



Interpreting flora motif in the Karmawibhangga relief: A Buddhist iconography of Borobudur

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Research

Abstract

Background: Borobudur Temple in Indonesia is one of the world's UNESCO World Heritage sites, known for its beautiful architecture, with reliefs, sculptures, and carved stone. The Karmawibhangga reliefs, hidden at the temple's foot, uniquely illustrate the law of karma through cause-and-effect vignettes. Despite their fragmented preservation, these reliefs reveal flora as active narrative elements, though their species and symbolic roles remain understudied.

Methods: This study employed a multidisciplinary approach to analyse the flora motifs in the 160-panel Karmawibhangga. Flora identification was conducted through a morphological approach, comparing the habitus, roots, stems, leaves, flowers, and fruits, and analysing relief as a discourse that combines social and ecological dimensions in an interpretive manner. Narrative structure was examined through intratextual, intertextual, and extratextual.

Results: This study identifies 39 plant species—dominantly *Mangifera indica* (mango), *Calophyllum inophyllum* (tamanu), and sacred composites such as the *Kalpataru*—through morphological analysis and cross-referencing with the Javanese flora and Buddhist texts. Results reveal intentional species selection: mango groves reflect abundance and meditation sites, while tamanu's riverbank habitat symbolises karmic dissemination. Spatial analysis shows that the flora is arranged hierarchically (middle > left > middle > right panels) and viewed from distinct angles (frontal, aerial, and ground-level), reinforcing narrative themes. The *Kalpataru*, blending *Ficus religiosa* (Bodhi tree), *Garcinia mangostana* (mangosteen), and *Nelumbo nucifera* (sacred lotus), exemplifies sacred hybridity, strategically placed in the north-east panels associated with heavenly realms (svargga). Agricultural depictions (taro, rice, millet) further intertwine subsistence with cosmology, as millet's north-facing panels align with Buddhist celestial symbolism. The study underscores flora as semiotic devices that encode karmic principles through ecological realism and artistic convention.

Conclusion: The Karmawibhangga reliefs depict flora as a dynamic semiotic system. By integrating naturalistic details with doctrinal symbolism, these reliefs can articulate a holistic vision of life's meaning.

Keywords: Borobudur, Buddhist iconography, Flora symbolism, Javanese ecology, Karmawibhangga reliefs

Background

The Karmawibhangga relief at Borobudur Temple, hidden at the structure's base and only partially ornamented in Javanese Hindu-Buddhist and Islamic art, transcends mere decoration, embodying aesthetic, symbolic, and technical functions (Sunaryo 2009). Temples such as Borobudur and Prambanan, as well as mosques such as Demak, feature intricate carvings that encode cultural and religious values through flora, fauna, and geometric motifs (Setiawan 2019, Supatmo 2016). While these ornaments enhance visual appeal, their more profound significance—particularly in Buddhist contexts—often reflects cosmological principles or doctrinal narratives (Ashari *et al.* 2021, Maryanto *et al.* 2025a, Rusdianto *et al.* 2020). Borobudur Temple, with its 1,460 narrative panels, exemplifies this tradition, in which floral fauna motifs are integral to storytelling rather than mere embellishments (Metusala *et al.* 2020, Mujiono 2021).

As the world's largest Buddhist monument (123 × 123 meters, 35.4 meters tall), Borobudur serves as a stone "text" depicting the Buddha's teachings through reliefs (Puspitasari *et al.* 2010, Santiko & Nugrahani 2012). Its panels narrate stories such as the Lalitavistara and the Jataka, with motifs of flora and fauna serving as symbolic anchors. The Karmawibhangga reliefs, hidden at the temple's foot, uniquely illustrate the law of karma through cause-and-effect vignettes (Fontein 1989, Krom 1920). Despite their fragmented preservation (only 4 of 160 panels are visible), these reliefs reveal flora as active narrative elements, though their species and symbolic roles remain understudied (Santiko & Nugrahani 2012).

Discovered in 1885 by J.W. Ijzerman and documented by Kassian Chepas, the Karmawibhangga reliefs depict moral consequences of human actions, divided into two thematic groups: (1) singular effects from multiple causes (panels O-1 to O-117), and (2) multiple effects from singular causes (panels O-124 onward) (Krom 1920, Fontein 1989). While human activities dominate these panels, accompanying flora motifs—ranging from lotuses to mythical *Kalpataru*—remain poorly identified (Maryanto *et al.* 2025b). Their sporadic appearance suggests intentional symbolism tied to karmic themes (Hardiati & Priyambodo 2009); however, prior studies have not conducted a systematic analysis of these botanical elements.

Existing studies of Borobudur reliefs, including Karmawibhangga, often prioritize human figures or narrative sequences, neglecting the taxonomic and symbolic dimensions of flora and fauna. However, using floral associations, for example, such as the lotus flower motif in the Lalitavistara story, is a symbol associated with Buddhist cosmology related to purity (Fauziah *et al.* 2018). When combined with symbolic fauna (Achmadi *et al.* 2020), the narrative story will be read more fully. An example of this finding is revealed through a queer analysis of the Karmawibhangga story on panel O-105 (Rusdianto *et al.* 2024), which offers unexpected expectations because the story was revealed during the construction of Borobudur, linking the relationship between humans and posthumans in life behavior. Therefore, not knowing the presence of flora in the outcrop can create a gap that obscures whether these motifs function for aesthetic, narrative, or doctrinal purposes, or a combination of the three. Furthermore, the inability to identify specific plant species in the reliefs hampers cross-referencing with Buddhist texts, thus limiting the interpretation of their spiritual meaning.

This study addresses these gaps by examining the symbolism of flora in the Karmawibhangga reliefs through the lens of Buddhist iconography. Specifically, it aims to: (1) identify depicted plant species, (2) analyse their narrative and spatial distribution across panels, and (3) interpret their symbolic functions within *karmic* teachings. By integrating art-historical analysis with textual sources (e.g., Jataka tales or Abhidharma cosmology), this research seeks to demonstrate how floral motifs enrich Borobudur's ethical storytelling. The findings will contribute to broader discussions on Javanese Buddhist art, highlighting the interplay between natural imagery and moral philosophy.

Materials and Methods

This study employed a multidisciplinary approach to analyse the flora motifs in the Karmawibhangga reliefs of Borobudur Temple (Figure 1), integrating art historical, botanical, and textual methodologies. Given that only four of the 160 panels are currently accessible, the research relied primarily on archival photographs taken by Kassian Cephas in the late 19th century, as published in Krom's *Beschrijving van Barabudur* (1920). These images, preserved at the Tropenmuseum in Amsterdam and the Borobudur Conservation Centre, provided the foundational data for analysis. The reliefs follow a *pradaksina* (clockwise) narrative sequence, beginning at the east gate (Panel O-01) and extending across the temple's south, west, and north sides, concluding with Panels O-140 to O-160 on the eastern wall.

Flora identification was conducted using a morphological approach, comparing the habitus, roots, stems, leaves, flowers, and fruits depicted in the reliefs with those of living plant species. Reference materials included Flora of Java (Backer & van den Brink 1963) and the Plants of the World Online (POWO 2025) database. Given the stylised nature of the carvings,

identifications were made at the species, genus, or family level based on the most consistent diagnostic features. This method builds upon prior studies of Borobudur's botanical iconography (Metusala *et al.* 2020), ensuring taxonomic rigour while acknowledging the challenges posed by artistic abstraction.

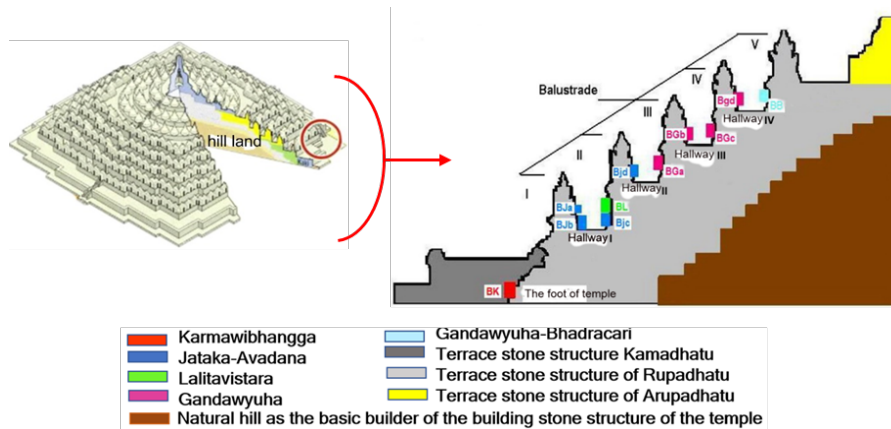


Figure 1. Location of the Karmawibhangga relief (hidden base level) at Borobudur temple (Santiko 2016, modified)

A multi-layered analytical framework was applied to interpret the flora's narrative and symbolic roles. Iconographic analysis documented the frequency, placement (*simba*), and depiction techniques (*wimba*) of motifs (Damisch 1975). Narrative structure was examined through intratextual (within-panel relationships) (Sharrock & Morales 2000), intertextual (cross-panel connections), and extratextual (links to Buddhist texts) lenses (Juvan 2005, Langlands 2018). Storytelling techniques such as dissmix (scene juxtaposition), symbolic representation, and non-linear sequencing were also evaluated to decode how flora functions as markers of setting, action, or moral themes.

To contextualise the findings, the identified flora were cross-referenced with panel narratives (Fontein 1989, Krom 1920, Santiko & Nugrahani 2012), Buddhist texts (Jataka tales, Abhidharma), and the ecological and social milieu of 8th-9th century Java (Mundayat 2021). This triangulation validated the interpretations while highlighting the interplay between artistic representation and cultural or doctrinal values.

The study acknowledges its limitations, including reliance on archival photographs, which may obscure details due to age or angle, and the inherent challenges of distinguishing between stylised depictions and realistic portrayals. To address these limitations, ethical considerations prioritised culturally sensitive interpretations grounded in Buddhist and Javanese traditions, aiming to avoid overgeneralization. By combining these methods, the research elucidates how floral motifs in the Karmawibhangga reliefs serve as both ecological records and vehicles of spiritual meaning.

Results

Botanical Symbolism in the Karmawibhangga Reliefs: Sacred Flora, Narrative Functions, and the Strategic Use of Realistic and Composite Species

The Karmawibhangga reliefs depict intricate narratives of karmic cause and effect, with flora playing a significant symbolic and contextual role. Among the 160 panels, 152 (95%) contain identifiable plant motifs, while the remaining eight panels (5%) show no discernible flora, either due to damaged carvings. A total of 384 floral sculptures were documented, with varying levels of identification success: 86.98% (334 sculptures/139 panels) were successfully identified to the species or genus level, demonstrating a precise morphological match with known Javanese flora, 2% (8 sculptures/8 panels) could not be determined due to physical damage obscuring key features, 4% (15 sculptures/13 panels) remained unidentified despite intact carvings, likely due to stylistic abstraction symbolize or non-literal representations (*Kalpataru*), 6.25% (24 sculptures/19 panels) were incomplete or ambiguously carved, preventing confident classification (Figures 2 & Table 1).

The diversity of flora includes sacred species (e.g., *Ficus religiosa* and *Nelumbo nucifer*) and native Javanese plants, suggesting intentional selection for their cultural, ecological, or doctrinal significance. However, distinguishing species with similar morphological features proved challenging, highlighting the limitations of relying solely on relief carvings for taxonomic precision.

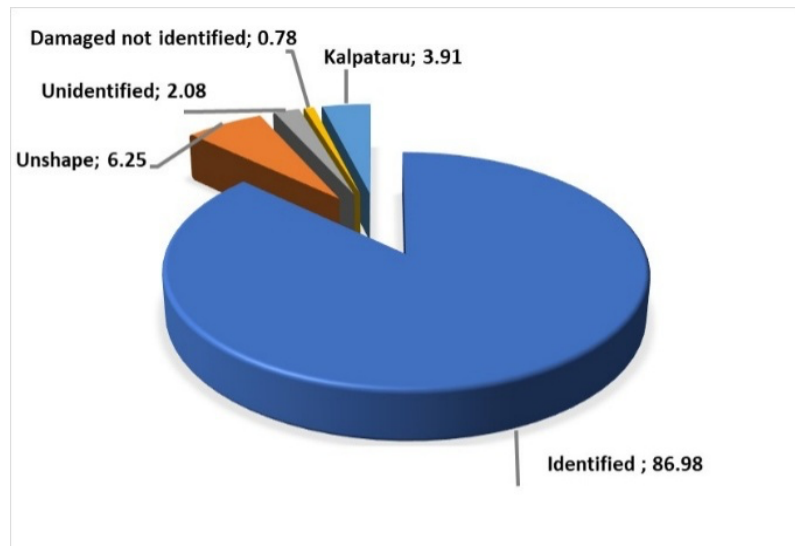


Figure 2. Distribution of floral motifs in Karmawibhangga relief panels

These findings underscore that the flora in Karmawibhangga is not merely decorative but serves as narrative anchors, marking settings (e.g., forests, villages) or symbolising karmic themes (e.g., the lotus's purity vs. thorny plants for moral consequences). The incomplete or stylised carvings in some panels suggest that floral depictions may prioritise symbolic meaning over botanical accuracy, aligning with broader Javanese Buddhist artistic conventions.

The analysis of plant species representation in the Karmawibhangga reliefs revealed significant patterns in botanical iconography. Among the 38 flora species identified to species level, *Mangifera indica* (mango; *mangga*) emerged as the most dominant species, appearing most frequently across the relief panels. This was followed by several other ecologically and culturally important species, with *Calophyllum inophyllum* (tamanu; *nyamplung*), *Terminalia catappa* (Indian almond; *ketapang*), *Artocarpus heterophyllus* (jackfruit; *nangka*), and *Syzygium aqueum* (water apple; *jambu air*) showing the following highest frequencies of occurrence (Figure 3 & Table 1).

The prevalence of these species suggests their cultural significance in 8th-9th-century Javanese society, as well as their potential symbolic functions within the karmic narratives depicted in the reliefs. *Mangifera indica*, for instance, may have been associated with abundance or spiritual nourishment. At the same time, *Calophyllum inophyllum* (traditionally used in boat-building and medicine) might symbolize resilience or healing in the context of karma's consequences. The repeated depiction of these species across multiple panels suggests their intentional incorporation as visual motifs, rather than arbitrary decorative elements.

These findings provide concrete evidence of how flora was used strategically in Borobudur's reliefs, potentially serving as environmental markers (indicating settings such as forests or villages), symbolic elements (representing Buddhist concepts), and cultural references (reflecting Javanese agroforestry practices). The quantitative dominance of these five species offers new insights into the botanical preferences of Borobudur's sculptors and their narrative priorities in visualizing karmic teachings.

The study reveals that the flora depicted in the Karmawibhangga reliefs is represented in both realistic and symbolic forms, with the *Kalpataru* (wish-fulfilling tree) serving as a prominent example of symbolic representation. This sacred motif, symbolising heavenly abundance and prosperity (Halim & Herwindo 2017), was identified as a composite of three distinct botanical elements: the heart-shaped leaves of the bodhi tree (*Ficus religiosa*), the distinctive fruit of mangosteen (*Garcinia mangostana*), and the iconic flowers of sacred lotus (*Nelumbo nucifera*) (Figure 4).

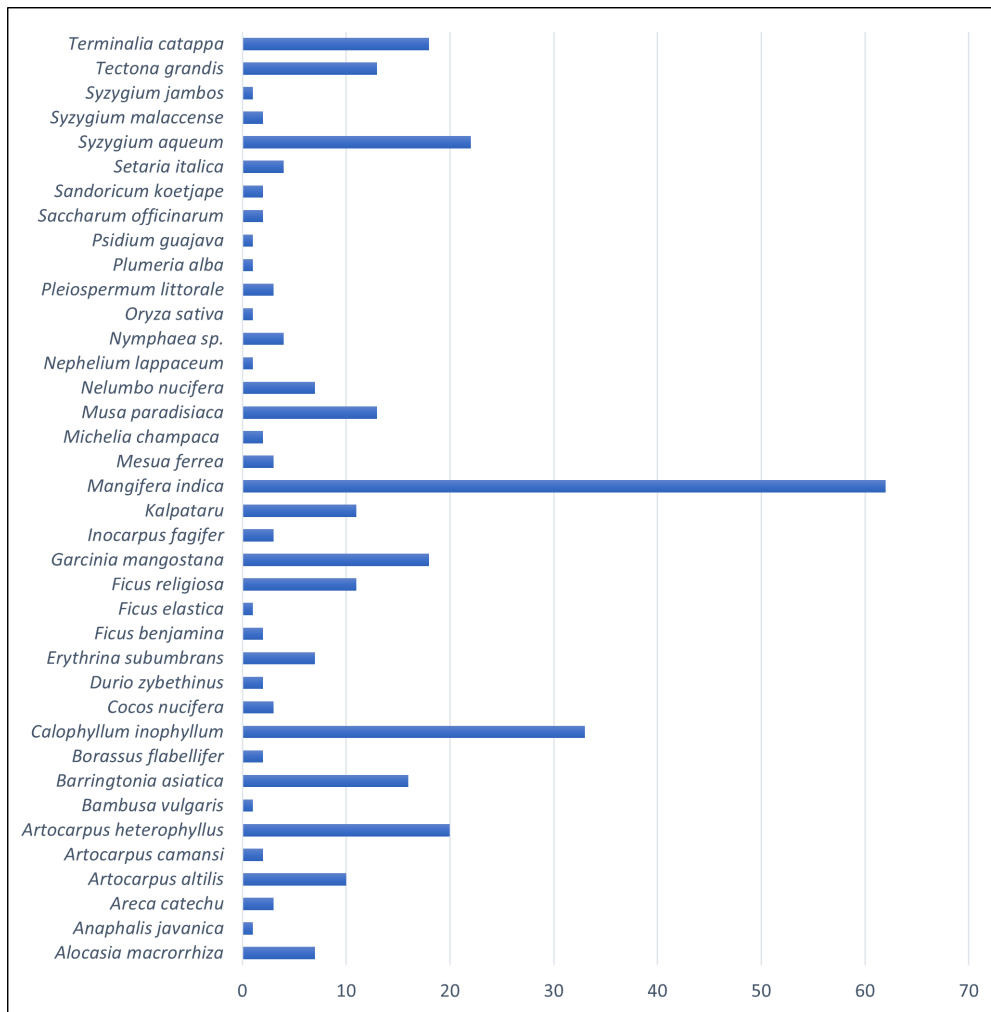


Figure 3. Number of plant species depicted in the Karmawibhanga reliefs of Borobudur temple

A total of 20 *Kalpataru* sculptures were documented across 13 panels, exhibiting a distinct spatial distribution pattern: Predominantly located on the eastern (right side: O-147, 149, 150, 154, 155, 160), and Northern (O-101, 102, 126, 130, 137, 143) temple walls. A single occurrence on the western wall (O-99), notably absent from the southern walls and the left side of the eastern walls. The *Kalpataru*'s iconographic context consistently associates it with the mythical *Kinara-Kinari* creatures, which appear together in all but two instances (O-99 and O-154). Panel O-160 presents a unique case where an intentionally incomplete *Kalpataru* depiction appears without its customary mythical companions, suggesting possible narrative or symbolic significance in its imperfect execution.

These findings demonstrate the deliberate use of composite botanical symbolism in Buddhist art, strategic placement patterns reflecting cosmological concepts, intentional variations in depiction that may carry narrative meaning, and the integration of real and mythical elements in conveying spiritual concepts. The concentration of *Kalpataru* depictions in specific temple orientations may reflect astronomical alignments, ritual procession routes, and the hierarchical organization of sacred space. The absence from the southern walls could indicate directional symbolism in Buddhist cosmology, narrative sequencing considerations, preservation, or documentation factors.

Spatial Distribution, Viewing Angles, and Symbolic Functions of Flora Depictions in the Karmawibhanga Reliefs

The analysis of flora depictions in the Karmawibhanga reliefs reveals distinct patterns in both panel positioning and viewing angles. The floral elements are systematically arranged across three spatial positions within the panels: the middle position dominates with 153 sculptures (including identified, unidentified, and unfinished forms), the left position features 117 sculptures, and the proper position comprises 99 sculptures.

Table 1. Flora species and their panel locations in the Karmawibhanga reliefs of Borobudur temple

Species	Common name	Panel number
<i>Alocasia macrorrhizos</i> (L.) G.Don	Giant taro	O-1, 9, 38, 44, 105, 122
<i>Anaphalis javanica</i> (Reinw. ex Blume) Martelli	Javanese edelweiss	O-36
<i>Areca catechu</i> L.	Area palm	O-34, 82, 123
<i>Artocarpus altilis</i> (Parkinson) Fosberg	Breadfruit	O-7, 8, 12, 21, 28, 67, 75, 93, 94, 100, 154
<i>Artocarpus camansi</i> Blanco	Breadnut	O-92, 154
<i>Artocarpus heterophyllus</i> Lam.	Jack fruit	O-6, 10, 21, 23, 30, 35, 36, 44, 46, 48, 50, 53, 58, 63, 65, 83, 84, 90, 105, 110
<i>Bambusa vulgaris</i> Schrad. ex J.C.Wendl.	Bamboo	O-61
<i>Barringtonia asiatica</i> (L.) Kurz	Fish poison tree	O-23, 67, 86, 89, 91, 118, 119, 128, 133, 140, 145, 153, 153
<i>Borassus flabellifer</i> L.	Palmyra palm	O-12, 55
<i>Calophyllum inophyllum</i> L.	Tamanu	O-11, 19, 24, 28, 37, 38, 54, 55, 56, 57, 63, 74, 75, 76, 79, 83, 86, 87, 93, 97, 98, 100, 108, 109, 112, 115, 116, 153, 157
<i>Cocos nucifera</i> L.	Coconut	O-97, 107, 129
<i>Durio zibethinus</i> L.	Durian	O-9, 11
<i>Erythrina subumbrans</i> (Hassk.) Merr.	December tree	O-12, 16, 22, 44, 75, 86, 158
<i>Ficus benjamina</i> L.	Weeping fig	O-32
<i>Ficus elastica</i> Roxb. ex Hornem.	Rubber fig	O-98
<i>Ficus religiosa</i> L.	Bodhi tree	O-20, 31, 33, 34, 35, 37, 39, 106, 156, 157, 159
<i>Garcinia mangostana</i> L.	Mangosteen	O-6, 14, 20, 31, 43, 109, 117, 118, 122, 123, 124, 129, 132, 142, 147, 159
<i>Inocarpus fagifer</i> (Parkinson) Fosberg	Tahitian chestnut	O-38, 77
<i>Kalpataru</i>	<i>Kalpataru</i>	O-99, 101, 102, 126, 130, 137, 143, 147, 149, 150, 154, 155, 160
<i>Mangifera indica</i> L.	Mango	O-4, 5, 9, 11, 15, 17, 21, 22, 24, 25, 27, 30, 34, 35, 47, 49, 53, 56, 59, 60, 61, 62, 74, 75, 76, 79, 80, 81, 85, 89, 91, 92, 93, 96, 97, 105, 107, 108, 109, 113, 116, 117, 121, 121, 122, 122, 123, 127, 128, 141, 142, 144, 145, 146, 147, 158
<i>Mesua ferrea</i> L.	Ceylon ironwood	O-51, 52, 54
<i>Magnolia champaca</i> (L.) Baill. ex Pierre	Champak	O-29, 55
<i>Musa paradisiaca</i> L.	Banana	O-9, 13, 26, 39, 61, 78, 105, 106, 118, 123, 148
<i>Nelumbo nucifera</i> Gaertn.	Sacred lotus	O-1, 9, 32, 88, 147
<i>Nephelium lappaceum</i> L.	Rambutan	O-26
<i>Nymphaea</i> L.	Waterlily	O-32, 63, 73, 132, 147
<i>Oryza sativa</i> L.	Rice	O-65
<i>Pleiospermium littorale</i> (Miq.) Tanaka	Jepara citrus fruit	O-87, 103
<i>Plumeria alba</i> L.	Cagoda tree	O-40
<i>Psidium guajava</i> L.	Common guava	O-95
<i>Saccharum officinarum</i> L.	Sugar cane	O-105, 117
<i>Sandoricum koetjape</i> (Burm.f.) Merr.	Santol fruit	O-18, 49
<i>Setaria italica</i> (L.) P.Beauv.	Foxtail millet	O-118, 121, 122, 123
<i>Syzygium aqueum</i> (Burm.f.) Alston	Watery rose apple	O-2, 21, 23, 32, 48, 56, 58, 59, O-60, 62, 65, 76, 80, 87, 88, 94, 107, 111, 117, 121, 124, 133, 142
<i>Syzygium malaccense</i> (L.) Merr. & L.M.Perry	Malay apple	O-60, 124
<i>Syzygium jambos</i> (L.) Alston	Rose apple	O-142
<i>Tectona grandis</i> L.f.	Teak tree	O-14, 31, 77, 80, 88, 89, 90, 94, 97, 98, 108, 113
<i>Terminalia catappa</i> L.	Tropical almond	O-5, 6, 12, 13, 25, 31, 42, 52, 65, 66, 79, 92, 96, 98, 104, 105, 112, 113

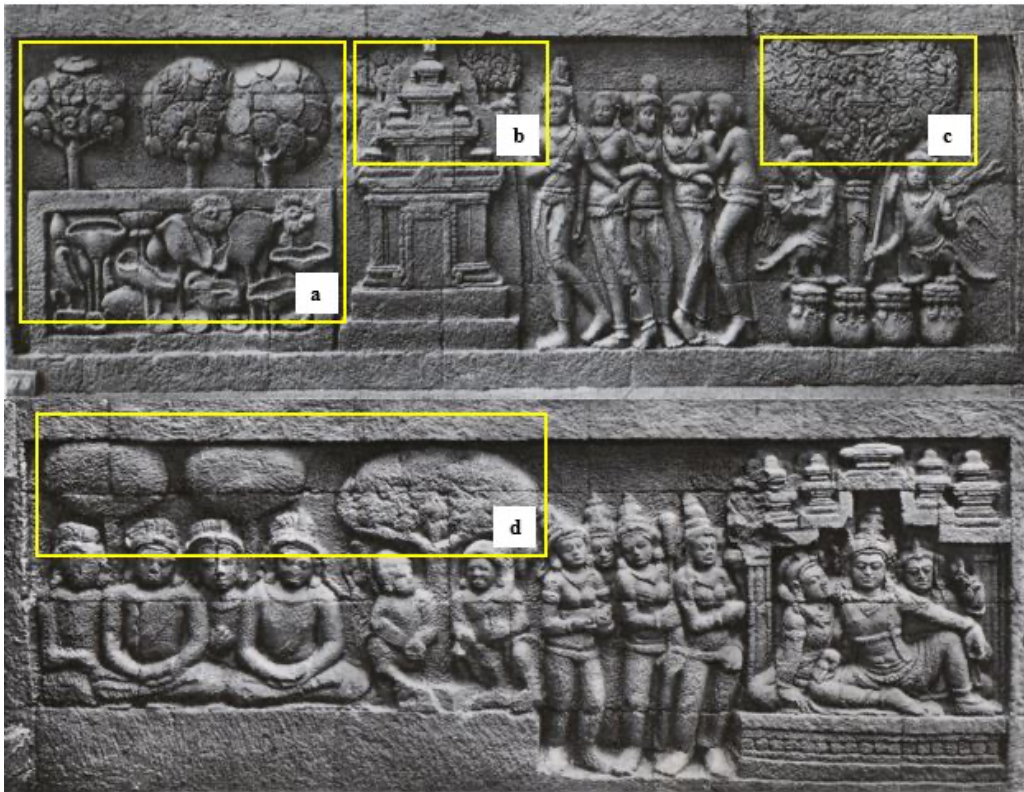


Figure 4. Flora representations in the relief: (a) identified species, (b) unidentified botanical elements, (c) symbolic *Kalpataru* depiction, and (d) unshaped flora

This distribution suggests a deliberate compositional strategy, potentially reflecting narrative hierarchy or visual balance in the reliefs. Furthermore, the flora is depicted from three primary viewing angles: (1) frontal view (222 instances): the most prevalent perspective, emphasising direct engagement with the viewer, aerial view (63 cases): suggesting scenes requiring spatial context, ground-level view (45 instances): possibly indicating rootedness or earthly connections.

The predominance of frontal depictions (Figure 5) implies that the sculptors prioritised immediate visual recognition of botanical elements, direct storytelling through plant symbolism, and audience interaction with the relief narratives. These patterns demonstrate how intentional use of flora positioning and perspective guided visual flow across panels, enhanced narrative comprehension, and created spatial depth in two-dimensional reliefs. The consistent use of these techniques across multiple panels indicates an established artistic convention in Borobudur's sculptural tradition. The analysis of *Calophyllum inophyllum* representations reveals distinct morphological emphases across viewing angles (Figure 6). When depicted from below (Figure 6a), the relief accentuates the abaxial leaf vein thickening, while aerial views (Figure 6b) highlight the phyllotaxis (leaf arrangement) with a distinctive coral-like branching pattern. Frontal depictions (Figure 6c) showcase both leaf orientation and fruit emergence between foliage. These intentional variations in botanical representation suggest that viewing angles carried specific semiotic purposes, potentially relating to narrative context or symbolic messaging. Similar multi-perspective treatment is observed in *Mangifera indica* (mango), which appears most frequently in frontal views among all documented species.

Three primary obstacles hindered species identification: (1) morphologically ambiguous carvings (23% of cases), (2) incomplete sculptural patterns (17%), and (3) weathering damage (12%). Notably, the functional role of flora influenced depiction styles; narrative settings featured flexible, naturalistic forms (e.g., forest backgrounds), while symbolic motifs, such as the Bodhi Tree (*Ficus religiosa*), were often represented in rigid, standardised forms. This distinction is particularly evident in panels depicting karmic allegories, where botanically implausible "composite species" (e.g., *Kalpataru*) appear alongside realistic flora.

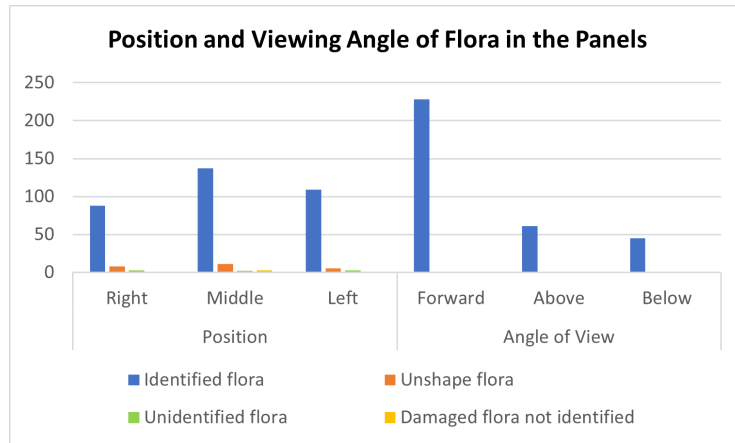


Figure 5. Positioning and viewing angles of flora in the Karmawibhangga reliefs

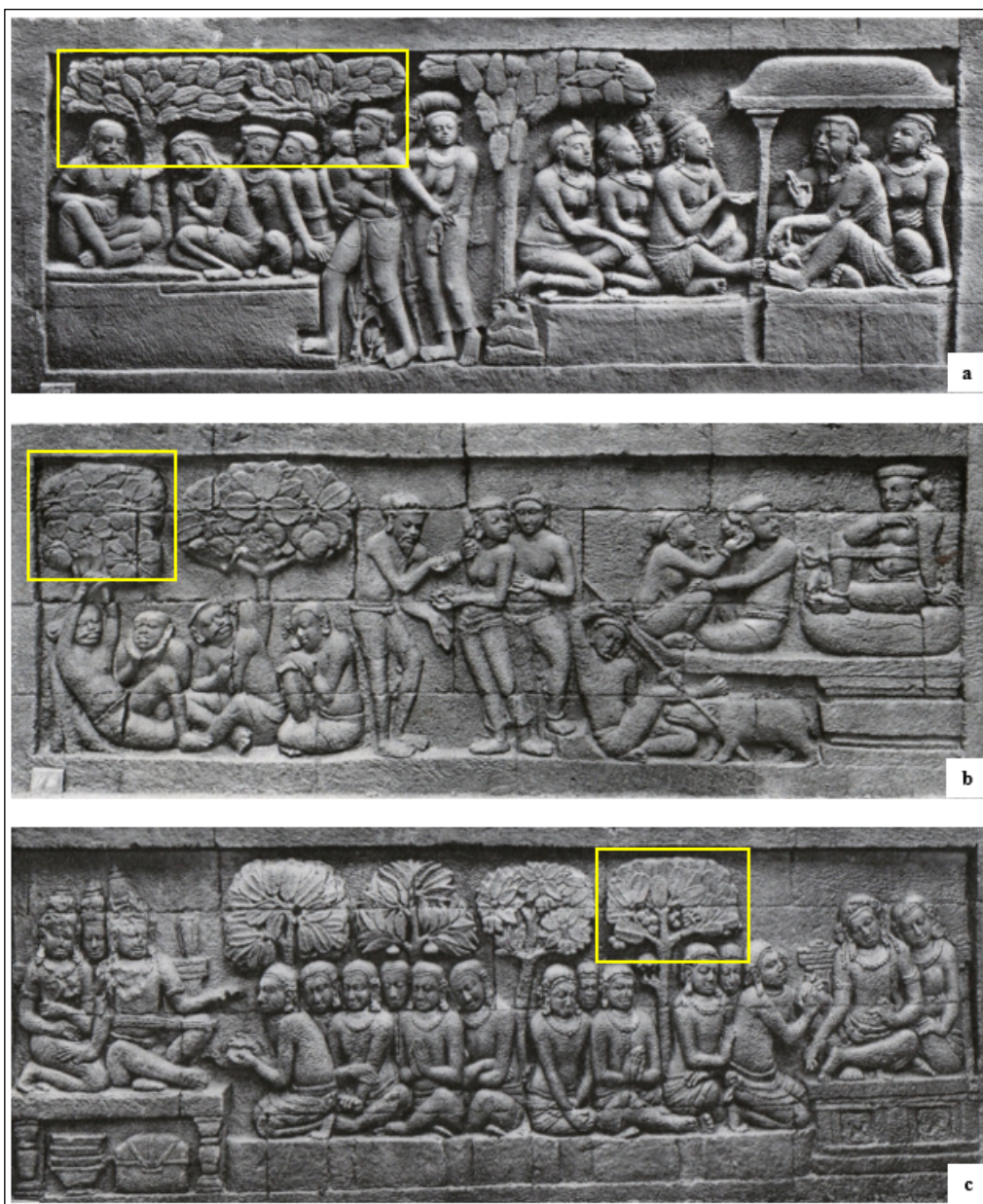


Figure 6. Depictions of *Calophyllum inophyllum* in Karmawibhangga reliefs: (a) below view (Panel O-38), (b) above view (Panel O-74), and (c) frontal view (Panel O-56)

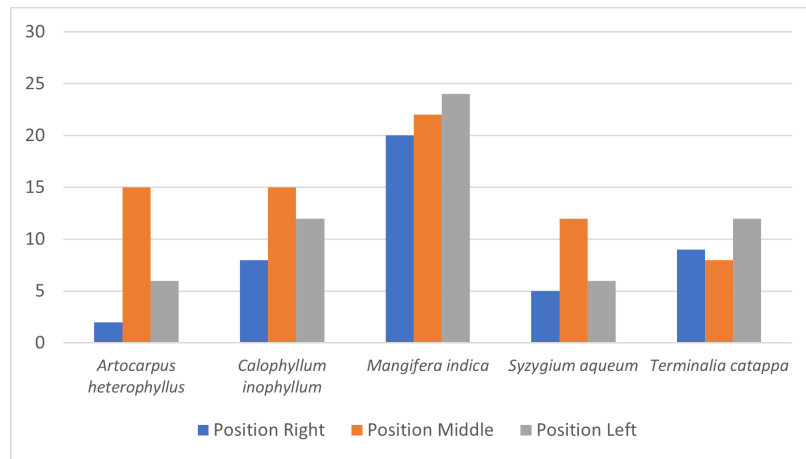


Figure 7. Panel positions of the most frequently depicted flora in Karmawibhangga reliefs

From 110 panels containing floral elements, 105 (95.5%) permitted species-level identification. Spatial analysis shows *Mangifera indica* dominates all panel positions (middle: 38%, left: 31%, right: 29%), followed by *Calophyllum inophyllum* (22%), *Terminalia catappa* (18%), *Artocarpus heterophyllum* (15%), and *Syzygium aqueum* (12%) (Figure 7). This distribution correlates with both the ecological prevalence of mangoes in 9th-century Java and their ritual significance in Buddhist tradition, where mango groves featured prominently in monastic life. The middle panel preference for dominant species (153 occurrences vs. 117 left/99 right) suggests that they serve as central narrative anchors.

Spatial Organisation and Floristic Patterns in Karmawibhangga Reliefs

The Karmawibhangga reliefs at Borobudur Temple are organised along the four cardinal directions—east, south, west, and north—with the east side further divided into two narrative sections (O-1 to O-20 and O-141 to O-160) following the *pradakṣiṇā* (clockwise) reading tradition. Notably, particular flora species, including *Mangifera indica*, *Calophyllum inophyllum*, and *Syzygium aqueum*, appear consistently across all orientations (Table 1), suggesting their ecological and symbolic significance in 9th-century Javanese Buddhist iconography. While some panels depict single species, others feature intricate combinations of two to over five plant species within a single relief, reflecting either natural habitats or deliberate symbolic arrangements (Figure 8).

The role of flora within the panels varies contextually: some serve as narrative settings (e.g., forests, gardens, or riverbanks), others as scene dividers, and a few as decorative fillers for empty spaces. However, the exact intent behind these compositional choices remains debated among scholars, as the sculptors employed diverse perspectives—frontal, aerial, and lateral views—within the same panel, complicating taxonomic identification. This artistic inconsistency, combined with weathering damage and unfinished carvings, poses significant challenges in species verification. The multi-perspective depictions hint at a sophisticated visual language in which botanical elements may encode layered meanings related to Buddhist teachings on karma; however, their full interpretation requires further interdisciplinary study that integrates art history, botany, and textual analysis.

Discussion

Botanical Narratives in Borobudur's Karmawibhangga Reliefs: Ecological Depictions, Sacred Symbolism, and the Spiritual Journey from Worldly Attachment to Enlightenment

The reliefs of Borobudur serve as visual representations of religious texts, providing an accessible medium for conveying spiritual messages to a broad audience, including illiterate people. These depictions, featuring humans, plants, animals, and transportation, reflect the socio-cultural and environmental conditions of ancient Javanese society (5th-7th century CE). The lush botanical elements in the reliefs are not merely decorative but serve as deliberate narrative devices, reinforcing the settings of the stories, whether wild forests, riverbanks, villages, or royal gardens. The flora and fauna depicted often provide contextual clues, enhancing the storytelling and symbolic meaning.

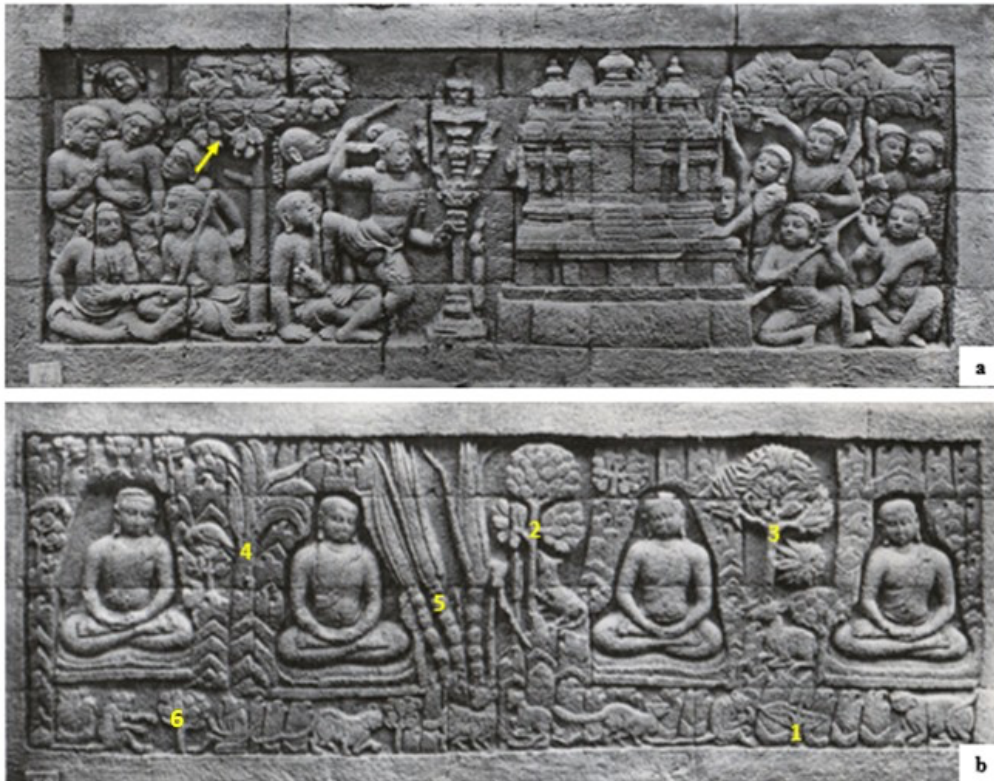


Figure 8. Flora combinations in Karmawibhangga relief panels: (a) *Mangifera indica* in panel O-24; (b) mixed species (*Alocasia macrorrhizos* (1), *Artocarpus heterophyllus* (2), *Mangifera indica* (3), *Musa paradisiaca* (4), *Saccharum officinarum* (5), and *Terminalia catappa* (6) in panel O-105.

A notable observation is the similarity in botanical diversity between the Karmawibhangga and Lalitavistara reliefs. Dominant species such as *Mangifera indica*, *Calophyllum inophyllum*, *Terminalia catappa*, *Artocarpus heterophyllus*, and *Syzygium aqueum* appear in both sets of reliefs, suggesting their cultural and ecological significance in ancient Java. The jackfruit (*A. heterophyllus*), for instance, held multifaceted importance, being valued for its timber, food, and symbolic role in Javanese society (Metusala *et al.* 2020). Meanwhile, the mango (*M. indica*) is depicted in various forms across the Lalitavistara reliefs, emphasising its prominence in both daily life and religious iconography.

The Karmawibhangga narrative begins with two significant plants—the sacred lotus (*Nelumbo nucifera*) and giant taro (*Alocasia macrorrhizos*)—positioned prominently at the top of Panel O-1, seemingly overshadowing human activities below. The lotus, a recurring motif in Buddhist art, symbolises spiritual purity and enlightenment, emerging unstained from muddy waters—an allegory for transcendence amidst worldly impurities (Fauziah *et al.* 2018, Sangharakshita 1993). This concept aligns with the Buddhist *Triloka* doctrine (Truth, Holiness, and Beauty) (Halim & Herwindo 2017), which explains its selective appearance in Karmawibhangga compared to its frequent depiction in the Lalitavistara, which chronicles Siddhartha Gautama's journey toward enlightenment.

The placement of Karmawibhangga at the base of Borobudur (in the *Kamadhatu* realm) reinforces its thematic focus on worldly existence and karmic consequences. The lotus and taro in Panel O-1 serve as metaphors—while the lotus represents spiritual aspiration, the taro, a carbohydrate-rich staple (Nastiti 2003), symbolises earthly attachment. The wax-coated leaves of the taro, which repel water, further illustrate the clinging of human desires (Dhammika 2015). This juxtaposition establishes the relief's central theme: the tension between material existence and spiritual liberation.

The panel O-160 of Karmawibhangga features an intriguing depiction of three unfinished trees, one accompanied by the mythical *Kinara-Kinari*—a creature typically associated with the *Kalpataru* (wish-fulfilling tree) (Maryanto *et al.* 2025b). This incomplete arboreal form may symbolise unrealised spiritual potential, in contrast to the preceding panel (O-159), where a crowned sacred elephant and a *Ficus religiosa* (Bodhi tree) suggest divine conveyance. The sorrowful expressions of the human figures in O-160, gazing at a nobleman engrossed in worldly affairs, reinforce the theme of unfulfilled enlightenment.

Intertextual analysis (Maryanto *et al.* 2025b) reveals that the *Kalpataru*—a composite of *Ficus religiosa* leaves, mangosteen fruit, and lotus flowers—often appears alongside *svargga* (heavenly) inscriptions in north- and east-facing panels (Santiko & Nugrahani 2012). Its absence in O-160, replaced by an incomplete tree, may signify deferred spiritual attainment. This aligns with Halim & Herwindo's (2017) interpretation of the *Kalpataru* as a symbol of celestial prosperity, suggesting that the nobleman in the panel remains bound by worldly attachments, even though the path to liberation is within reach.

The flora in Karmawibhangga transcends decorative function, serving as narrative anchors and spiritual metaphors. From the sacred lotus to the dominant food crops, each species reflects the ecological and cultural milieu of ancient Java while reinforcing Buddhist teachings. The *Kalpataru* and unfinished trees in the final panel encapsulate the relief's overarching message: enlightenment is attainable, yet worldly attachments may hinder its realization (Maryanto *et al.* 2025b). Through intra- and intertextual analysis, the reliefs emerge not just as artistic masterpieces but as profound theological texts carved in stone.

Flora as Narrative and Symbolic Elements in Karmawibhangga Reliefs

The depiction of flora in Karmawibhangga reliefs is intrinsically connected to human activities, serving not merely as decorative elements but as integral components that complete and reinforce each panel's narrative. This parallels findings from studies on the representation of fauna in Borobudur's Lalitavistara reliefs (Ashari *et al.* 2021, Rusdianto *et al.* 2020) and in Karmawibhangga (Maryanto *et al.* 2025a), where animal depictions carry specific symbolic meanings. Our analysis focuses on two dominant plant species - the mango tree (*Mangifera indica*, appearing in 56 panels) and the tamanu tree (*Calophyllum inophyllum*, 33 panels) - examining their spatial placement (right, middle, or left side of panels) and viewing angles (frontal, aerial, or ground-level) to decode their narrative significance.

The prominence of *Mangifera indica* in Karmawibhangga reliefs (56 panels with 66 individual depictions) is particularly noteworthy, given its seasonal fruiting pattern compared to more consistently productive species, such as banana or coconut. This suggests the mango held special cultural and religious significance in 8th-9th-century Javanese society. Buddhist texts (Tripitaka, Attakatha, Jataka) frequently mention the Buddha meditating in mango groves (*Amravana*) (Bidari 1995), while Dhammapada Pali XV:204 metaphorically associates the mango with health and happiness (Mahàthera 2005). The tree's medicinal uses in Ayurveda and traditional Javanese medicine (Fauziah *et al.* 2018), along with its culinary applications for the young leaves, further underscore its importance.

The morphological variations of mango depictions across reliefs raise essential questions about varietal diversity in ancient Java. POWO (2025) records 64 *Mangifera* species native to South and Southeast Asia, and our findings suggest that Javanese artisans may have depicted multiple varieties. The seasonal versus perennial symbolism becomes particularly meaningful when comparing fruiting and non-fruiting mango trees in adjacent panels (e.g., Panel O-24), where these states likely represent karmic concepts rather than mere ornamental differences.

The tamanu tree's ecological preference for riverbanks (Backer & van den Brink 1963) informs its symbolic representation in reliefs. Its seed dispersal mechanism, carried by water currents, serves as a powerful metaphor for the spread of good deeds and teachings, particularly in panels depicting discussion or donation scenes (77% of tamanu appearances). The "V" shaped water symbols (Rusdianto *et al.* 2020, 2024, Ashari *et al.* 2021), though not consistently depicted with tamanu, provide additional contextual clues for interpretation.

The viewing angle proves significant in tamanu depictions, with 13 individuals shown from below—a perspective that likely emphasizes the human-divine relationship. This vertical dimension complements the horizontal symbolism seen in the tree's panel placement (right versus left sides), where *pradaksina* (circumambulatory) reading patterns affect interpretation. For instance, Panel O-24's right-side non-fruiting mango and tamanu contrast with the left-side fruiting mango, creating a narrative of potential versus realized karma that Santiko and Nugrahani (2012) overlooked in their purely textual analysis.

Our study demonstrates the necessity of combining extra-textual analysis (cultural, ecological, and religious contexts), intra-textual reading (relationships within single panels), and intertextual connections (across multiple panels). The case of tamanu oil's medicinal properties, symbolically translating as "healing" of spiritual afflictions, exemplifies how botanical characteristics inform narrative meaning. Similarly, varied depictions of *Artocarpus* species (breadfruit, jackfruit, breadnut) require this multidimensional approach to avoid oversimplification.

The Karmawibhangga reliefs employ flora as sophisticated semiotic devices, where mango trees represent both material and spiritual nourishment, tamanu trees symbolize the fluid transmission of karma, phenological states (fruiting/non-fruiting) indicate karmic potential/fulfillment, and viewing angles and panel positions create spatial narratives. This analysis moves beyond decorative interpretations, revealing how Javanese artisans encoded Buddhist teachings through precise botanical representations that married ecological reality with spiritual metaphor. Future research should further explore the intra- versus inter-textual significance of left- and right-side plant placements across Borobudur's narrative systems.

Agricultural Depictions in Karmawibhangga Reliefs: Nutritional Sources, Cultivation Practices, and Spiritual Symbolism in 9th-Century Javanese Society

The Karmawibhangga reliefs offer valuable insights into the carbohydrate sources of 8th- to 10th-century Javanese society, depicting three primary categories: root crops, cereals, and fruits. Giant taro (*Alocasia macrorrhizos*) emerges as a significant root crop, appearing in panels facing east (O-1, O-9), south (O-38, O-44), and north (O-105, O-122). Its prominent placement, particularly in panel O-1, which opens the narrative, underscores its fundamental role as a staple food. The consistent appearance across multiple cardinal directions, except west, indicates taro's widespread cultivation and consumption during this period. This aligns with Nastiti's (2003) findings regarding the importance of taro in Javanese trade and daily life. The plant's symbolic meaning extends beyond nutrition, as evidenced by its frequent pairing with royal insignia, such as umbrellas and banners, in other Borobudur narratives, suggesting its cultural elevation beyond mere sustenance.

The reliefs depict two cereal crops, rice (*Oryza sativa*) and foxtail millet (*Setaria italica*), with distinct spatial distributions that reveal the agricultural preferences of the time. Rice appears solely in panel O-65 (west-facing), while millet features prominently in four north-facing panels (O-118 to O-123). This distribution pattern suggests millet may have held greater dietary importance, supported by its higher nutritional value (Wijaya *et al.* 2015). The archaeological evidence of stone and bone farming tools (Kartodirdjo *et al.* 1977) suggests that ancient Javanese were familiar with both dryland and wetland cultivation methods. The presence of water symbols and field rats (*Rattus argentiventer*) (Maryanto *et al.* 2025a) in rice-growing scenes confirms the existence of irrigated paddy fields. However, the predominance of millet depictions implies that dryland farming remained prevalent during the Borobudur construction era.

Panel O-65's rice cultivation scene demonstrates sophisticated storytelling through agricultural imagery. The right-to-left progression shows farmers discussing rat infestations (right), damaged fields (center), and proposed solutions (left), capturing a complete agricultural cycle. This composition reveals how reliefs documented both farming challenges and community cooperation, with the jackfruit tree (*Artocarpus heterophyllus*) symbolizing the nobility of collective action. The golden hue of jackfruit wood, traditionally associated with sanctity in Javanese and Balinese cultures, reinforces this symbolic meaning. Meanwhile, the millet panels' exclusive north-facing orientation is connected to spiritual concepts, as the northern direction in Buddhist cosmology represents the realm of the heavens. The association of millet with "svargga" (heaven) inscriptions suggests this grain held not just nutritional but ritual significance, possibly reflected in the "Madhusahasa" porridge offered to Siddhartha Gautama.

The reliefs' agricultural depictions reveal a complex interplay between subsistence and spirituality. While taro represented foundational sustenance, cereals carried deeper symbolic meanings tied to their cultivation methods and cardinal orientations. Rice cultivation, with its irrigation requirements, demonstrated advanced agricultural knowledge; yet, its limited depiction suggests it may have been less accessible than hardier millets. The spatial organization of these crops within the temple's cosmology, with millet positioned in spiritually significant northern panels, illustrates how daily sustenance was interwoven with spiritual aspirations. The integration of agricultural practice and religious symbolism offers unique insights into how 9th-century Javanese society conceptualized the relationship between earthly and spiritual nourishment within the karmic cycle.

Conclusions

The Karmawibhangga reliefs at Borobudur Temple serve as a profound visual narrative, intricately weaving together ecological, cultural, and spiritual dimensions through their depictions of flora. The systematic representation of plant species—ranging from the sacred lotus (*Nelumbo nucifera*), tamanu (*Calophyllum inophyllum*), and giant taro (*Alocasia macrorrhizos*) to dominant food crops like mango (*Mangifera indica*)—reveals a deliberate artistic strategy that transcends mere ornamentation. These botanical motifs serve as narrative anchors, symbolizing karmic principles, marking environmental settings, and reflecting the socio-agrarian life of 8th-10th-century Javanese society. The prevalence of particular species, such as the mango, underscores their dual role as both ecological staples and spiritual metaphors, linked to Buddhist teachings on abundance, health, and enlightenment.

The reliefs' compositional sophistication is further evident in the strategic placement and viewing angles of flora, which guide the viewer's engagement with the karmic narratives. Frontal depictions emphasize direct symbolism, while aerial and ground-level perspectives contextualize scenes within cosmic or earthly frameworks. The *Kalpataru* (wish-fulfilling tree), a composite of sacred botanical elements, exemplifies the interplay between realism and symbolism, its selective distribution across panels reinforcing cosmological hierarchies and ritual pathways. Meanwhile, the unfinished trees in Panel O-160 poignantly encapsulate the tension between worldly attachment and spiritual aspiration, a central theme of the *Kamadhatu* realm.

Methodologically, this study emphasizes the need for interdisciplinary approaches—combining iconographic analysis, textual cross-referencing, and ecological contextualization—to decipher the complex meanings of Borobudur's flora. Challenges such as stylized carvings and weathering damage underscore the limitations of relying solely on visual morphology, yet they also invite deeper inquiry into the artisans' intentional abstractions. The reliefs' agricultural scenes, particularly the juxtaposition of rice and millet, not only document historical cultivation practices but also allegorize the Buddhist ethos of communal harmony and the pursuit of higher states of being.

Ultimately, the Karmawibhanga reliefs serve as a testament to the ingenuity of Javanese Buddhist artistry, in which flora is rendered as a dynamic semiotic system. By integrating naturalistic detail with doctrinal symbolism, the reliefs articulate a holistic vision of existence—one where earthly sustenance and spiritual liberation are inextricably linked. Future research could further explore the intra- and intertextual relationships of these motifs across Borobudur's other narratives, deepening our understanding of how botanical iconography served as a bridge between the material and the transcendent in ancient Javanese thought.

Declarations

List of abbreviations: There are no abbreviated terms used in this manuscript.

Ethics approval and consent to participate: Verbal informed consent was obtained from all participants.

Consent for publication: All participants in this study have given verbal consent for the publication of the research results.

Availability of data and materials: All supporting data available in the article.

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