: Landscape Transformation Dynamics (*satoyama* status) RS-CSL: Cultural Significance of Landscape (*satoyama* heritage)	Problem: A standard approach can analyze ecological change without deeply connecting it to the underlying socio-economic roots. Solution: These variables explicitly link landscape-level changes that drive HWC (e.g., *satoyama* degradation) directly to their historical (S-HIST) and demographic (S-DEM) drivers.
Resource Units (RU)	RU1 Mobility, RU2 Economic Value, RU3 Size	RU-CSV: Species-Specific Cultural Significance & Perception (ambivalent views) RU-ECO: Ecological Role vs. Perceived Nuisance	Problem: Standard variables struggle to capture the non-material, often ambivalent, cultural meanings of wildlife that are central to social conflict. Solution: These variables are designed to diagnose the complex, often contradictory cultural views of key species, explaining why technically sound management can be socially contested.

Table 1. *Cont.*

Core Sub-System (Ostrom, 2009 [22])	Key Variables (Standard SES—Examples)	Proposed Adaptations/Refinements for Japanese HWC Context	Rationale/Relevance & Link to Limitations (Problem -> Solution)
Governance System (GS)	GS2 Govt. Type, GS6 Collective-Choice Rules, GS8 Monitoring	GS-IH: Institutional Hybridity & Stress (*Ryōyūkai* Focus) GS-MC: Multi-Level Coordination Dynamics GS-LEG: Legitimacy & Social Acceptance GS-POW: Authority Structures in Rule-Making	Problem: Generic governance variables can miss the fragility of unique local institutions and often overlook the influence of power. Solution: These variables provide specific tools to diagnose the vulnerability of unique institutions like the *Ryōyūkai* (GS-IH) and make the analysis of legitimacy (GS-LEG) and power (GS-POW) a core, explicit part of governance assessment.
Actors (A)	A1 Number, A5 Leadership, A6 Norms & Social Capital, A7 Knowledge (TEK)	A-DC: Demographic Constraints & Capacity A-CVR: Cultural Values & Relationality A-MOT: Shifting Motivations A-POW: Differential Influence & Authority A-PSY: Risk Perception & Psychological Factors	Problem: Standard actor analysis often lacks sufficient granularity to explain behavior driven by deep demographic, cultural, and psychological forces. Solution: These variables provide a richer, more realistic view by directly integrating the demographic crisis (A-DC), cultural values (A-CVR), and psychological factors (A-PSY) into the analysis of actor capacity and motivation.
Interactions (I)	Harvesting, Monitoring, Conflict, Lobbying, Self-organization	I-POW: Influence of Power on Negotiations I-KNO: Contested Knowledge Claims I-COL: Breakdown/ Adaptation of Collective Action	Problem: Interactions can be viewed as simple actions, while they are often arenas of contestation over power and knowledge. Solution: These variables explicitly frame interactions as political processes, foregrounding power (I-POW) and knowledge conflicts (I-KNO) while linking the potential for collective action (I-COL) directly to actor capacity (A-DC).
Outcomes (O)	Ecological Sustainability, Economic Efficiency, Equity	O-PSY: Psycho-Social Well-being (stress, fear) O-CUL: Cultural Acceptability & Sustainability O-EQU: Equity & Justice O-ADA: Adaptive Capacity	Problem: An overemphasis on material or ecological outcomes leads to an incomplete evaluation of management success. Solution: These variables broaden the assessment to include the critical "hidden" social, psychological, cultural, and equity dimensions, ensuring a more holistic and accurate measure of sustainable coexistence.

4.5. Power Dynamics: Unequal Influence and Hidden Conflicts

Power dynamics permeate HWC governance but are often under-analyzed in standard SES applications [31]. Power influences who defines the HWC "problem", whose knowledge is deemed legitimate (e.g., formal scientific data vs. local experiential knowledge), and who bears the costs of management decisions [30]. Power imbalances are evident between national agencies and local actors, between powerful agricultural interests and marginalized rural communities, and between urban and rural populations with different stakes in wildlife management [3,18,48].

This tension is often visible in debates over annual deer culling targets in Hokkaido, where national-level conservation goals and scientific population models can clash with the experiential knowledge and economic concerns of local farmers and hunters [15]. The perception among some rural residents that wildlife management has become solely "the government's responsibility" may reflect a sense of disempowerment, illustrating how power relations can erode local engagement and governance effectiveness [8]. Acknowledging these power imbalances, which our adapted framework seeks to capture through variables like I-POW (Influence of Power) and I-KNO (Contested Knowledge Claims), is essential for designing collaborative solutions that are not only ecologically rational but also socially just and politically feasible [53].

4.6. Synthesizing the Context: The Imperative for an Adapted SES Framework

Synthesizing the evidence from this scoping review reveals a detailed picture of the Japanese HWC context: a complex system defined by deep historical roots, ambivalent cultural values, multifaceted impacts, and a unique institutional landscape. These key findings—the legacy of *satoyama* decline, the wildlife expansion fueled by rural depopulation, the demographic crisis of the *Ryōyūkai*, the intricate multi-level governance, and the subtle but powerful influence of power dynamics—all intertwine to create a uniquely challenging socio-ecological system. These interconnected realities, identified through our review, demonstrate precisely why the standard SES framework is insufficient for effective analysis in Japan. It is this multi-layered complexity that necessitates the development of an adapted SES framework, one that is explicitly designed to diagnose the historical, cultural, institutional, and political realities that a standard approach overlooks. The following section, therefore, constructs this essential analytical tool.

5. The Adapted SES Framework for HWC Management in Japan

Building directly on the systemic challenges and contextual realities identified in the scoping review (Section 4), this section presents the adapted Social–Ecological Systems (SES) framework. The framework is designed to overcome the limitations of standard SES applications by providing specific, context-attuned variables that can capture the key dynamics—historical, cultural, demographic, institutional, and political—revealed in our literature synthesis. Building upon Elinor Ostrom's foundational work [22,24], the proposed adaptation retains the core multi-tiered structure of the SES, analyzing the Interactions (I) between Resource Systems (RS), Resource Units (RU), Governance Systems (GS), and Actors (A) that lead to Outcomes (O), all embedded within broader Social, Economic, and Political Settings (S) and related Ecosystems (ECO).

However, it critically modifies, augments, and refines the specific second-level variables to ensure greater contextual relevance. This is achieved by explicitly integrating the critical cultural, demographic, institutional, and power dimensions that our scoping review identified as essential for a comprehensive analysis but often underrepresented in standard SES applications. The framework moves these factors from passive background settings to active, system-shaping forces. As detailed in Table 1, this adapted lens is not merely a list of new components but a nuanced diagnostic tool crafted to generate deeper, more actionable insights into fostering sustainable coexistence.

5.1. Conceptual Utility: Re-Analyzing HWC Scenarios Through the Adapted Lens

To demonstrate the potential analytical difference and enhanced insights offered by the adapted framework, this subsection conceptually re-examines three representative HWC scenarios prevalent in contemporary Japan. These scenarios—(1) the systemic strain on the *Ryōyūkai* system in wildlife control, (2) the interplay of *satoyama* degradation, sika deer expansion, and responsibility conflicts, and (3) the complexities of cultural ambivalence and power in Asiatic black bear management—were selected because they vividly illustrate the critical interplay of the cultural, demographic, institutional, and power-related factors central to HWC in Japan. These are precisely the types of complexities where standard SES applications may prove insufficient, thus allowing for a clear demonstration of the adapted framework's added value. This is an illustrative conceptual analysis based on documented situations and existing literature, designed to highlight the framework's diagnostic utility, not an empirical application with new primary data.

5.1.1. Scenario 1: The Systemic Strain on the Ryōyūkai System

(1) The Scenario: Rural municipalities across Japan are heavily reliant on local hunters association (*Ryōyūkai*) for implementing population control measures, formalized through government contracts deemed essential for managing significant agricultural damage [5]. However, this system faces a profound crisis. Registered hunter numbers plummeted from over 500,000 in the mid-1970s to under 200,000 in recent years, and the remaining cohort is severely aged, with over 60% being 60 or older by the mid-2010s [17,45]. This demographic collapse places immense pressure on the aging *Ryōyūkai*, with hunter motivations reportedly shifting from recreation toward a burdensome sense of duty [48].

(2) Standard SES Analysis (Potential Focus & Limitations): A standard SES analysis would correctly identify symptoms like a declining number of actors (A1), leading to insufficient harvesting. The diagnosis would likely focus on ineffective rules or poor compliance within the Governance System (GS). However, this risks a critical misdiagnosis. By treating profound demographic change as merely an external "setting" (S2), this approach would frame the problem as a simple "hunter shortage" and fail to diagnose the deep structural crisis, interpreting it instead as a mere operational failure.

(3) Adapted SES Analysis (Enhanced Insight): In contrast, the adapted framework enables a multi-level, systemic diagnosis. The analysis begins at the macro level with S-DEM (Fundamental Demographic Trends), which frames rural depopulation and societal aging not as external factors but as core endogenous drivers. This macro-level force then manifests at the actor level through A-DC (Demographic Constraints & Capacity), explaining the severe erosion of hunter capacity and the intergenerational loss of place-based hunting skills—a dynamic of TEK (Traditional Ecological Knowledge) erosion [19,20]. This actor-level crisis, in turn, places immense pressure on the unique governance structure, a dynamic best analyzed through GS-IH (Institutional Hybridity & Stress). This variable allows a focused diagnosis of the precarious quasi-governmental role this association inhabits. The resulting conflict between strained institutional capacity and government demands can then be understood as a power imbalance, analyzed through I-POW (Influence of Power on Negotiations).

(4) Deeper Insight & Management Implications: This analysis reframes the problem entirely, from a "hunter shortage" to a "systemic institutional vulnerability". This deeper diagnosis shows that superficial solutions like recruitment drives are insufficient. Instead, it points toward fundamental interventions: institutional reform and direct financial support to address GS-IH, the creation of systematic knowledge preservation programs to combat TEK erosion, and the design of collaborative, power-aware target-setting processes (I-POW) that respect the real-world motivations (A-MOT) and capacity (A-DC) of aging hunters. Such measures are crucial for enhancing the perceived legitimacy (GS-LEG) of the entire management system.

5.1.2. Scenario 2: *Satoyama* Degradation and Sika Deer Conflict

(1) The Scenario: Expanding sika deer populations are causing significant agricultural and forestry damage across Japan, a trend intrinsically linked to the degradation of *satoyama* landscapes [15]. This degradation is driven by rural depopulation and aging (S-DEM), leading to widespread land abandonment and diminishing the critical buffer zones between wildlife habitats and human areas [11]. Farmers bear not only the economic costs but also significant psychological burdens (O-PSY), while responsibility for management is often contested between local communities and government agencies [8].

(2) Standard SES Analysis (Potential Focus & Limitations): A standard SES framework would identify habitat alteration (RS) leading to increased deer numbers (RU) and damage (O). The analysis would then search for failing rules within the Governance Sys-

tem (GS). This approach risks a narrow, ahistorical diagnosis, failing to deeply connect the landscape change to its underlying socio-demographic drivers and treating farmer stress as a secondary issue rather than a core outcome.

(3) Adapted SES Analysis (Enhanced Insight): The adapted framework constructs a more integrated and historically-grounded causal narrative. It explicitly links macro-level drivers like S-DEM and S-HIST (Historical Land-Use Legacies) to the landscape-level changes captured by RS-LC (Landscape Transformation Dynamics), revealing deer expansion as a direct symptom of rural social–ecological decline. This landscape change directly impacts local communities, whose capacity to respond is shown to be limited by A-DC (Demographic Constraints). The resulting conflicts over management responsibility are then analyzed as a political process through I-POW (Influence of Power) and I-KNO (Contested Knowledge Claims). Finally, the framework recognizes that the degradation of the *satoyama* itself constitutes a cultural loss, a dynamic captured through RS-CSL (Cultural Significance of Landscape) and A-CVR (Cultural Values & Relationality).

(4) Deeper Insight & Management Implications: The problem is reframed from a "deer overpopulation" issue to a "systemic rural social–ecological decline". This insight immediately clarifies that species-centric controls alone are inadequate. The analysis points toward integrated, place-based solutions that address the identified root causes: embedding HWC management within broader rural revitalization policies (to address A-DC) and supporting stewardship initiatives that recognize and bolster the deep cultural and relational values (RS-CSL, A-CVR) tied to these threatened landscapes.

5.1.3. Scenario 3: Cultural Ambivalence and Power in Bear Management

(1) The Scenario: Encounters with Asiatic black bears in rural Japan lead to heightened public anxiety and intense debate (O-PSY), particularly in northern and central Honshu [28]. Management often involves lethal control, but these actions are frequently contested. This contestation is fueled by the bear's powerful and ambivalent cultural status (RU-CSV)—simultaneously feared as dangerous but also respected as a mountain deity (*yama no kami*)—and by clashing value systems (A-CVR) among stakeholders like local residents, urban conservationists, and government agencies [3,38].

(2) Standard SES Analysis (Potential Focus & Limitations): A standard analysis would identify a conflict between different stakeholder preferences, likely diagnosing the problem as a simple clash of values. It would fail to capture the deep-seated cultural ambivalence that often exists within individuals and communities, and would lack the explicit tools to analyze how power dynamics determine whose definition of the "bear problem" ultimately dominates policy.

(3) Adapted SES Analysis (Enhanced Insight): The adapted framework explains the social contestation by centering the analysis on RU-CSV (Species-Specific Cultural Significance) and A-CVR (Cultural Values & Relationality), which clarifies why technical solutions often lack social legitimacy (GS-LEG). It then elevates public fear to a central analytical variable through A-PSY (Risk Perception) and O-PSY (Psycho-Social Well-being). Decisions made in this emotionally charged context are then analyzed as a political process, using I-POW (Influence of Power on Negotiations) and GS-POW (Authority Structures) to diagnose how power asymmetries shape the policy agenda.

(4) Deeper Insight & Management Implications: This reframes the problem from a "bear control" problem to a "human–human conflict rooted in risk perception, cultural values, and power". This makes it clear that effective management must be human-centric. The framework points toward a portfolio of human-dimension-focused solutions: strategic risk communication (to address A-PSY), participatory governance processes designed to navigate value conflicts and build legitimacy (GS-LEG), and psycho-social support for

communities (to mitigate O-PSY), all while considering the limited capacity (A-DC) of local actors to implement preventative measures.

5.2. Synthesis: The Value of an Adapted Lens for Understanding and Action

These conceptual applications collectively demonstrate the significant added analytical value of the adapted SES framework. By systematically incorporating crucial contextual factors indigenous to Japan—such as deep-seated cultural values (A-CVR, RU-CSV), profound demographic transformations (S-DEM, A-DC), unique institutional arrangements like the *Ryōyūkai* (GS-IH), embedded power structures (I-POW, GS-POW), and often-neglected psycho-social outcomes (O-PSY)—the adapted framework moves significantly beyond the generic component listing found in many standard SES applications. It thereby functions as a more powerful and nuanced diagnostic tool, capable of revealing the deeper, systemic drivers and complex interconnections shaping HWC in Japan.

The scenarios illustrated how the framework, through specific variables like GS-IH (Institutional Hybridity & Stress) and O-PSY (Psycho-Social Well-being), helps to disentangle the socio-demographic roots of landscape change, understand the institutional stresses leading to governance failures, appreciate the role of cultural ambivalence in shaping management acceptability, and identify hidden power dynamics captured through I-POW (Influence of Power). This enhanced, systemic understanding surfaces critical leverage points often missed by standard analyses—such as the need for *Ryōyūkai* institutional adaptation, addressing the socio-economic roots of *satoyama* deterioration, and navigating cultural ambivalence through legitimate participatory processes. This is essential for formulating management interventions that are not only ecologically sound but also socially acceptable, institutionally feasible, culturally resonant, and politically viable within the specific context of contemporary Japan [2,23]. In essence, the adapted framework moves the analytical focus from merely managing "problem animals" to understanding and governing complex, stressed, and culturally rich social–ecological systems, which is a more accurate and ultimately more effective approach to fostering long-term coexistence.

6. Discussion and Implications

This concluding section synthesizes the contributions of this study, which stem from the application of a scoping review methodology to develop an adapted Social–Ecological Systems (SES) framework for Human–Wildlife Conflict (HWC) in Japan. The discussion first articulates how the adapted framework, as the primary output of this review, achieves its goal of providing a more nuanced analysis. It then translates these analytical insights into actionable policy recommendations, explores the broader theoretical contributions of this work to SES scholarship, and acknowledges the study's limitations before offering concluding remarks on the path toward sustainable coexistence.

6.1. Discussion: Advancing the SES Framework for a Culturally Informed HWC Analysis in Japan

This paper's central aim was to develop and demonstrate a culturally and institutionally attuned adaptation of the SES framework to enable a more robust analysis of HWC in contemporary Japan [1,2]. This objective was achieved through the scoping review methodology detailed in Section 3, which allowed for the systematic synthesis of evidence needed to construct the adapted framework presented in Section 5. By moving beyond a generic model, this adaptation provides a more potent diagnostic tool capable of revealing the deep-seated, interconnected drivers of HWC in Japan. Its value lies not in discarding the foundational architecture of the SES approach, but in sharpening its focus to reveal the specific causal pathways and feedback loops driving conflict within Japan's unique socio-ecological landscape [22].

The primary contribution of the adapted framework, as constructed from the evidence synthesized in our review, is its capacity to address critical contextual gaps inherent in many standard SES applications. First, by internalizing Japan's profound demographic shifts as a core endogenous driver (S-DEM), it offers a more dynamic and realistic analysis of system change. Where standard models might treat population trends as an external pressure, our framework operationalizes rural depopulation (*kaso*) and societal aging (*kōreika*) as a fundamental force shaping the entire system [9]. As demonstrated in the analysis of the deer expansion scenario (Section 5.1.2), this allows for a direct causal linkage to landscape-level transformations (RS-LC), such as the degradation of *satoyama* buffer zones [12], and to the erosion of community capacity for collective action (A-DC).

Second, the framework successfully incorporates the cultural and psycho-social dimensions that are central to Japanese human–nature relationships but are often treated as externalities. The adapted variables A-CVR (Cultural Values & Relationality) and RU-CSV (Species-Specific Cultural Significance) provide the analytical vocabulary to explore non-utilitarian motivations, the complex meanings of *kyōsei* (coexistence), and the ambivalent cultural status of animals like the Asiatic black bear [3,25]. This enables an analysis grounded in the relational ethics that shape human–nature interactions [26,40]. Furthermore, by broadening the scope of outcomes to include O-PSY (Psycho-Social Well-being), the framework formally recognizes the "hidden" human costs of HWC, ensuring that crucial impacts like farmer stress and anxiety are treated as core outcomes rather than secondary externalities [6,55].

Third, the framework provides the necessary tools to diagnose institutional realities and power dynamics with greater precision. The variable GS-IH (Institutional Hybridity & Stress) facilitates a focused analysis of the *Ryōyūkai* hunters association, capturing their unique quasi-governmental role and extreme vulnerability to demographic pressures [17,28]. This is complemented by the explicit integration of power variables (I-POW, GS-POW), addressing a well-documented flaw in many apolitical SES applications and recognizing that governance is an inherently political, not merely technical, process [30,31]. The cumulative effect of these adaptations is a significant enhancement of diagnostic power. As conceptually demonstrated, the analysis is elevated from identifying a "hunter shortage" to diagnosing a systemic "institutional vulnerability" crisis, and from framing the issue as a "deer problem" to understanding it as a symptom of "rural social–ecological decline". This deeper diagnosis provides a far stronger foundation for the targeted policy implications that follow, helping to avoid the trap of proposing simplistic solutions that are unlikely to succeed [32].

6.2. Policy Implications: Towards Culturally Informed and Adaptive Management

The systemic understanding of HWC generated by the adapted SES framework translates directly into integrated policy recommendations. These proposals move beyond fragmented, species-centric measures toward holistic strategies aimed at building adaptive capacity and fostering sustainable human–wildlife coexistence in Japan. They are grouped into three interconnected thematic areas.

First, policy must focus on reforming and supporting wildlife management structures and capacities. The framework's diagnosis of the *Ryōyūkai* crisis—captured through GS-IH and A-DC (Demographic Constraints & Capacity)—points to the urgent need for direct institutional support. With hunter numbers having plummeted and the remaining cohort aging, relying on a declining volunteer base is unsustainable [17,81]. Policies must provide tangible support, including stable funding, logistical aid, and a clarification of mandates that realistically aligns with the capacity and shifting motivations (A-MOT) of its aging members [28,45]. This must be coupled with systematic programs for preserving and

transmitting traditional ecological and hunting knowledge (A-TEK) before it is lost [18,19]. To complement the strained *Ryōyūkai*, policy must invest in diversifying management actors, for instance by fostering professionalized Certified Wildlife Control Operators and enhancing the role of municipalities [79,82].

Second, policy must integrate HWC management with broader rural development and landscape stewardship. The framework reveals that HWC is a symptom of broader rural decline (S-DEM) and landscape transformation (RS-LC). Therefore, HWC management must be embedded within comprehensive rural revitalization policies, such as the *chiiki okoshi kyōrokutai* (Local Vitalization Cooperator) program, that tackle the root causes of depopulation and support sustainable rural economies [9]. This includes promoting a *satoyama* renaissance through initiatives that support the active management of these vital buffer landscapes, recognizing not only their ecological function but also their deep cultural significance (RS-CSL) and the relational values (A-CVR) they embody [11,83]. As part of this integrated approach, the sustainable utilization of wildlife as a resource, such as through *gibier* (wild game), should be explored, though its success is contingent on overcoming significant logistical, market, and cultural challenges [74,75].

Third, policy interventions must be designed to enhance governance legitimacy and address social and psycho-social dimensions. To build trust and social acceptance (GS-LEG), governance must shift towards inclusive, participatory decision-making processes that explicitly acknowledge and work to mitigate power imbalances (I-POW) between stakeholders [2,3]. Communication strategies must be sensitive to diverse cultural viewpoints (A-CVR) and engage in genuine dialogue to define *kyōsei* in context-specific ways [63]. Crucially, policy must recognize and address the significant psycho-social burden (O-PSY) of HWC by establishing community support mechanisms for those affected by stress and fear, thus ensuring that management is not only technically sound but also procedurally just [6,8,55]. This enhances procedural justice, which is fundamental to ensuring that the costs and benefits of management are distributed equitably (O-EQU).

6.3. Theoretical Implications: Context, Power, and Demography in SES Analysis

Beyond its application to Japan, the contextual adaptation undertaken in this study holds broader theoretical implications for SES research. It powerfully reinforces the imperative of contextualization and offers a methodological pathway for adapting the SES framework to culturally distinct or rapidly changing societies. This paper's unique contribution is in offering a transferable methodology for adapting the framework itself by foregrounding three critical elements:

(1) Contextualization and Culture: By systematically integrating variables like A-CVR and O-PSY, this paper provides a model for how SES analysis can be made more culturally sensitive. It demonstrates a concrete pathway for incorporating the often-neglected relational, emotional, and ethical dimensions of human–nature interactions, offering a richer understanding of motivations and well-being [26,56].

(2) Power and Politics: The study contributes to the call to make SES analysis more politically aware. Explicitly incorporating authority and influence (GS-POW, I-POW) aligns with critical perspectives arguing that resource governance is an inherently political, not merely technical, process [30,31]. Recognizing that power shapes whose knowledge counts and who bears the costs is fundamental for diagnosing governance failures and designing equitable interventions [84].

(3) Endogenous Demography: The study highlights the need to treat demographic drivers as core components of SES analysis. The profound impact of *kaso* and *kōreika* in Japan demonstrates that demographic shifts should not be treated merely as external "settings". They must be integrated as fundamental, endogenous drivers that dynamically

reshape the system. This has direct relevance outside Japan, as many developed nations in North America and Europe grapple with similar conservation challenges defined by aging rural populations and shifting cultural values [1].

6.4. Limitations of the Study

This study possesses several inherent limitations. First and foremost, the adapted framework is primarily theoretical and conceptual, derived from an extensive synthesis of existing literature rather than new primary data collection. Its empirical validity and diagnostic robustness therefore require rigorous field-testing across Japan's diverse ecological, cultural, and institutional landscapes. Second, any framework, by its nature, involves a degree of simplification. The immense complexity and significant regional variations within Japan mean that further localized refinements will almost certainly be necessary. Third, the analysis is contingent upon the scope and potential biases of the available secondary sources included in the scoping review. Finally, the operationalization of key qualitative variables—particularly relational values (A-CVR), psycho-social well-being (O-PSY), and power dynamics (I-POW)—presents methodological challenges that will require further development in future empirical research.

6.5. Future Research Directions

The adapted SES framework provides a rich and structured agenda for future empirical research. Key avenues for inquiry include:

(1) Empirical Validation and Refinement: A primary need is to test the framework through comparative, mixed-methods case studies in different Japanese regions. This would assess its robustness, refine variable definitions, and gauge its real-world diagnostic power.

(2) In-depth Institutional Analysis: Ethnographic and institutional studies are needed to deeply investigate the dynamics of GS-IH (Institutional Hybridity & Stress), exploring how *Ryōyūkai* are adapting to demographic pressures (A-DC), how knowledge is transmitted (A-TEK), and their interactions with other actors. Social network analysis could be used to map governance interactions (GS-MC) and unpack power dynamics (I-POW, GS-POW) [49].

(3) Investigating the Human Dimensions: Research using mixed-methods (e.g., Q-methodology, surveys, interviews) is required to explore relational values (A-CVR), species-specific perceptions (RU-CSV), social tolerance, and the drivers of management legitimacy (GS-LEG). Such studies should prioritize measuring the lived experience and psycho-social impacts (O-PSY) on community well-being.

(4) Longitudinal and Evaluative Studies: Research is required to track how SES dynamics—especially landscape change (RS-LC) and demographic shifts (S-DEM)—evolve and influence HWC patterns over time. The framework can also serve as a robust tool for evaluating the multi-dimensional effectiveness of policy interventions, assessing impacts beyond animal numbers to include psycho-social well-being (O-PSY) and social equity (O-EQU).

6.6. Concluding Remarks

This paper has argued that HWC in Japan is a systemic social–ecological problem that defies analysis by standard SES applications. To address this, we conducted a scoping review to diagnose the specific cultural, demographic, institutional, and political factors that define the Japanese context. Using the evidence synthesized from this review, we developed a theoretically grounded adapted SES framework capable of illuminating the complex interplay of these factors. The resulting diagnostic tool, as we have demonstrated, is a more context-sensitive instrument for identifying leverage points for intervention.

The broader significance of this work lies in its answer to the urgent need to move beyond generic, "one-size-fits-all" conservation models. As demonstrated by the Japanese case, effective and equitable management is impossible without a deep engagement with the specific social, cultural, and political context of a place. By explicitly incorporating demographic change, cultural values, power dynamics, and institutional specificity, this work provides a methodological template for tailoring SES analysis to the unique challenges of other developed nations facing similar pressures.

Ultimately, the goal extends beyond mere conflict management to the cultivation of resilient social–ecological landscapes where both people and wildlife can thrive. This endeavor requires moving beyond managing "problem animals" to governing complex and dynamic "social–ecological systems". Grappling with the complexity of these connections is a central challenge of the Anthropocene, and by offering a more context-sensitive tool for this task, this research contributes to the global effort to foster more sustainable forms of human–wildlife coexistence.

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