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Preserving traditional Balinese architecture: exploring the relevance of *undagi's* indigenous knowledge in post-pandemic interior design

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ABSTRACT

This research is focused on exploring the relevance of *undagi's* indigenous knowledge implemented on post-pandemic interior design as a recommendation for preserving traditional Balinese architecture in the modern era. As UNESCO promoted safeguarding the "Intangible Cultural Heritage" in 2003, all designers must strengthen the cultural side in still relevant designs for the modern era. In Bali, *undagi's* (traditional architect) existence declined in the modern era. *Undagi's* indigenous knowledge is the basis for the architectural development of traditional Balinese houses (*umah*) for designing tourism facilities as research objects. This research is a desk study with a critical analytical approach that qualitatively conducts a comparative study between indigenous knowledge and post-pandemic interior design recommendations with two stages of research—in the first stage, critically analyzing post-pandemic interior design recommendations by previous researchers with a systemic literature review. In the second stage, exploring *undagi's* indigenous knowledge consists of explicit and tacit knowledge. The result of the two stages is the formulation of the relevance of *undagi's* indigenous knowledge in post-pandemic interior design in Bali. The study results show that the *undagi's* indigenous knowledge has relevance, which aligns with the recommendations for post-pandemic interior design criteria by previous researchers. This relevance is closely relevant, and several relevant values require development and interpretation to have interconnectivity between modern and traditional values. This process of interconnectivity must prioritize the principle of preserving traditional Balinese architecture in the modern era.

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1. Introduction

The COVID-19 pandemic causes global uncertainty [1]; and changes the social order and the human perspective on architectural design [2]. The built environment spaces played a pivotal role in the recent global crisis of COVID-19, which clarified radical changes in the paradigm of indoor spaces and how we live within them [3]. In the post-pandemic era, interior design began to change, focusing on improving health, wellness, and functionality; enhancing air filtration systems; and increasing access to nature [4]. This phenomenon changed the design paradigm in the post-pandemic era, which became a challenge for interior designers in practice [5]. As a case example, Bali is one of the areas in Indonesia famous for its international cultural tourism [6]. Cultural tourism is the core of Bali's tourism products [7], [8]. During the pandemic, Bali experienced a major economic impact due to the closure of international tourism as its main economic source [9]. One of the elements supporting Bali's tourism is architectural design, including interior design, which develops cultural identity in appearance as destination branding and landmarks [10].

In the pre-pandemic period, the development of interior design in Bali has shown how traditional architecture has been "modernized,"; called Bali-style interior design [11] or "New Tropical Internationalism'. As Bali-style interior design is an example, Bali has experienced a tug-of-war between local culture and the challenges and influences of globalization. On the other hand, globalization is seen as an opportunity to develop Balinese fine art and culture [8]. Traditional Balinese architecture resulted from a long process of Balinese experience in understanding the natural environment and the social environment they live in [12], [13]. The history of traditional architecture is shaped by the continuation of the building profession, knowledge and techniques influenced by the development of a society inherited by local craftsmen or master builders [14]; followed by certain rules and regulations, and it has a strong bond with culture, values and behavior of society [15].

The building tradition is the product of the master builder's knowledge and creativity in using local building materials and in handling environmental features, which have been transferred from generation to generation through master-apprentice relationships for centuries [16]. Bali architecture tradition inherited by the traditional architect or master builder is called "*undagi*" [12], [17, p. 9], [18], [19, p. 3]. Bali's "*undagi*" in practice is being able to visualize a finished structure in his mind, mastering concepts of spatial orientation, religious philosophy, and local customs (*awig-awig*), and performing various rituals from groundbreaking (*ngeruak*) to blessing the finished structure (*pemelaspas*). *Undagi* practices based on ancient manuscripts such as the *asta bhumi* and *asta kosala-kosali* are the handbooks of Balinese architecture [12].

However, in its development, there has been a degradation of "*undagi's* role in the contemporary era [20], [21]; it became elusive [22]; have decreased in number and qualification [23]. Modern Balinese architects who try to preserve the "feeling" of implementing *Asta Kosala Kosali* in modern buildings tend to no longer adhere to the content in the *lontar* manuscript [17]. About 70% of today's buildings do not comply with ejection guidelines and are more concerned with various conveniences in implementing residential model development [24]. The majority of contemporary craftsmen called *'tukang'* ("non-*undagi*") lack an understanding of the principles of earthquake-resistant Balinese traditional architectural construction, including understanding the placement of aesthetic ornaments/carvings [25]. At the global scale, the traditional master builder, including Balinese *undagi*, whose presence has, after all, seen universal decline [26]. The degradation and decadence of Bali's *undagi* led Balinese architecture to a crisis of local spirit [23]; and jeopardized Bali's holistic spatial arrangements, destination branding, and landmarks.

In post-industrial societies, culture must be strengthened during an era of uncertainty and post-COVID-19 to return to the roots and strengthen cultural foundations to produce designs with character with a strong identity and cultural sustainability. As UNESCO promoted safeguarding the "Intangible Cultural Heritage" in 2003, Bali *undagi's* Indigenous knowledge manifested, among other things, in Article 2 in knowledge and practices concerning nature and the universe and traditional craftsmanship domains [27]. In implementing these UNESCO goals, it is necessary to revive traditional indigenous master builder knowledge into design. The revival of building tradition, as practiced by a traditional master builder in design education, will help in bringing studios, workshops, and site experiences more attuned and more responsive to the realities and challenges facing the profession in changing developing world [28].

Previous research that examined *undagi* as research objects discussed the definition of *undagi*, the scope of work, and the practice of *undagi* [29], declining existence in Bali from the anthropological perspective [22]. Epistemological side of *undagi* [30]. Mastering traditional Balinese architectural idioms shows that building practice is about social praxis from ideological, sociological, and biological aspects [31]. There is a degradation of textual practice among the *undagi*, causing the *undagi* to put forward their creativity in building practice [32]. The a need for resilience for *Undagi's* role in the development of traditional Balinese architecture in contemporary times, and most of the development is carried out by senior *Undagi*, so there is a need for regeneration of the successor [21]. Previous research has not

touched on the relevance of *undagi's* indigenous knowledge to post-pandemic interior design. Therefore, this research is focused on exploring the relevance of *undagi's* indigenous knowledge implemented in post-pandemic interior design.

2. Method

This research is a desk study with a critical analytical approach that qualitatively conducts a comparative study between indigenous knowledge and post-pandemic interior design recommendations. The interior design here as an object refers to a general understanding, not specific buildings. However, it is focused on residential design and residential-based tourism facility buildings (villas and bungalows) which develop the Balinese house for commoners called '*umah.'* The comparative study was carried out with two stages of research. In the first stage, critically analyzing post-pandemic interior design recommendations by previous researchers with a systemic literature review. The selected articles are international journal publications from 2020-2023 that discuss post-pandemic interior or architecture design and provide recommendations on home design.

The number of articles is set at 20 due to the limited scope of study and discussion following journal rules. The analysis of these articles will summarize several keywords as the main criteria for post-pandemic interior design recommendations. In the second stage, the recommendations in the first stage will be tested with a summary of *undagi's* indigenous knowledge obtained from traditional literature studies (*lontar* manuscripts) from *undagi's* "manual books" (*lontar*) as *undagi's* explicit knowledge and interviews with contemporary *undagi* and Balinese architects in searching for *undagi's* tacit knowledge. Both *undagi's* explicit and tacit knowledge will be formulated to become *undagi's* indigenous knowledge as a comparison criterion with the post-pandemic interior design criteria formulated in the first stage. The result of the two stages is the formulation of the relevance of *undagi's* indigenous knowledge in post-pandemic interior design, with a locus in Bali.

2.1. Post-Pandemic Interior Design Recommendation: A Systematic Literature Review

The current COVID-19 pandemic has resulted in significant changes in the lives of every human being and caused an economic crisis and travel bans in most countries [33]. In this period in which the world is living due to the outbreak of the Coronavirus and the call for social distancing, the practice of work and learning from home is more important than ever before. The role of the residential environment is more important than ever [34]. The experiences of the COVID-19 pandemic have provided us with a unique opportunity for a complete rethink of our approach to habitation. We should embrace this opportunity to not only design pandemic-resistant buildings but also make these buildings environmentally and, importantly, socially sustainable by espousing universal design principles [2].

Symptoms caused by the Coronavirus vary, ranging from mild to moderate to severe and even death. However, the recovery rate is higher when the sufferer is in a healthy environment. Covid-19 can even be cured with home treatments, so adaptation of home designs is necessary during Covid-19. This adaptation increases the chances of recovery from the patient and can also reduce the spread of the disease [35]. A collection of articles in international journals published from 2020 to 2023 that discuss and recommend post-pandemic architecture and interior design can be seen in Table 1. In Table 1, the keywords from the 20 international journals show that most are repeated. These are the main recommendations for looking for correlations with *undagi's* indigenous knowledge at the next research stage. Repeated keywords are shown in Table 2.

Table 1. Post-Pandemic Architecture and Interior Design Recommendation

Researcher	Focus	Recommendation on Post-Pandemic Interior Design
Navaranam *et al.* [36]	Indoor environmental quality (IEQ).	indoor air quality, thermal comfort, ventilation, acoustic performance, lighting, and spatial layout
Hanna [37]	Design visions	Healthy design, smart environment, green architecture, larger residences
Berens [38]	Interior Design	improving health and wellness in residential spaces, as well as functionality; enhanced air filtration systems; and increasing access to nature
Kizilova [39]	Pandemic architecture design	(1) Modularity and aggregation (2). Inflatability (3). Buoyancy/flexibility (4) Vertical expansion
Alhadedy and Gabr [40]	Home design features post-COVID-19	(1) flexibility/open spaces, (2) natural light and ventilation, (3) indoor entertainment space, (4) food and supply storage, (5) home office, (6) terrace with view/private garden, (7) bedroom with enclosed bathroom, and (8) separated entrance
ElZein and ElSemary [41]	Home interior design	People spent more time indoors after the pandemic started, and their need for a connection to the outer world increased
Ibrahim *et al.* [42]	Home interior design	Multifunctional space with modular furniture systems, Modular pods as isolated environments, Using UV light for premise disinfection
Al-Murahhem [43]	Home interior design	Furniture arrangement (modularity), fresh air, natural light, green space, flexibility of space, inherited cultural norms, spacious interior, green architecture
Alkhateeb and Peterson [44]	Home interior design	flexibility in space, Separate guest living spaces that are infrequently used but may still be an important cultural requirement, outdoor space, and permanent sanitizing area (transitional space).
Spennemann [2]	Post-pandemic architecture	Flexibility interior, environmentally friendly, socially sustainable, and espousing the principles of universal design
Alhadedy and Gabr [40]	Home design features post-covid-19	good environmental conditions inside homes, the home office, and the unit entrance connected to a lobby, flexible open spaces that might be altered to meet the changing needs, and family entertainment space food and supply storage.
Hingonekar and Kemkar [45]	Post-pandemic architecture	Open space will become more dominant than floor space
Tokazhanov *et al*. [46]	Post-pandemic architecture	"environmental impact" and "energy performance" of buildings will receive a significant shift towards emphasizing "social and health" aspects.
Sedky [47]	Post-pandemic architecture principles	sophisticated technologies, environmental awareness, sustainable architecture
Alonso and Jacoby [48]	Post-pandemic housing design	Flexibility of space, built-in storage, in-home outdoor space, universal and inclusive design, socially connected
Rosa-Jimenez and Jaime-Segura [49]	Housing design post-pandemic era	Environmental consideration, flexibility of space, indoor open-space
Abed [50]	Post-pandemic residential environment	Flexibility space, environmentally friendly, multi-function room, technology integrated
Zaher [3]	Interior-Architecture Post-Pandemic	Environmental Friendly, sustainable green building, digital technology integration
Gur [51]	Housing design	Flexible design, partition and modular panels, open space (balconies and patios), green architecture
El-Din [52]	Home interior design	Green architecture, sustainability, smart technologies

Table 2, it can be seen that the highest order of keywords from articles containing post-pandemic interior design recommendations, among others, Green architecture/design (14), flexibility of space (9), indoor open-space and smart technologies integration (4), modular and access to outdoor/nature (3), partition & separation, home-office and storage (2) universal design and sanitizing area (1).

Table 2. Repeated Keywords About Post-Pandemic Interior Design

Keywords	Appearance	Researcher
Flexibility of Space	9	5, 7, 8, 9, 10, 11, 15, 16, 19
Green Architecture/Design or Environmental Friendly and Sustainability Design	14	1, 2, 3, 5, 7, 8, 10, 11, 13, 14, 16, 18, 19, 20
Modular	3	4,7, 8
Partition and Separation	2	5, 9
Indoor Open Space	4	5, 12, 15, 16
Universal Design	1	10
Smart Technologies Integration	4	2, 14, 18, 20
Home-office	2	5, 11
Storage	2	11, 15
Access to outdoor/nature (balconies, patios)	3	6, 9, 19
Sanitizing area	1	9

2.2. *Undagi's* Indigenous Knowledge

Hutchings and Morrison [53] state that 'indigenous knowledge' is defined as; (1) a philosophy or a way of thinking; and (2) Indigenous environmental knowledge. Over the past few decades, Indigenous knowledge systems have been described using various descriptors, such as 'Traditional knowledge' (TK), 'traditional ecological knowledge' (TEK), and 'local knowledge' [53]. From the definition above, in the context of Balinese architecture, Bali architectural indigenous knowledge cannot be separated from the '*undagi*' figure [22], [30]. *Undagi* is a standard term in the Indonesian Language Dictionary defined as 'expert' is a traditional 'architect' figure [54].

The definition of *undagi* in *lontar* guidelines for traditional Balinese architecture *Asta Kosala Kosali* has the meaning "virtue comes from the body", which comes from *Kawi+Sanskrit*, which comes from the words *U is* main, *nda* is base and *gi* is body. On *Lontar* No. IIIc. 231 *Gedong Kertya* parses the term *undagi* as *wundagi*, which means, *Wu* is Shiva (Divine), *nda* is *wit* (source; origin), and *gi* is *sarira* (body) [55]. 'Wu' in the sense of 'Shiva' is the center of orientation in the *concept of Nawa Sangha* (nine cardinal directions as Balinese traditional architecture spatial foundation). So the understanding has something in common; they both state that the body as self is the base of virtue [56, p. 241].

Therefore *undagi* can be interpreted as a traditional priest-architect in Bali as the heir of knowledge and skills that are passed down from generation to generation, which become a benchmark in design and build practices in traditional Balinese architecture. The Balinese traditional architecture manuscript mentioned a "traditional architect", *undagi,* who follows the palm-leaf manuscript of architectural rules, which considers the principal tenets of Balinese Hinduism. These Balinese architecture rules are known as *Asta Kosala Kosali.* The main principle of *Asta Kosala Kosali* is the acknowledgment of the human entity (microcosm/*bhuana alit*) as part of the universe at large (macrocosm/*bhuana agung*), and thus, it is the task of an *undagi* to keep the architecture in a state of balance between God, human beings and the environment to achieve happiness (*Tri Hita Karana*) [30].

Fig 1. Contemporary Undagi Bali at Work on Temple Construction

Fig. 1 depicts the construction process of the *Pura*, a holy place, by the Balinese *undagi*. The *undagi* employs a traditional design approach and adheres to metaphysical standards as a guide

for creating holy places that possess spiritual self-cleaning attributes (*mawinten*). This is done to prevent the *undagi's* metaphysical pollution (*leteh*) from tainting the building. Consequently, the *undagi* must maintain concentration in their work, ensuring that their thoughts and actions do not compromise the temple's sanctity [57].

Moreover, in specific circumstances, the *undagi* abstains from sexual relations during construction to avoid contaminating the building [22]. In traditional Balinese architecture, the building process is a collaborative effort involving the *sulinggih* (priest), *pemangku* (ceremonial leader), *undagi* (architect/designer/master builder), *sangging/juru* (artisan), and *tukang* (builder) [58, p. 158]. The *undagi's* role is crucial in the collaboration process as they serve as the regulator and supervisor from the project's inception to completion. The term *'undagi'* can mean a 'traditional designer/master builder' or be used synonymously with 'traditional Balinese architect'[17]. However, there is also a different opinion which states that *undagi* is not an architect but a carving specialist who also has much experience designing and building traditional Balinese temples and houses, as well as decorating them with stone and wood carvings [19].

2.3. *Undagi* Explicit Knowledge (Lontar Manuscript Text-Based)

The early term 'architect' can be traced back to Ancient Greece in the term 'architekton'. The term is a title given to a builder who will oversee the design and construction of each construction project. A literal translation of the term shows that *'arkhi'*, in Greek, means head chief or master, while *'tekton'* means workers or builders in the context of a building. So *arkhitekton* (in Greek) is equivalent to 'master builder' (English) as the chief carpenter or chief craftsman on the project, depending on the main materials used for construction [59]; in the modern era, the term 'architects' replacing the 'master builder' in rising of the industry, education and profession.

"Architects" in Bali are equated with *undagi.* If architects are synonymous with *undagi,* then the understanding of architecture in Bali is complemented by a work that has fulfilled the principles of *asta kosala-kosali*, the concept of auspicious time in building (*warning*), building materials, up to the ceremony from digging the ground to roofing and finally for the entire building. Thus, a Balinese architect called *undagi* understands design and acts as a constructor, executor, and ceremony [60]. *Undagi's* explicit knowledge is written in *a lontar* manuscript with various symbolic, mythological, and even threatening meanings [61].

The term *lontar* refers to the *lontar* tree- the Palmyra species of palm, *Borassus flabellifer/flabelliformis* - and manuscripts made from its leaf [62]. *As* the source of *undagi's* practice, *Lontar* contains codes of Balinese architectural knowledge. One example is the instructions for selecting the length and width of a building written on *Asta Kosal Kosali.* These instructions contain a variety of size choices with a variety of good or bad. Consequences caused when choosing these sizes include having many children, being very happy, suffering from pain, being often wasteful, and others [61]. This title probably derives from the Sanskrit words *hasta* (hand) and *kausalya* (skill).

The *Asta Kosali* is consulted and interpreted about specific circumstances by the *undagi*, or local architect-builder, who is an expert in architectural rituals. Every aspect of construction and design, including shape, size, directional orientation, and position of buildings about other structures, is exhaustively documented in this Balinese building manual, which even prescribes the type of social background from which the builders of a particular type of structure should be recruited [12]. Gede Maha Putra [63] mentions that in guides to traditional Balinese architecture in the form of *lontar* manuscripts such as *Ashta Kosali* (building for humans), *Ashta Kosala* (building for the dead), *Ashta Bhumi* (spatial layout) and *Sikuting Umah* (home measurement) generally include *undagi's* indigenous knowledge, as shown Table 3.

Table 3, Balinese architectural knowledge written on *lontar*'s majority contains general philosophy (of Balinese architecture), *undagi's* profession understanding, *wariga* (concept of time), ritual and offering (*upacara* and *upakara/banten*), *Mantra*, wood knowledge (materiality, tectonics, metaphysical and sustainability concept), land knowledge (geographical, cosmological and private spatial), land use (geomancy), measuring yard (layout and

architectural dimension with the human body as base), building names (correlation for wellbeing for the occupant), placing building (with utilitarian and cosmological order), wood construction), non-wood construction/decoration, doors (for wellbeing living according to occupant day of birth (same like *feng shui* (Chinese); *vastu shastra* (Indian), social status and occupation-way of placing for good fortune).

Mastery of *lontar*-based knowledge encourages an *undagi* to study religious knowledge like a Balinese Hindu priest. According to Hinduism, buildings are not just a shelter but are for life with a soul and a certain function [64]. An update, while possessing expertise in the field of building and architecture, cannot be considered an architect. Despite sharing the same task of designing buildings, there exist distinctions between the two professions. Prior to designing, an update must exhibit an understanding of various elements such as philosophy, mythology, customs, environment, and region. The role of an *undagi* encompasses not only designing houses, but also the creation of *puri* (nobleman houses), *bade* (sarcophagi for noblemen), *wadah* (sarcophagi for commoners) for *given* (corpse burning ceremony) ceremonies, house planology, as well as the planning of shape and environment of prayers (*sanggah*-family shrines), *pura*-temples) [65]

Table 3. *Undagi's* Indigenous Knowledge from Various *Lontar*

Content	Darmaning Hasta Kosala No. 361	Hasta Bumi No. 243	Hasta Kosali No. 231	Asta Kosali L.04.T	Sikuting Umah L.14T
General Philosophy		•	•	•	
Undagi's Profession Understanding			•	•••	
Wariga (Auspicious Day; time concept)		•	•	•••	
Ritual dan Offering (*Banten*)		••	•	•••	
Mantra		•	•	•••	
Wood Knowledge (Materiality)		•	•••	•	•
Land Knowledge	•			••	
Land Use		•		•	•
Measuring Yard	•	•••		•••	•
Yard Entrance	•	•		•	•
Building Names			•		
Placing Buildings	•	•		•	
Wood Construction		•••	•••	•••	•
Non-Wood Construction/Decoration				•	
Doors	•	•		•	•

Source: Putra [63]; with permission

2.4. *Undagi's* Tacit Knowledge

As stated earlier, one indigenous knowledge is *lontar* manuscript text-based, but in practice; most *undagi* still need to fully use *lontar* guidelines in their work [17]. The texts themselves are available to anyone in the village should one wish to consult them, but in practice, this is limited to the priests and specialists who are competent in the language of the manuscripts. This condition means that general carpenters and builders need to learn what is in the texts by reading them. On the contrary, they acquire their knowledge by being taught by those already conversant with the trade. The texts are then only consulted when there is some disagreement about rules or procedures or when it is necessary to become acquainted with a rule only rarely implemented [66]. Although these building regulations are available for inspection by anyone who wishes to consult them, the arcane nature of the language means that, in practice, only language experts and priests are likely to do so. Instead, carpenters and builders generally learn their trade through informal apprenticeship.

The sacred texts are usually referred to only when there is disagreement about procedures or when constructing rarely erected building types [12]. Bali, a region in eastern Asia, "master builders" and "great craftsmen," who dominate highly developed woodworking techniques, have erected complex timber frame structures, reaching five stories and a height of 50 m, since the 6th century. An example is the structures of the 18th century Pura Besakih Temple in Bali

displays 11 stories at a total height of 44 m [67]. Therefore, in addition to explicit knowledge, the basic skill of an *undagi* is carving stone and wood materials. This skill is the basis of being an *undagi* before becoming a maestro in planning a building according to *lontar* guidelines.

Undagi usually starts to pursue this traditional building carpentry by following *the undagi* who is more experienced when making the building, or it can be said to help the more experienced *undagi* when helping out, *undagi* who was just learning, began to learn the methods used, the existing rules through the more experienced. Then after helping for several years and knowing the existing knowledge, *undagi* started to try himself and read some literature such as *lontar's,* which contained knowledge about making traditional Balinese buildings. Then after they had enough knowledge, *Undagi* started trying to be independent without following the more experienced *undagi*. The mistakes they make while trying to be independent become part of their current knowledge [32]. These skills are also required when a senior *undagi* oversees the entire building work. An *undagi* needs to care for the stone craftsman, the brick builder, the wood craftsman, the occupants, and the surrounding neighbors [30].

In the contemporary era, Government policy in Bali is now trying to protect traditional culture by encouraging the use of Balinese ornamentation on public buildings. However, the results cannot be characterized as hybridization in this context. Balinese culture and craftsmanship have developed new artistic expressions to give a direction to the social change fostered by modernization, particularly under the influence of tourism. This situation has created harmonious architectural forms [68]. As there are fewer *undagi* with explicit knowledge of traditional building work in the modern era, *undagi* work collaboratively. The knowledge possessed by *undagi* regarding the production of traditional Balinese buildings is primarily informal in nature, as the majority of *undagi* have not received formal education. This knowledge has been passed down through generations and has endured the test of time [32].

The construction process involves the collaborative efforts of several key individuals, including *sulinggih* (priests or religious leaders), *pemangku* (ceremonial leaders), *undagi* (architects/designers/master builders), *sangging/juru* (artisans), and *tukang* (builders) [58]. In this collaborative process, the role of the *undagi* is crucial, serving as both a regulator and supervisor. The explanation above shows that explicit and tacit indigenous *undagi* knowledge refers to the understanding of green architecture, which is sustainable, environmentally friendly materials, handcrafted structures, and full of philosophy for well-being living, both for occupants and the environment. Therefore, the main potential of *undagi's* indigenous knowledge is the practice of sustainable architecture, eco-interior, mind, body, and spirit (holistic) interior, natural-tropical-interior, and human well-being, which can be developed globally [69].

Undagi's indigenous knowledge formulation in the creation of architecture has several considerations that are adhered to in building practice (see Fig. 2); (1) Cosmological balance (*Tri Hita Karana*); (2) Hierarchy of values (*Tri Angga*); (3) Cosmological orientation (*Sanga Mandala*); (4) Concept of open space (*Natah*); (5) Proportion and scale; (6) Chronology and procession of the built environment; (7) clarity of structure; and (8) the truth of material [70]. The *lontar*'s manuscript as *undagi's* Indigenous Knowledge is the basis for the Bali Province Regional Regulation No. 5 of 2005 concerning building architecture. That regulation prioritizes the principles of traditional Balinese architecture that are in harmony, balanced and integrated with the local environment in the following categories: (1) Spatial Principles; (2) Building Forms; (3) Principles of Structural Forms; (4) Principles of Utilities and Human Factors; (5) The Ornament Principle; (6) The Material Principle [71]. This regulation is the principle of *undagi's* indigenous knowledge which is used as a guide in the development of modern architecture in Bali.

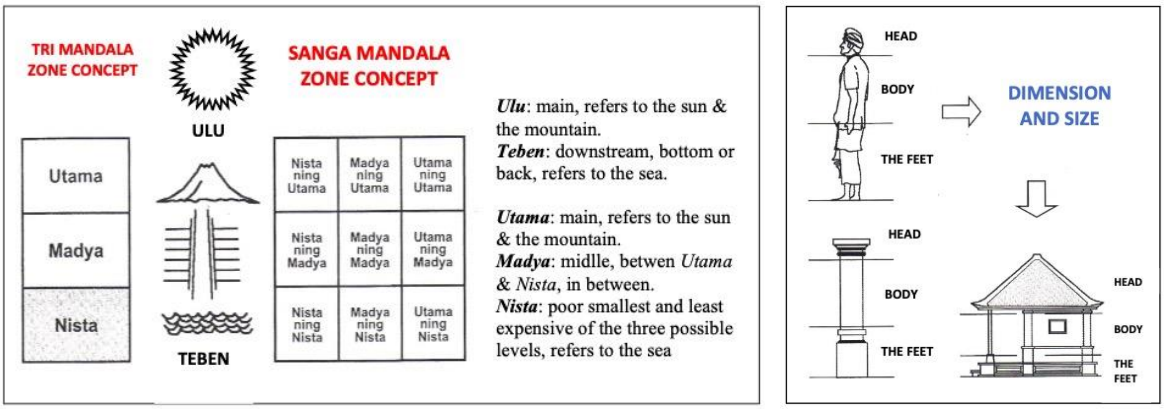

Fig 2. Balinese Traditional Concept as *Undagi's* Indigenous Knowledge

3. Results and Discussion

3.1. The Relevance Between *Undagi's* Indigenous Knowledge in Post-Pandemic Interior Design

In order to reveal the relevance of *undagi's* indigenous knowledge in post-pandemic interior design, knowledge management is presented to examine both entities. Knowledge Management (KM) addresses the generation, representation, storage, transfer, and transformation of knowledge; the knowledge architecture is designed to capture knowledge and enable KM processes. Underlying knowledge architecture is the recognition of the binary nature of knowledge, namely its objective and subjective components [72]. Table 4 shows several keywords suitable for disclosing the relevance of *undagi's* indigenous knowledge in post-pandemic interior design, such as tacit knowledge, explicit knowledge, knowledge architecture and knowledge infrastructure. *Undagi's* indigenous knowledge explicitly refers to adherence to the *lontar* manuscripts as a guide. *Undagi* as a builder must be able to read Balinese script in Kawi-Balinese and understand *lontar*'s customs, culture and religious aspects. The value of knowledge in traditional Balinese architectural *lontar* is usually not contained in one *lontar* but also requires reading of supporting *lontar* to enrich and deepen understanding of the text (interview with Gede Sedana and Made Sandi, senior *undagi*, 2022) [17]. *Undagi* as a builder must be able to read Balinese script in Kawi-Balinese and understand *lontar*'s customs, culture and religious aspects. The value of knowledge in traditional Balinese architectural *lontar* is usually not contained in one *lontar* but also requires reading of supporting *lontar* to enrich and deepen understanding of the text (interview Gede Maha Putra, architect-researcher, 2023) [17], [22], [32]. *Undagi's* indigenous knowledge tacitly refers to the basic skill of labor practice, including carving stone and wood materials [32].

Table 4. Key Knowledge Management (KM) Concepts

Concept	Definition
Tacit knowledge	Knowledge that resides in people' heads, "know how"
Explicit knowledge	Knowledge that is written down as facts, "know what"
Knowledge architecture	The blueprints for identifying where subjective and objective knowledge and/or tacit and explicit knowledge reside in an organization
Knowledge infrastructure	The design of the socio-technical requirements for ensuring appropriate KM, i.e. the design of the necessary people and technology requirements for facilitating Km in a specific organization
Objective perspective of knowledge	Following the Lokean/Leibnitzian forms of inquiry, such knowledge facilitates greater effectiveness and efficiency
Subjective perspective of knowledge	Following the Hegalian/Kantian schools of inquiry, such knowledge facilitates sense making and innovation
Knowledge Spiral	The transformation of one type knowledge to another
Socialization	The transformation of tacit knowledge into new tacit knowledge
Internalization	The transformation of explicit knowledge into new tacit knowledge
Externalization	The transformation of tacit knowledge into new explicit knowledge
Combination	The transformation of explicit knowledge into new explicit knowledge

The knowledge architecture of *undagi* is a combination of explicit and tacit knowledge. However, in contemporary times the current practice of *undagi* does not fully use *lontar* as a reference, purely experience [24]. Knowledge infrastructure of *undagi* is built from how buildings are not merely material but have souls that bring their inhabitants to prosperity (interview with Oka Saraswati, Professor at Architecture Department Udayana University, 2023) [12]. Therefore the building was built by prioritizing the harmonization of the environment between people and increasing the occupants' spirituality. Therefore, occupants as objects and architecture as subjects merge into a unified goal of achieving world harmony (*jagadita*). The knowledge infrastructure of the university in the contemporary era gave birth to the concepts of sustainable, human-centered, well-being, green architecture, natural architecture, and holistic architecture. Disclosing the relevance between *undagi's* indigenous knowledge in post-pandemic interior design and comparing the keywords recommended by researchers about post-pandemic interior design with *undagi's* indigenous knowledge, shown in Table 5.

Table 5. Study of the relevance between *Undagi's* indigenous knowledge in post-pandemic interior design

Keywords	***Undagi's* Indigenous Knowledge**	
	Explicit	***Tacit***
Green Architecture/Design or Environmental Friendly and Sustainability Design	Cosmological balance (*Tri Hita Karana*), The truth of material, wood knowledge	Woodcarving techniques, making wooden structures and building tectonics
Flexibility of Space	Clarity of structure, Placing Buildings	*Pengurip* (additions to the size of the building according to the *lontar* guidelines, as the *undagi's* authority; to make the building "alive (urip)') [1]
Indoor Open Space	Concept of open space (*Natah*)	-
Smart Technologies Integration	-	-
Access to outdoor/nature (balconies, patios)	Concept of open space (*Natah*)	-
Partition and Separation	Cosmological orientation (*Sanga Mandala)*	-
Modular	Proportion and scale	Making *kekuwub* (structure pattern) and *Gegulak* (measurement module)
Home-office	-	-
Storage	Placing Buildings	-
Sanitizing area	Cosmological orientation (*Sanga Mandala)*	Concept *pemesuan* (non-direct entrance) as filtration to main building
Universal Design	Cosmological balance (*Tri Hita Karana*),	-

Table 5 shows that out of 11 keywords, 9 post-pandemic interior design keywords are relevant to *undagi's* indigenous knowledge (about 82 %). The explanation of each keyword's relevance is:

3.2. Green Architecture, Indoor Open Space and Access to Outdoor/Nature Relevance

The main keyword is green architecture, where *undagi's* indigenous knowledge plays a major role. Gunawan [30] states that the *undagi* has contributed to sustainability in the Balinese culture through architecture. The *undagi* successfully achieves the goal of *Tri Hita Karana*: happiness, by keeping the balance between God, the environment, and the people involved: the construction workers and the villagers [30]. Mustika and Dwijendra [73] stated that the philosophy of using local building materials has been reflected in the traditional material selection approach in Balinese Traditional Architecture. These conditions align with the philosophy of the material aspect of green buildings. It shows that traditional Balinese architecture already has the same sustainability principles as green building principles [21]. Since vernacular materials and construction methods have multiple environmental and socio-economic advantages, a policy maker or an architect should promote the preservation of such

traditional knowledge regarding indigenous communities' architecture and settlement planning, thus facilitating the continuity of their existing social fabric and ensuring their sustainable development [74]. The traditional Balinese house called *umah* which the house is one of the Balinese traditions' manifestations. It reflects collective historical practices and communal cultural codes. It can be perceived as creating distinctiveness and identity [75]. The Balinese '*umah'* for commoners is shown in Fig. 3.

Fig. 2 shows how the arrangement of traditional Balinese houses as artifacts from the heritage of *undagi's* indigenous knowledge put forward green aspects of architecture. The implementation of the *Tri Hita Karana* concept (harmonization between human amongst humans, environment and the divine) affects the layout of the traditional Balinese house, where certain rules regulate the distance between buildings, and each building (*bale*) has a specific designation [66]. The resistance of traditional settlements to the spread of the virus can be evaluated from activities taking place at different spatial scales. On a residential scale, the control and selection process through measuring body temperature and the obligation to wear a mask and wash hands can be done at the entrance gate. Social distancing protocol may be carried out inside the house because the buildings are separated from one function to another [76].

Balinese traditional architecture layout has a resilience concept against pandemics by placing separate pavilion buildings according to the owner's zoning. This concept helps isolate infected residents. Also, traditional Balinese architecture utilizes natural utility optimization and open space within the dwelling (*natah* and *lebuh*) to optimize natural air circulation [75], [77]. So it can be concluded that the green architecture aspects contained in the knowledge architecture *undagi* are relevant to the concept of green architecture in post-pandemic interior design.

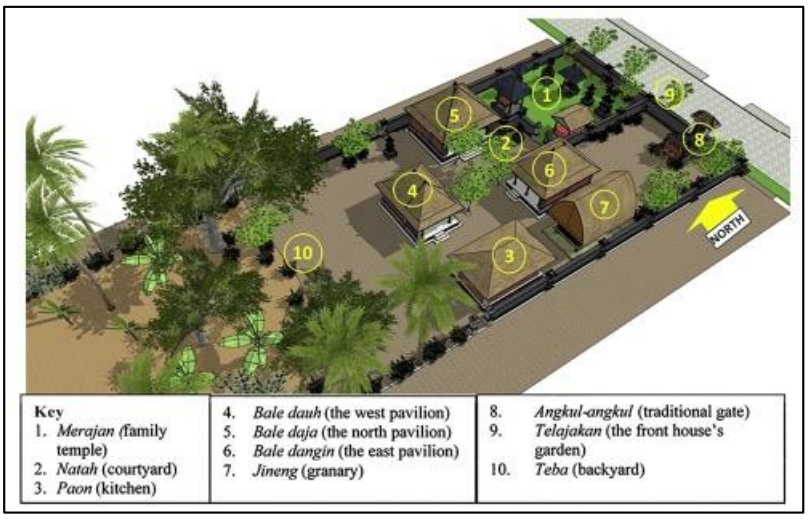

Fig 3. The pattern of the traditional Balinese house (*umah*)

3.3. Flexibility of Space, Partition, and Separation; and Sanitizing Area Relevance

Balinese traditional architecture layout has a resilience concept against pandemics by placing separate pavilion buildings according to the owner's zoning. This concept helps isolate infected residents. Also, traditional Balinese architecture utilizes natural utility optimization and open space within the dwelling (*natah* and *lebuh*) to optimize natural air circulation [75], [77]. So it can be concluded that the green architecture aspects contained in the knowledge architecture *undagi* are relevant to the concept of green architecture in post-pandemic interior design. In terms of daily functions, traditional Balinese houses have adequate resilience in contagious pandemic emergencies. Single entrance allows an easy selection of people who will enter. The arrangement of buildings with several separate functions allows the application of social distancing when needed [76]. These distances give the flow of the air into the building. The buildings get enough sunrise to lighten the room in the building.

The surroundings of the buildings are planted with vegetation that has the aesthetic function of a barrier from ash and sunlight. Disaster risk management is also adapted to this pattern; if there is an earthquake, the people run out from the building to the center of building orientation or *natah* as a central point meeting for security. The distance between the buildings also brings security from the fire risk. If one building is fire risk, another building will avoid and be spared from the fire. The small building's design of traditional housing is a unique design that answers the challenge of the risk of disaster [78]. *Undagi's* indigenous knowledge, implemented in *bale* architecture as a separate pavilion, provides many opportunities to develop in post-pandemic interior design. The separation of the space zones provides space flexibility as a multifunctional space that simultaneously, under certain conditions, can operate separately.

3.4. Smart Technologies Integration and Home-office Relevance

Balinese house or *umah,* as an example of vernacular architecture, was based on available resources, human needs, and climatic conditions. It exemplified sustainable design principles through solutions that evolved over long periods of trial and error using local materials and technology emerging from the ambient natural and cultural environment [79]. *Undagi's* indigenous knowledge as a builder of the *umah* has yet to extend to smart technologies integration and home-office applications, as both are products of modern life. But in principle, smart technologies integration aims to streamline human life, improve performance, control the built environment and also the dromology of information; it can be integrated into vernacular buildings to enhance sophistication while still maintaining their sustainable architectural philosophy [80].

Vernacular knowledge offers different characteristics and forms based on local conditions of climate, materials and live cultures. In consequence, the role of vernacular in the process of cultural memory, connecting different spaces and times, is to mediate new technological innovations and development throughout history new connectivity [81]. Abo-Elazm and Ali [82] conclude that the role of sustainable architecture and appropriate technology is achieving local communities' needs and build on their skills while minimizing the environmental impact. Importance of using modern, innovative technologies, traditional and culturally sensitive materials, and know-how to meet local communities' needs while preserving the past. As Noorwatha recommended, the application of Antivirus Built Environment (ABE) in the interior of modern Bali can also be made either on (1) the skin of the building, including the exterior enclosure and roof; (2) the interior including construction, interior finishes, vertical circulation system (conveying) and (3) Interior utilities including Heat, Ventilation and Air Conditioning (HVAC) conditioning in buildings [77]. Therefore, in the future, smart technologies that align with the philosophy can be implemented with the spirit of preservation but, on the other hand, can increase work productivity and optimize interior conditioning.

3.5. Universal Design Relevance

The architect and designer Ronald L. Mace, who coined the term Universal Design (UD), and after whom a major research center is named, saw the movement as encouraging the "design of products and environments to be useable by all people, to the greatest extent possible, without the need for adaptation or specialized design". Architects deploying UD to "design better" face a key challenge vis-à-vis developing and embedding appropriate modes of user participation in the process [83]. The definition of universal design sets no aesthetic criteria, only stating the functional requirements that need to be met. Architecture that has to be developed in a universal direction must be about more than finding the best possible solution based on practical needs and technical and financial constraints [84].

The principle of universal design focuses on human-centered design, which is designing buildings accessible to everyone with various physical conditions, gender and age. In traditional Balinese architecture, the understanding of human-centered is using the body size of the head of the family, priest or *undagi*, which is used as the basis for the size of the building [12], [17]. Therefore, in post-pandemic interior design, universal design principles have the same spirit as human-centered design principles as *undagi's* indigenous knowledge. However, universal design aspects are more emphasized in applications to residential-based tourism facilities.

4. Conclusion

As studied in the previous discussion, *undagi's* indigenous knowledge has a strong relevance in implementing the principles of post-pandemic interior design. As studied in the previous discussion, *undagi's* indigenous knowledge is relevant to implementing the principles of post-pandemic interior design. From the two stages of the research, the criteria for post-pandemic interior design include green architecture, space flexibility, smart technologies integration and universal design, aligned with *undagi's* indigenous knowledge, both explicit and tacit knowledge. This relevance is closely relevant, and several relevant values require development and interpretation to interconnect modern and traditional values, such as smart technology integration. This process of interconnectivity must prioritize the principle of preserving traditional Balinese architecture in the modern era. This is also in line with the spirit of the law on the Advancement of Culture (Undang-Undang Pemajuan Kebudayaan) of Republic Indonesia Number 5 of 2017, especially in article 1 point 3, which states that the Advancement of Culture is an effort to increase cultural resilience and contribute to Indonesian culture amid world civilization through the Protection, Development, Utilization and Development of Culture. For future research, *undagi's* indigenous knowledge studies need a deeper exploration at the praxis level to provide recommendations for developing modern Balinese interior design in the post-pandemic era. This effort is to preserve the value of traditional Balinese architecture in the modern era and to have resilience against future pandemics.

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