

## Lekesan: Interdisciplinary Journal of Asia Pacific Arts

Journal homepage <http://jurnal.isi-dps.ac.id/index.php/lekesan>

# GRINGSING ETHNOSCIENCE: STRUCTURAL HOMOLOGY AND BALI AGA IDENTITY IN TENGANAN PEGRINGSINGAN

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This study analyzes the integrated ethnoscience system of the *Wayang* patterned *Gringsing* cloth, examining its role as an active agent in rituals, and understanding its function as a marker of cultural identity for the Bali Aga Tenganan Pegringsingan community. Qualitative-ethnographic research in Tenganan Pegringsingan, Bali. Data collection techniques: in-depth interviews, participant observation in the *Usaba Sambah* ritual, and analysis of *awig-awig* documents. Data analysis techniques: Miles and Huberman's model, Spradley's ethnographic analysis. Theoretical framing: ethnoscience, cultural semiotics, and structuralism. *Gringsing* is a woven codex that integrates ethno-chemistry (overdyeing as *Rwa Bhineda*) and ethno-technology. This cloth functions as spiritual armor during liminal rites of passage and a portable constitution that replicates the *Tri Mandala*. Structural homologies are found that connect the logic of purity in the domains of cloth, body (endogamy), and law (*awig-awig*). This study introduces productive inefficiency (slowdown as resistance) and structural homology as theoretical frameworks. Practically, this study identifies a controlled commodification model in which Geographical Indications (GI) are used as a defensive shield, leveraging market value to address the artisan regeneration crisis.

**Keywords:** *Ethnoscience, Gringsing, Wayang Motifs, Cultural Identity, Tenganan Pegringsingan*

Received November 2, 2025; Accepted November 2, 2025; Published November 7, 2025

<https://doi.org/10.31091/lksn.v8i2.3565>

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## INTRODUCTION

Among Indonesia's invaluable intangible cultural heritage, encompassing over 1,300 ethnic groups and having produced 13 UNESCO-recognized heritages, the Gringsing Cloth from the Tenganan Pegringsingan Traditional Village, Bali, stands out as one of the most technologically and philosophically unique textile heritages (Landrawan & Juliawan, 2022). Its global significance is underscored by its status as one of only three communities worldwide, along with the Patola in Gujarat, India, and the Kasuri in Okinawa, Japan, that still practice the double ikat weaving technique. *This method* demands mathematical precision and extreme patience, with a production process that can take up to five years (Hauser-Schaublin & Nabholz-Kartaschoff, 2012).

More than just an aesthetic artifact, Gringsing is a key pillar of the Bali Aga people's identity. This pre-Majapahit community steadfastly maintains ancestral traditions, an egalitarian social structure without caste, and resists assimilation into Bali's dominant Hindu-Javanese culture (Reuter, 2002). However, despite its visual beauty and high economic value, a comprehensive understanding of the holistic local knowledge system that gave birth to it, an ethnoscientific system integrating botany, chemistry, technology, and cosmology, remains very limited, with most previous research tending to focus on its historical, aesthetic, or commercial aspects (Darmawati, 2023).

This research problem is crucial because this tradition faces existential threats from modernization, mass tourism, and globalization. These threats include not only the loss of craft techniques but also the erosion of philosophical meaning, the erosion of traditional ecological knowledge (*indigenous ecological knowledge*) relevant to the discourse of global sustainable development, and the breaking of the chain of intergenerational knowledge transmission due to the penetration of digital technology and the shift in values among the younger generation (Rukmawati et al., 2023). With the number of active artisans continuing to decline drastically to around 12 people, the majority of whom are now over 50 years old, this integrated knowledge system is on the verge of extinction, making documentation and critical analysis a pressing urgency (Wirawan & Rosandini, 2021). Therefore, this study has the fundamental objective of filling this gap by (1) systematically documenting and analyzing the integrated ethnoscience system behind the Gringsing Wayang motif; (2) examining its role as an active agent in ritual representation, and (3) developing a theoretical framework to understand its function as a fundamental marker of cultural identity. To achieve this goal, this study adopts three main complementary theoretical lenses: an ethnoscientific approach is used to unpack local knowledge systems from an emic perspective (Mardika & Yuniati, 2022). Cultural semiotic theory is applied to read Gringsing as a sacred text that actively participates in rituals (Turner et al., 2017) and structuralism is utilized to analyze how identity is constructed through binary oppositions, as well as a new concept proposed in this study, namely structural homology (Marzali, 2014).

Based on this framework, this study specifically seeks to answer three interrelated fundamental research questions: How is the local knowledge system (ethnoscience) of the Bali Aga community in Tenganan Pegringsingan Village related to the making of Gringsing cloth with Wayang motifs? How is the representation of rituals in Gringsing cloth with Wayang motifs as a manifestation of the ethnoscience of the Bali Aga community? Moreover, how does Gringsing cloth with Wayang motifs become a marker of the cultural identity of the Bali Aga community in Tenganan Pegringsingan Village?

## RESEARCH METHOD

This study uses a qualitative research design with an ethnographic approach enriched by an ethnoscience perspective, chosen for its ability to uncover and describe the local knowledge system of the Tenganan community from the perspective of the cultural actors

themselves (*emic*) with a focus on life experiences, cultural practices, and symbolic meanings attached to Gringsing cloth (Sugiyono, 2009). This research was conducted in the Tenganan Pegringsingan Traditional Village, Manggis District, Karangasem Regency, Bali, for eight months from March to October 2025, a location chosen for its status as the only place in Indonesia where the Gringsing double ikat weaving tradition is still alive and practiced authentically. Participants or research subjects (informants) include Gringsing artisans (*artisans*) who have in-depth technical knowledge, traditional elders (*tua adat*) who are the guardians of philosophical and ritual knowledge, and the younger generation (*generasi muda*) to understand the challenges and dynamics of knowledge transmission in the modern era, with the object of research being Gringsing cloth with Wayang motifs.

Data collection was conducted through three main techniques to ensure the richness and depth of information: in-depth interviews with artisans and traditional figures to explore technical and philosophical knowledge; participant observation by directly engaging in the process of cloth-making and key traditional ceremonies such as *Usaba Sambah*; and document studies of *awig-awig* (customary law) and historical archives to provide a broader context. Furthermore, data analysis was conducted interactively and integratively using the interactive model from Miles and Huberman, which includes data reduction, data presentation, and conclusion drawing, and was then deepened through ethnographic analysis from Spradley across four stages: domain analysis, taxonomic analysis, componential analysis, and cultural theme analysis. To ensure the validity and reliability of the findings, the data were triangulated across multiple sources and methods, and *member checking* was conducted with informants (Spradley, 2016).

## RESULT AND DISCUSSION

A thorough analysis of the process of making Gringsing cloth with Wayang motifs shows that it is not just a craft product but a living archive-codex that records and embodies the sophisticated, integrated local knowledge system (ethnoscience) of the Bali Aga people (Juliawan, 2023). This system holistically unites various inseparable domains of knowledge. The philosophical foundation found is the material practice of the *Tri Hita Karana* and *Rwa Bhineda* concepts (Sastrawan & Giri, 2022). The *palemahan* (nature) dimension is manifested in the selection of natural raw materials such as Keling Cotton (*Gossypium arboreum*), noni roots (*Morinda citrifolia*), and candlenut oil (*Aleurites moluccanus*). The *pawongan* (human) dimension is manifested in socio-ecological relations with other villages, such as Bugbug Village, for the indigo dyeing process. The *parahyangan* (God) dimension is present in every prayer and ritual that accompanies the process.

In the Ethno-chemical domain, it was discovered that the deep black color of the Gringsing Wayang motif (*Gringsing Selem*) is not the result of a single pigment, but rather a sophisticated achievement through the *overdyeing technique*, where the yarn that has been dyed blue (indigo) is then dyed repeatedly in a red solution (mengkudu). From the Ethno-technological side, sophistication is manifested in the waist-clothing loom (*cagcag*) and its specific devices, such as the *pengekekan*, a small tool made of buffalo bone for micro-adjustment of each thread crossing. This process, which takes two to ten years, is identified by the community as a strategy of productive inefficiency. In the Ethnomathematics domain, it was discovered that the Wayang motif is built on the foundations of transformational geometry principles, such as bilateral symmetry (fold), reflection (mirroring), and translation (shifting), which the weavers apply intuitively.

These findings comprehensively answer the first research question by confirming that Gringsing is a holistic manifestation of ethnoscience, in line with (Pryanka & Saskara, 2023) definition, which emphasizes ethnoscience as a structured knowledge system from an emic perspective. The intertwining of material practices with the philosophies of *Tri Hita Karana* and *Rwa Bhineda* demonstrates that Tenganan ethnoscience does not separate science, art,

and spirituality, a finding that echoes research on Balinese textile cosmology (Pebryani et al., 2020). The ethnochemical process of *overdyeing* to create black is a perfect material embodiment of the *Rwa Bhineda philosophy*, where two opposing color forces unite to create a new, more sacred entity. This proves that ethnoscience and ethnophilosophy in Tenganan are two sides of the same coin, a conclusion that deepens previous understandings that often focused only on the technical aspects of dyeing (Wirawan & Rosandini, 2021).

The concept of productive inefficiency identified in this study offers a new theoretical contribution. From a modern economic perspective, this slowness is a weakness. However, within the framework of cultural resistance, this slowness and complexity become the most powerful identity defense strategies. By consciously maintaining inefficient processes, the Tenganan people symbolically sabotage the possibility of mass production and banal commodification, thereby engaging in a subtle yet effective form of everyday resistance. Finally, the intuitive application of geometric principles in Wayang motifs as visual representations of *Rwa Bhineda* is a concrete example of ethnomathematics, where mathematics serves as a bridge between the abstract (philosophy) and the concrete (cloth), communicating the most fundamental principles of cosmology.

This study found that Gringsing Cloth goes far beyond its role as a passive object in the rite, it is an active agent that represents, participates in, and shapes the rite's meaning. Production as an initiation rite in the entire process of making Gringsing itself is a long initiation rite. Each stage is sacred, from the selection of a good day (*dewasa ayu*) to the communal ceremony of *Nyikat* (thread purification), which is part of the *Usaba Sambah festival*. This process aims to infuse *taksu* (spiritual energy) into the cloth. The second social skin in the *Rites of Passage* in life cycle rites, from tooth filing (*Mepandes*) to marriage (*Nganten*), until death (Gringsing), functions as a second social skin. Individuals in a transitional or *liminal phase* are wrapped in Gringsing cloth as spiritual armor to protect them. In funeral ceremonies, Gringsing is used as a covering for the body and to carry the deceased's efigi (*Petrem*). In the portable constitution, Gringsing's role as a transformative agent reaches its peak in the *Usaba Sambah festival*. During the *Mekare-kare* (Pandan War) ritual, young men (*teruna*) wear Gringsing as their main cloth, transforming them into a *community of holy warriors*.

Each motif in the Gringsing Wayang corpus has a unique iconography that conveys specific aspects of Tenganan's social and spiritual order. Careful visual analysis reveals a rich and structured symbolic language.

## 1. Wayang Kebo Motif

**a. Visual Description:** This motif features three prominent figures, interpreted as a central authority figure (teacher or priest) giving teachings to two students. The central figure is a man wearing a turban, seated at a higher level to signify authority, facing the other two figures in a respectful gesture. The overall composition of the cloth contains 24 figures arranged around the central motif of *panggal asu* (a square motif symbolizing a village, protected by four scorpions). In this motif, the scorpions' claws are depicted as connected, forming a complete protective circle.

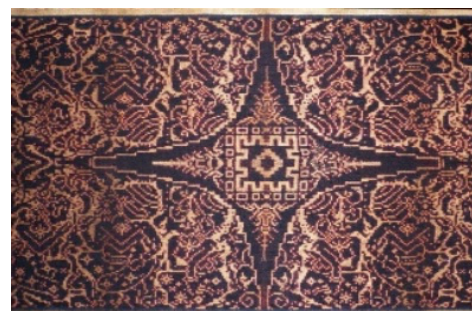


Figure 1. Gringsing Wayang Kebo

(Source: Researcher, 2025)

**b. Symbolic Meaning:** This motif is a visual narrative about achieving social and spiritual harmony through the transmission of ancestral knowledge. The name Wayang itself is derived from the word *Wah-Ya*, which means the act of explaining or teaching something. This motif symbolizes the hierarchical yet harmonious relationship between older and

younger generations, the importance of preserving tradition, and the continuity of the community's sacred knowledge.

## 2. Wayang Putri Motif

**a. Visual Description:** Unlike Wayang Kebo, this motif features only two human figures, both female, in a dynamic interaction. One figure is depicted in a higher position, while the other is in a lower position, as if worshipping. This implies a relationship of seniority, such as between a mother and daughter, or between senior and junior women in the *Daha organization* (a group of village girls). The composition contains 16 figures in total, and the scorpion claws in the *panggal asu motif* are depicted separately or unconnected.



Figure 2. Gringsing Wayang Putri

(Source: Researcher, 2025)

**b. Symbolic Meaning:** This motif powerfully reflects the role and ethics of women in Tenganan society. It visualizes the transfer of matrilineal knowledge, social etiquette, and the complex relationships between women of different generations.

## 3. Temple Wayang Motif

**a. Visual Description:** This is the most complex figurative motif, combining human figures (male and female), architectural elements resembling a temple (a sacred building), and other sacred icons such as the *cakra* (wheel/cycle) and the *trident*. The composition is dense, with 24 figures interacting around the sacred structure. The visual style of the figures and temple is said to resemble reliefs from the 13<sup>th</sup>- to 14<sup>th</sup>-century East Javanese Hindu era, such as those at Penataran and Singosari. It is said that this motif originated from a commission from a Javanese king.



Figure 3. Gringsing Wayang Candi

(Source: Researcher, 2025)

**b. Symbolic Meaning:** This motif represents the Tenganan people's conception of the cosmos, which maps the sacred interaction between humans (*pawongan*), the natural environment and its sacred buildings (*palemahan*), and the realm of the gods (*parahyangan*). It is a visual embodiment of the *Tri Hita Karana* philosophy, the three causes of happiness.

## 4. Mesila Wayang Motif

**a. Visual Description:** This motif depicts two figures sitting in a cross-legged position (*mesila*), representing a married couple. The fabric composition contains a total of 8 figures, and the scorpion claws on the *panggal asu* are depicted as unconnected.



Figure 4. Gringsing Wayang Mesila

(Source: Researcher, 2025)

**b. Symbolic Meaning:** This motif directly represents social and ethical ideals in marriage and domestic life. It symbolizes the harmony, balance, and mutual respect that should exist between husband and wife, the basic unit of the Tenganan community.

## 5. The Wayang Putri Dedari Motif and the Isi Motif

**a. Visual Description:** A crucial point is that, despite bearing the name Wayang, the *Wayang Putri Dedari motif* is described as non-figurative, containing no human figures whatsoever. The design consists of architectural and abstract elements, including a complete temple structure and a pattern of small stars.

*Isi motif* is identified as exactly half of the *Wayang Putri Dedari motif*, showing only the upper part of the temple structure.



Figure 5. Gringsing Wayang Putri Dedari and Motif Isi

(Source: Researcher, 2025)

**b. Symbolic Meaning:** This motif is considered the conceptual ancestor of all figurative *wayang motifs*. It represents the pure spiritual realm of the gods or nymphs (*dedari*), and is directly linked to the culture of offerings (*rantasan*) and worship. Its abstract nature suggests a more primordial representation of the sacred realm, before it was manifested as human figures.

The visual details that distinguish these motifs, such as the position of the scorpion's claws in the *panggal asu motif*, function as narrative devices. Connected claws, as in *Wayang Kebo* (communal knowledge) and *Putri Dedari* (the realm of the gods), may symbolize a state of complete communal unity or a high degree of spiritual protection.

In contrast, the separate claws on *Wayang Putri* (relationships between women) and *Wayang Mesila* (marriage) may represent a more personal, interpersonal, or domestic realm. Thus, these textiles employ a subtle visual code to distinguish between harmony at the public/sacred and private/social levels.

Furthermore, the relationship between the abstract *Wayang Putri Dedari* as a precursor and other figurative *wayang motifs* suggests an evolutionary trajectory in Gringsing's design language. This development moves from abstract representations of the divine realm to representations of sacred manifestations within human social structures. The history of this design reflects a theological development within the community itself.

An iconographic analysis of the *Wayang Kebo motifs* shows that their layout consciously replicates the Balinese sacred architectural concept of *Tri Mandala* (sacred, human, and profane zones), making them a portable constitution. Table 1 presents the typology and visual characteristics of the various Gringsing Wayang motifs found.

Table 1. Typology and Visual Characteristics of Gringsing Wayang Motifs

(Source: Researcher, 2025)

| Motif Name                 | Classification         | Total Number of Figures | Key Visual Elements (Figures & Icons)                      | Type of Asu (Claw) |
|----------------------------|------------------------|-------------------------|------------------------------------------------------------|--------------------|
| <i>Wayang Kebo</i>         | <i>Gringsing Selem</i> | 24                      | 3 main figures (teacher & student), men in turbans         | Connected          |
| <i>Wayang Putri</i>        | <i>Gringsing Selem</i> | 16                      | 2 female figures (senior & junior)                         | Separated          |
| <i>Wayang Candi</i>        | <i>Gringsing Selem</i> | 24                      | Male & female figures, temple buildings, chakras, tridents | Separated          |
| <i>Wayang Mesila</i>       | <i>Gringsing Selem</i> | 8                       | 2 figures sitting cross-legged (husband & wife)            | Separated          |
| <i>Wayang Putri Dedari</i> | <i>Gringsing Selem</i> | 0 (Non-figurative)      | Intact temple building, star pattern, dog                  | Connected          |
| <i>Isi</i>                 | <i>Gringsing Selem</i> | 0 (Non-figurative)      | The upper half of the Princess Dedari motif                | Connected          |

This finding answers the second research question by applying a cultural semiotics framework, which views Gringsing as a living sacred text. The concept of the production process as a ritual aligns with Darmayuda (2020) research. However, this study deepens it by showing that this ritualization ontologically transforms ordinary materials into entities that possess *taksu* from birth. Gringsing's function as a second social skin in *rites of passage* is a direct application of theoretical framework on *liminality* (Turner et al., 2017).

Individuals in a spiritually vulnerable transitional phase are wrapped in the cosmic harmony embodied by the cloth, a practice also found in other sacred textile traditions in Indonesia (Weiner & Schneider, 2013). The culmination of this analysis is the interpretation of Gringsing as a portable constitution. The finding that the layout of Wayang motifs replicates the sacred architecture of *the Tri Mandala* is a significant contribution that has not been explicitly addressed in previous research. This suggests that wearing Gringsing is an act of *embodying* and reaffirming the entire cosmological, theological, and social order of the Tenganan people. The role of Gringsing in creating *communitas* during the *Mekare-kare ritual*, as analyzed through Turner's lens, also strengthens Ramseyer, (2009) argument about *Usaba Sambah* as a theater of the universe, where Gringsing functions as a sacred costume that transforms its actors.

This study also found that Gringsing Cloth is the main arena in which the unique identity of Bali Aga Tenganan is constructed, strengthened, and maintained. Identity through binary opposition. Tenganan identity is fundamentally defined through a series of binary oppositions to the outside world, including: (1) Tenganan (inside/Bali Aga) vs. Outside (Bali Majapahit/Modern); (2) Sacred vs. Profane; and (3) Original vs. Imitation, where the emergence of imitation cloth actually strengthens the authentic value of Gringsing's authenticity.

**Structural homology** The most significant theoretical finding of this study is the existence of structural homology, a fundamental logic of purity and boundary maintenance that is coherently applied in three crucial cultural domains, cloth (Cloth), which rejects foreign materials and techniques; body (Body), which rejects foreign blood through strict endogamous marriage rules; and law (Law), where *awig-awig* rejects foreign ownership by prohibiting the sale of land. In the modern era, this identity is maintained through strategies of resistance and adaptation. In addition to daily resistance through slow production processes, the Tenganan community also engaged in institutional *bricolage* by adopting modern legal instruments, namely registering Geographical Indications (GI) in 2016. The use of Gringsing as a souvenir for the G20 Summit and its significant price increase indicate a controlled commodification strategy.

Table 2. Structural Homology in Tenganan Culture

(Source: Researcher, 2025)

| Domain       | Applicable Rules                                                                                 | Object of Regulation                            | Underlying Logic                                                                                     |
|--------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Cloth</b> | <i>double ikat</i> technique, natural dyes, and exclusively in Tenganan.                         | The textile itself.                             | Rejection of foreign techniques and materials. Maintaining the purity and authenticity of materials. |
| <b>Body</b>  | Endogamous marriage was enforced; women who married out had to leave the village.                | Lineage/blood.                                  | Rejection of foreign blood. Maintaining genealogical purity and community integrity.                 |
| <b>Law</b>   | <i>Awig-awig</i> prohibits the sale of land to outsiders and strictly regulates social behavior. | The social and territorial body of the village. | Rejection of external ownership and influence. Maintaining legal and cultural sovereignty.           |

This finding answers the third research question using (Strauss & Corbin, 2003) structuralist framework, which states that cultural meaning is often constructed through binary oppositions. This study demonstrates how the Bali Aga Tenganan identity is actively constructed by distinguishing itself from others. The concept of structural homology proposed in this study represents a significant theoretical contribution. It demonstrates that Gringsing is not merely a symbol, but rather a material manifestation of the most fundamental organizing principles of Tenganan society.

The same logic of purity and rejection of foreign elements is woven into the fabric, written into law, and reproduced through the body. This provides a much deeper understanding of why Gringsing is so fundamental to Tenganan identity. In addressing contemporary challenges, this study's findings align with (Kurniawan et al., 2024) research on Geographical Indications but go further by interpreting it as institutional *bricolage*. The Tenganan community has cleverly adopted modern legal tools not for mass commercialization, but to control cultural narratives and combat plagiarism. This reveals a paradoxical dynamic of controlled commodification, often viewed as a threat (Sendra, 2023) and strategically leveraged as a tool for preservation. Interaction with the global market has boosted the price of Gringsing, thereby creating a strong economic incentive for younger generations to learn the craft, directly addressing the regeneration crisis identified (Sudarmanto, 2022). It demonstrates the resilience and cultural intelligence of communities as they navigate the challenges of the times, offering a dynamic, adaptive model for cultural heritage preservation.

## CONCLUSION

This research concludes that the *Gringsing* cloth with *Wayang* motifs from Tenganan Pe Gringsingan is not simply a traditional textile but rather a woven codex, a living, holistic system embodying ethnosience, ritual order, and the cultural identity of the Bali Aga people. Key findings reveal, first, that *Gringsing* is the product of a sophisticated ethnoscientific system that intrinsically connects philosophy and practice. This system integrates ethnochemistry, specifically the overdyeing technique to create black from blue and red, as a direct material manifestation of the philosophy of *Rwa Bhineda* (sacred dualism), with ethnotechnology, such as the specialized *pengekeke* tool for micro-adjustments, and ethnomathematics, the intuitive application of geometric principles to encode cosmology.

Furthermore, this research finds that *Gringsing* functions as an active agent in ritual rather than a passive object. Its production is an initiation rite that infuses *taksu* (spiritual energy) into the cloth. In practice, *Gringsing* functions as a second social skin, protecting individuals during liminal rites of passage, such as tooth filing or death, and as a portable constitution, where the layout of *Wayang* motifs replicates the *Tri Mandala* (sacred architecture) for the wearer to embody. Third, *Gringsing* is a central arena for identity construction, defined through binary oppositions (Tenganan vs. outside, sacred vs. profane,

original vs. imitation). The most significant theoretical finding is the identification of structural homology, a single, coherent logic of purity and boundary preservation reflected in the domains of cloth (rejecting synthetic materials), the body (strict endogamous rules), and law (*awig-awig* prohibiting the sale of land).

Theoretical implications of this research include recognizing productive inefficiency and the deliberate delay of production (up to 10 years) as forms of cultural resistance to mass commodification. The concept of structural homology (cloth/body/law) offers a new analytical framework for the study of material culture. Practically, this research identifies a successful model of controlled commodification. It demonstrates how a community can engage in institutional bricolage by adopting modern legal instruments, such as Geographical Indications (GI), not for mass commercialization but as a defensive shield to control cultural narratives and combat plagiarism. This strategy paradoxically leverages market forces to generate the economic value needed to resolve the internal crisis of artisan regeneration, offering a vital policy model for sustainable heritage.

The limitations of this research stem from its qualitative-ethnographic methodology. It must be acknowledged that the contextual-specific (Tenganan) and non-quantitatively generalizable nature of the findings are not weaknesses, but rather characteristics of the ethnographic design itself. More substantive limitations lie in several areas. First, the scope of this research deliberately focused on *Wayang* motifs; as a result, other sacred motifs such as *Lubeng* or *Cecempakan* were not analyzed using the same ethnoscientific framework. Second, a critical methodological limitation lies in the tension between etic (researcher) theoretical construction and emic (community) validation. Although key concepts such as structural homology have been proposed, future research should present more explicit emic evidence demonstrating that the logic of purity is indeed consciously similarly conceptualized by the community, to avoid the risk of overinterpretation by researchers. Third, discussions of research ethics and researcher reflexivity, particularly regarding the researcher's position as an outsider interpreting sacred knowledge, could be presented in greater detail to demonstrate how meaning and data representation are negotiated. Fourth, while the symbolic impact of GI certification has been established, its direct quantitative impact on artisans' incomes has not been measured.

These limitations suggest several avenues for future research. We recommend (1) a longitudinal quantitative study to precisely measure the economic impact of GI status on artisan regeneration rates; (2) a comparative ethnoscientific study of two other double-ikat traditions worldwide (Patola in India and Kasuri in Japan) to identify similar patterns of cultural resilience; and (3) the application of digital humanities methods to computationally map ethnomathematical algorithms across the Gringsing motif corpus. Ultimately, this research makes a significant contribution by repositioning the Kain Gringsing from a static artifact to a dynamic, living knowledge system. This research highlights the profound cultural intelligence of the Tenganan people, who have successfully navigated globalization by utilizing modern markets and legal instruments to protect, rather than dilute, their sacred traditions. This adaptive model of controlled commodification serves as a powerful and essential blueprint for the preservation of intangible cultural heritage worldwide.

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