



Economic Sustainability and Land Conversion in Bali's Tourism Sector: A Longevity Perspective through Tri Hita Karana and Hartwick's Rule

Novan Prasetyo Mukti* and Chuanchen Bi

College of Graduate Study in Management, Khon Kaen University

*mukti.n@kkumail.com

Abstract. Introduction. Bali's rapid tourism expansion has accelerated land conversion, raising concerns about long-term environmental and societal sustainability. **Methods.** Four OLS regression models (2014–2025, $n=12$) integrate Tri Hita Karana with Hartwick's Rule, using data from BPS Bali, BPN, and the Bali Tourism Board, with COVID-19 structural break controls. **Results.** International arrivals significantly drive hotel occupancy ($\beta=5.556$, $p<0.001$) and occupancy drives GRDP growth ($\beta=0.337$, $p<0.001$), confirming the tourism-to-growth mechanism. Arrivals also robustly drive land conversion ($\beta\approx 26$ ha per million tourists, $p<0.001$), while economic growth is not a significant driver. The OSS policy effect cannot be disentangled from COVID-19. **Conclusions.** Findings reveal structural imbalance across Tri Hita Karana pillars and indicate Hartwick non-compliance. Land conversion compounds societal longevity costs through physical (pollution) and psychological (solastalgia) health pathways. Tourism volume not economic growth is the primary environmental driver, underscoring the need for stronger institutional governance.

Keywords: Tri Hita Karana; Hartwick's Rule; Sustainable tourism; Land conversion; Economic growth; Longevity; Ecological grief; Pollution; Mental health; COVID-19 structural break.

1 Introduction

Bali is one of the world's leading tourism destinations, consistently recognized for its strong tourism performance and economic contribution, including being awarded the Top World Best of the Best Destination by the TripAdvisor Travelers' Choice Award 2026[1]. According to BPS Bali, in 2025 Bali recorded 9.6 million tourists, supported by 5,894 accommodations and 155,342 rooms, with an average occupancy rate of 60.62%. The tourism sector contributed 21.23% to Gross Regional Domestic Product (GRDP) in the first quarter of 2025, with unemployment declining to 1.49% and economic growth reaching 5.82% [2]. These indicators demonstrate that tourism plays a central role in Bali's economic performance.

Despite tourism's economic contributions, land conversion reaches 600–700 hectares annually, raising concerns about environmental sustainability and long-term

resilience[3]. This study examines whether Bali's tourism-driven development sustainably supports intergenerational welfare, using four OLS regression models tracing the chain from tourist arrivals through hotel occupancy and GRDP growth to land conversion. Given the small sample ($n=12$), findings are interpreted as indicative rather than definitive.

Tri Hita Karana, introduced in 1966 by Wayan Mertha and meaning “three causes of well-being” provides a cultural sustainability framework emphasizing harmony between humans and the divine (*Parhyangan*), among humans (*Pawongan*), and between humans and the environment (*Palemahan*) [4]. Beyond its cultural significance, *Tri Hita Karana* serves as a normative framework for longevity, *Parhyangan* fosters spiritual well-being associated with reduced existential risk [5], *Pawongan* sustains cooperative economic structures including the irrigation system (*subak*), and *Palemahan* preserves the ecological conditions essential for physical health, food security, and long life [6–8]. In parallel, Hartwick's Rule addresses intergenerational equity by proposing that rents derived from exhaustible resources must be reinvested into reproducible capital to maintain long-term welfare [9, 10]. Integrating *Tri Hita Karana* with Hartwick's Rule bridges cultural sustainability and economic theory, further extended here to incorporate physical (pollution) and psychological (solastalgia) health pathways. This study contributes a novel framework for assessing societal longevity in tourism-dependent economies, demonstrating that land conversion is driven by tourism volume rather than economic growth.

2 Literature and Research Framework

2.1 Tri Hita Karana and Longevity

The concept of *Tri Hita Karana*, as associated with Balinese wisdom, aims to harmonize humans, the divine, and nature [11, 12]. The foundation of this concept consists of three philosophical pillars *Parhyangan* (spiritual), *Pawongan* (social), and *Palemahan* (environmental) widely adopted by the Balinese community as their moral foundation for governing society [13]. The *Parhyangan* principle emphasizes spiritual devotion associated with lower hazard of mortality from despair [5]. *Pawongan* sustains cooperative economic structures, including the *subak*, that support livelihoods and food security. The *Palemahan* dimension provides the ecological conditions necessary for the proper functioning of both *Parhyangan* and *Pawongan* [13, 14]. Empirical findings show that environmental quality significantly contributes to life expectancy and long-term societal well-being [6–8], reinforcing the centrality of *Palemahan* as a longevity prerequisite. Therefore, degradation of the natural environment will directly weaken social harmony and spiritual life, confirming that *Palemahan* is the essential enabling condition for the sustainability of the entire *Tri Hita Karana* framework [13]. However, *Tri Hita Karana* is documented to be applied selectively in practice, with environmental problems persisting despite the philosophy's emphasis on *Palemahan* stewardship [15], underscoring the need to examine structural regulatory factors alongside cultural frameworks [16].

2.2 Hartwick's Rule, Intergenerational Welfare, and Psychological Dimensions

Hartwick's Rule is a concept for maintaining welfare across generations, requiring that all economic rents derived from exhaustible resources be reinvested into reproducible capital to maintain constant consumption over time [9], captured by the accounting equation:

$$x(t) = c(t) + \Delta k + ay(t) \quad [9]$$

Subsequent studies argue that the Hartwick Rule should be viewed as a theoretical framework explaining the conditions for maintaining constant consumption, rather than as a direct policy prescription [14]. Importantly, this study applies Hartwick's Rule as a normative evaluative lens. However, a key limitation is that direct measurement of resource rents and capital stock is not possible with currently available data at the provincial level for Bali. As a result, the analysis is limited to noting that the ongoing pattern of land conversion, coupled with the absence of a documented reinvestment mechanism, provides observable signals consistent with non-compliance as predicted by Hartwick's framework [14, 17]. Future research should incorporate adjusted net savings indicators as empirical proxies [18, 19].

Furthermore, this study extends the conventional framing of Hartwick's Rule to encompass psychological welfare. Li and Tao (2022) demonstrate that natural capital depletion reduces happiness and psychological wellbeing independently of income loss [20]. When natural capital is depleted without reinvestment, the resulting environmental change produces ecological grief the mourning of lost ecosystems and land-based ways of life which constitutes a measurable mental health burden [21]. Helm et al. (2022) quantify this empirically, finding depression and anxiety scores 2–7.5 times above population averages in communities facing land degradation and threatened resettlement [22]. Within the *Tri Hita Karana* framework, this psychological dimension maps directly onto *Parhyangan* and *Pawongan*, confirming that Hartwick non-compliance threatens not only intergenerational material welfare but the psychological integrity of the present generation.

2.3 Tourism, Land Conversion, Human Health, and Comparative Evidence

The tourism-led growth hypothesis is well established across Asian economies, with panel analysis of eleven ASEAN nations confirming that tourism substantially impacts economic growth [23], while hotel occupancy is documented as a key transmission mechanism [24]. Tourism demand modelling across post-pandemic periods consistently identifies COVID-19 structural breaks that, if uncontrolled, subject regression models to omitted variable bias [24]. Land conversion is driven more by institutional than market factors [25, 26], though tourism volume creates the demand pressure that institutional frameworks must govern. Environmental degradation resulting from land conversion carries documented longevity consequences: Rahman et al. (2022) confirm increased mortality among vulnerable populations [8], while Beyene

and Kotosz (2021) demonstrate that environmental quality improvements significantly increase life expectancy [7]. Extending this evidence base, Patz et al. (2020) document that land conversion generates particulate air pollution and groundwater nitrate contamination producing chronic disease burdens [27]; Ahmad et al. (2021) corroborate this finding [28] and Mastel et al. (2018) estimate approximately one quarter of the global disease burden attributable to environmental change operates through this pathway [29]. Together, these pathways establish that land conversion is a compound health stressor with direct longevity consequences. Comparative evidence from Phuket (coastal mangrove loss), Lombok (Mandalika community displacement [25]), and the Canary Islands (successful regulatory decoupling [26]) confirms that Bali's trajectory is neither inevitable nor unique.

2.4 Integrated Framework

Building on this literature, the integration of *Tri Hita Karana* and Hartwick's Rule provides a comprehensive framework for evaluating sustainability by bridging cultural philosophy and resource economics. Within this integrated framework, *Palemahan* ensures the preservation of natural capital, while Hartwick's Rule offsets resource depletion through capital reinvestment. At the same time, *Pawongan* and *Parhyangan* reinforce social cohesion and spiritual well-being as essential components of long-term societal stability. Moreover, Hartwick non-compliance activates a full-spectrum welfare failure material, physical through pollution pathways [27–29], and psychological through ecological grief [20–22] that together threaten the structural conditions for societal longevity. Together, these perspectives enable a holistic assessment ensuring that economic growth does not compromise environmental integrity, social harmony, or the conditions necessary to support long-term societal well-being and longevity.

3 Research Approach

3.1 Data

Secondary data from BPS Bali, BPN, the Bali Tourism Board, and government publications cover 2014–2025 ($n=12$). Four OLS regression models examine structural relationships among tourist arrivals, hotel occupancy, GRDP growth, and land conversion, with findings contextualized within the *Tri Hita Karana*–Hartwick's Rule framework. Macro-level data limitations mean community-level well-being and health outcomes are incorporated interpretively rather than empirically.

3.2 Model Specification

Four OLS models examine tourism's environmental impact using: international/domestic arrivals (demand pressure), hotel occupancy (transmission mechanism), GRDP growth (economic rent), and annual land conversion (natural capital depletion). An OSS policy dummy captures the post-2019 regulatory shift. To address COVID-19 confounding, a structural break dummy ($\text{COVID} = 1$ for 2020–2021) is

included following Nunkoo et al. (2023) and Gossling et al. (2021) [30, 31]. Three specifications are reported: (A) full sample without COVID control; (B) COVID dummy added, $n=12$ [primary]; and (C) excluding COVID years, $n=10$. Durbin-Watson and Shapiro-Wilk normality tests are reported for diagnostic adequacy.

4 Results and Discussion

4.1 Empirical Finding

International tourist arrivals significantly drive hotel occupancy ($\beta = 5.556$, $p < 0.001$, $R^2 = 0.893$), while domestic tourism has no significant effect. Occupancy in turn significantly drives GRDP growth ($\beta = 0.337$, $p < 0.001$, $R^2 = 0.758$), confirming tourism as the key transmission mechanism between external demand and regional economic performance. Results remain robust when controlling for COVID-19 ($\beta = 0.282$, $p < 0.001$, $R^2 = 0.919$). These findings highlight the structural dependence of Bali's economy on international tourism and are broadly consistent with the tourism-led growth hypothesis documented across ASEAN economies [23]. Each additional million international tourists is associated with approximately 26 hectares of annual land conversion ($\beta \approx 26.0$, $p < 0.001$, $R^2 = 0.978$), a relationship that remains stable across all model specifications. Economic growth shows no significant effect on land conversion, indicating that tourism volume not GDP is the direct environmental driver. The apparent reduction in land conversion during 2020–2021 is attributable to the COVID-19 shock rather than OSS policy, as the policy effect cannot be statistically distinguished from the pandemic structural break.

4.2 Theoretical Interpretation and Human Health Consequences

Tourism effectively drives economic growth (Pawongan), yet land conversion is driven by tourist volume rather than economic growth itself, revealing a structural Pawongan–Palemahan imbalance. The absence of reinvestment conditionality is broadly consistent with Hartwick non-compliance, though this remains normative rather than formally proven [17, 18, 32]. More importantly, this imbalance reveals consequences that extend beyond ecological accounting. The observed land conversion of 600–730 hectares annually activate a dual health pathway. Physically, loss of vegetative cover and permeable soil intensifies groundwater contamination and particulate air pollution, generating chronic respiratory, cardiovascular, and waterborne disease burdens among resident populations [21, 22, 27–29]. Psychologically, the displacement of farming communities from agricultural and sacred land produces ecological grief a measurable mental health burden producing depression, anxiety, and somatization scores 2–7.5 times above population averages [21, 22]. In Bali's context, where identity, spiritual practice, and social cohesion are inseparably tied to agricultural land and the *subak* system, forced land conversion constitutes a form of identity loss that directly undermines *Parhyangan* and *Pawongan* and through these, the longevity conditions *Tri Hita Karana* is designed to preserve. As a result, the

fundamental conditions required to maintain intergenerational welfare and societal longevity are not fully achieved.

4.3 Structural Imbalance and Longevity Implications

Together, these findings reveal structural imbalance across all three *Tri Hita Karana* pillars, consistent with Hartwick non-compliance, suggesting intergenerational welfare conditions for societal longevity are at risk [18, 19]. Hartwick non-compliance in Bali threatens material, physical, and psychological welfare — the full spectrum upon which societal longevity depends. Governance must treat community health as a core sustainability metric alongside economic and environmental indicators. The Canary Islands demonstrate that decoupling tourism growth from environmental degradation is institutionally achievable [26], confirming Bali's trajectory reflects reformable regulatory choices.

5 Conclusion

This study examined the sustainability of tourism-driven development in Bali by integrating *Tri Hita Karana* with Hartwick's Rule, with a focus on structural conditions for societal longevity. The results show that international tourist arrivals significantly drive hotel occupancy ($\beta = 5.556$, $p < 0.001$) and occupancy significantly drives GRDP growth ($\beta = 0.337$, $p < 0.001$, $R^2 = 0.758$), confirming the *Pawongan* tourism-to-growth transmission mechanism. Furthermore, international arrivals are a robust and statistically significant driver of land conversion ($\beta \approx 26.0$ ha per million tourists, $p < 0.001$ across all specifications), while economic growth is not a significant independent driver and the OSS policy effect cannot be distinguished from the COVID-19 structural break. These findings reveal a structural imbalance across all three pillars of *Tri Hita Karana* and are consistent with the signals of Hartwick non-compliance, indicating that the conditions required to sustain intergenerational welfare and societal longevity are not fully achieved. Moreover, land conversion activates two compounding health pathways — physical, through pollution-related morbidity [27–29, 33], and psychological, through ecological grief and solastalgia [20–22] that together mean the longevity costs of non-compliance extend far beyond economic accounting.

This study is constrained by a small dataset ($n=12$), normative rather than formal application of Hartwick's Rule, and the absence of community-level health data. Bali's sustainability requires managing tourism volume, not just revenue. Policy should enforce carrying capacity limits, environmental conditionality in investment licensing, and reinvestment of tourism rents into ecological and community health. These principles apply broadly across tourism-dependent Asia-Pacific economies.

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