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Abstract. Tri Hita Karana is known for harmonizing the relationship between human God and nature in Hindu Bali tradition, Indonesia. This traditional philosophy is implemented in some aspects of life. For instance, the Balinese community designs their house in customary spatial using this philosophy. This tradition faces various threats of extinction due to modernization which continues to develop over time. Such modern buildings that come from outside investors can destroy the existing traditional order. In this study, researchers propose a technology, namely Dynamic BIM, to record the spatial structure of conventional Balinese buildings that adopt the Tri Hita Karana concept. So with this technology, it can accommodate changes in function and use of space before and after. Moreover, it can provide historical and cultural information on ownership. In addition, this technology can make efforts to conserve customary space.

Keywords: Tri Hita Karana · Balinese · Cadastre · Dynamic BIM · Technology

1 Introduction

Bali is known as a favorite destination for vacation, and it has full of beautiful nature and a unique tradition. Balinese people have a philosophy of life known as Tri Hita Karana (THK), i.e., the concept of harmonization between humans, God, and nature. Indeed, this philosophy has been implemented in several aspects of Balinese life and culture. For instance, Balinese customary spatial

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is designed using the concept of THK. Traditionally, Balinese houses are consist of Pura or Temple for the manifestation of God, a living room for human interaction, and a garden for preserving nature.

Currently, the land system (land registration) performs digital data management in a 2D model. This model has some weaknesses in several aspects of document legalization. So it is necessary to transition into a 3D model to provide better visuals, legal certainty and keep the essence of existing buildings. In addition, this model can help some related parties to assess, assure mastery, and easy to find the implementation. Various researchers offer various concepts of 3D cadastre and their application in multiple fields, which are integrated into various existing models and technologies [10, 13, 24, 27, 32]. According to [5], the use of Building Information Modeling (BIM) is a feasible approach in managing land and property information in the administration of high-rise buildings. BIM is a digital form of a building that contains building knowledge and manages assets in it. BIM consists of three components, namely technology, processes, and digital information, that are used to improve the operation of assets in the [19] building.

The BIM platform uses a proprietary format in model storage and refers to a collaborative and multi-disciplinary process for managing buildings in different phases of the building's lifespan [9]. BIM products can be made different according to the needs of the actors who use them, such as architects, civil engineers, surveyors, and others. The BIM process can integrate different products with a common data environment to provide a complete building model. One of the organizations that promote BIM is known as BuildingSMART, where this organization develops Industry Foundation Classes (IFC) standards as an open data model and vendor to facilitate interoperability across various BIM platforms [16].

This research is reinforced by Suhari (2020) [25], explaining that BIM can be used to model, inventory, and manage 3D cadastral information data that is integrated with customary law and local wisdom in Bali. However, setting a static BIM is still problematic and cannot accommodate changes that will occur continuously due to various existing factors. Various researchers discuss the static to dynamic changes by providing data and driven models. In the paper, [7], structural monitoring of train bridges with time series sensors using parametric methods and R-Tree model is elaborated, moreover in [6], the database system is modified to be able to perform queries on the 3D land system by utilizing the Boundary Representation Model (Brep). In addition, BIM can be developed into workflow activities on 3D land systems and dynamic systems with GIS (see [17, 20] for more detail).

Tourist destinations that are proven to be a source of income for local communities do not automatically realize the preservation of local culture but are highly dependent on the participation of residents (stakeholders). Sustainable Development Goals (SDGs) are efforts to create prosperity for the world community, as well as efforts to protect the environment and create sustainable development for future generations [3, 14, 23]. The concept of sustainable development proposed by the United Nations Environment Program and the World

Tourism Organization (2005) states that there are 3 (three) dimensions or pillars in the conceptual system of sustainable development ([2,18], namely: economic sustainability, social-cultural sustainability, and ecological sustainability.

The involvement of the Penglipuran tourism village (Bali-Indonesia) residents is very high, so to maintain cleanliness, they work voluntarily to clean the environment. The local government of Bangli Regency, Kubu Village, is also building various infrastructures such as road construction and community economic needs. The proceeds from the sale of rural tourism tickets are mostly used for the needs of the Penglipuran tourism village community in the form of necessities [15]. To maintain the tourist village, Penglipuran residents maintain a clean environment and preserve the traditional structure of their house building. This village has its uniqueness and is attractive to tourists because it can maintain its culture and customs by presenting old buildings and accepting structural modernization [12,22,31]. According to Primadi [22], the influence of modernization has brought concerns about the continued development of tourism in the village. The existence of the traditional houses of the residents has been threatened by the action of modernization and the improvement of the economic level of the local community, as well as the shift in the cultural values of the traditional society towards the modern one.

This study aims to present the concept of dynamic BIM, which can be a link to existing problems and solutions by modifying the idea of land administration and spatial unit [1,11]. Thus it can create the concept of customary cadastre. It will present this technology can take inventory of digital data in the form of 3D and accommodate changes in the use and use of space based on applicable customary law. Therefore, this concept can apply customary cadastre and be used to reference conservation actions in traditional areas.

2 Materials and Methods

2.1 Tri Hita Karana Concept in Balinese Traditional Cadastre

The concept of Tri Hita Karana (THK) is a harmonious relationship between humans and God, fellow humans and humans, and nature. The Balinese people apply this concept to spatial planning and cardinal directions that the ancestors of the Balinese people have inherited. The spatial layout of the Balinese THK is limited to the space on the earth that is stepped on and the sky above it. So this traditional concept was developed from the spatial orientation of “sky-earth” in the early Bali period, “mountain-sea” during the Bali Aga period, and “sunrise and sunset” to the time of Bali Arya/Majapahit [29]. The Tri Mandala pattern is a reference pattern building layouts in traditional Balinese architecture. The three aspects of the Tri Mandala are Utama Mandala, Madya Mandala, and Nista Mandala. According to Parwata (2011) [21,26] explains that the elaboration of the teachings of Tri Hita Karana and its relation to the concept of Tri Mandala is the relationship between humans and God, which is carried out in the dimensions of the Utama Mandala space, Human relations are carried

out in the *Madya Mandala* space. Meanwhile, the *Nista Mandala* dimension is the relationship between humans and their environment.

In Hindu belief, the concept of horizontal orientation is based on two axes, namely the axis at sunrise and at sunset Kangin-Kauh (East-West) and the mountain-sea axis called Kaja-Kelod (north-south). The ritual axis or sun (sunrise-sunset) has a meaning from the naming of Kangin, which is the direction of the sun's rising and is considered the most important area. The rising of the sun means the start of a day, meaning the beginning of life with new energy. At the same time, Kauh is the direction of sunset which means the end of all daily activities, replaced with a night. This condition means that the direction of Kauh is a dirty area or a dirty place. Kaja is the direction of the Mountain, which is considered the highest direction and is considered the Main area. In contrast, Kelod is the direction of the sea, which is regarded as a direction that represents bad or dirty things and has a Nista value. Figure 1 shows an illustration of the cardinal orientations of the two axes and their relationship to the Tri Mandala.

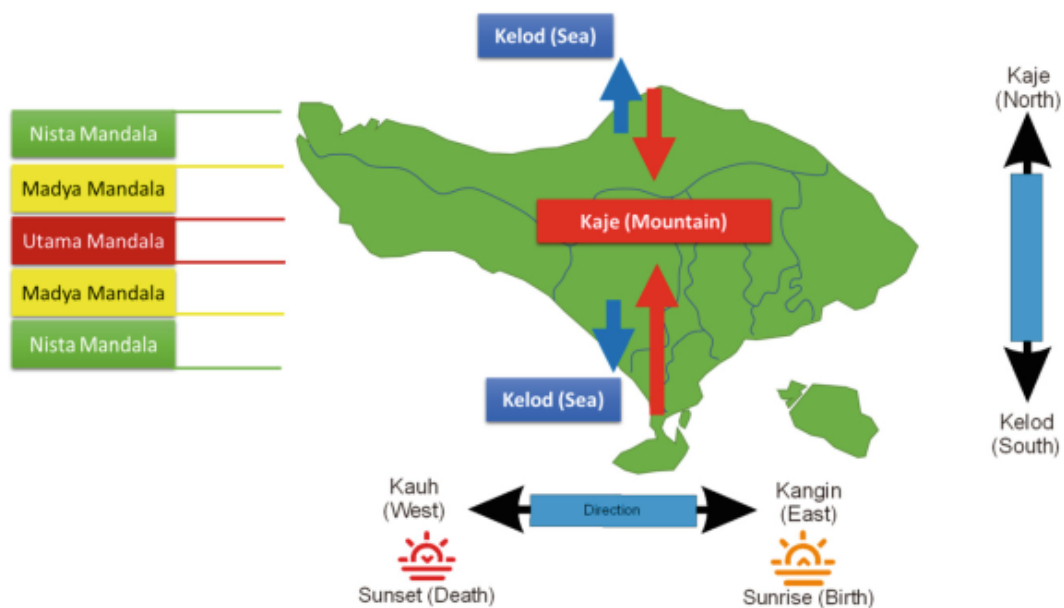


Fig. 1. The cardinal orientation of the two axes and the relationship on the Tri Mandala

Traditional Balinese architecture has a basis in development, namely determining functions and zones by using the Tri Angga concept as the vertical axis and the Tri Mandala concept as the horizontal axis so that the parts of the building have a high traditional value [28]. Vertically (the Tri Angga concept), facilities in Bali illustrate the human body, namely Utama Angga is identified with the head located at the top, the Madya Value is the body part is located

in the middle. The legs are found below, which is called Nista. Horizontally (the Tri Mandala concept) forms zoning with a hierarchy of values corresponding to the natural axis's value, such as the upstream or inner part of Utama value, the middle part is of Madya value, and the downstream or outer part will be Nista. Figure 2(a) illustrates the use of the Tri Angga, Tri Bhuana, and Tri Mandala concepts.

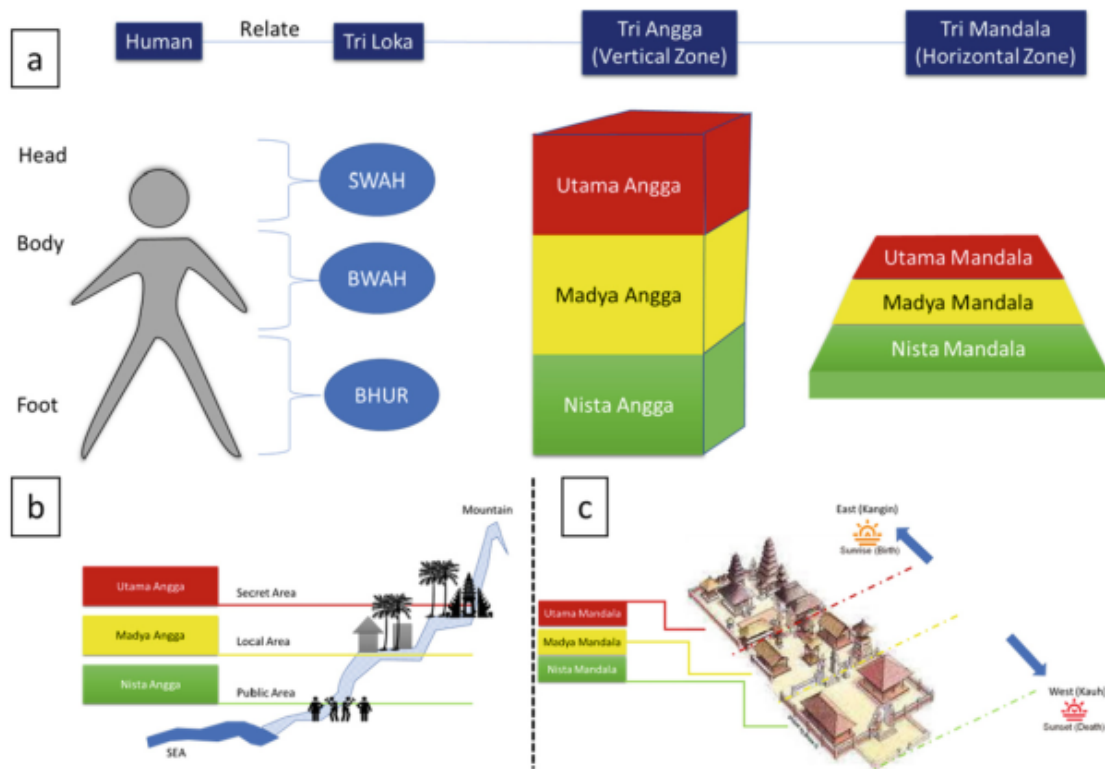


Fig. 2. (a) The use of the concept of Tri Angga, Tri Bhuana and Tri Mandala; (b) illustration of sea-mountain orientation with Tri Angga; (c) Illustration of kaje-kelod using Tri Mandala

Figure 2(b) shows an illustration of the regional scale. A mountain is a sacred place, so that it is in the Utama Mandala or a limited place is only allowed for prayer and spiritual purposes. A temple is a sacred place so that in the construction and establishment of the temple, it must follow several requirements with the structure of the temple building following the Tri Mandala concept. While in Fig. 2(c) is the pattern of Balinese community buildings, which are divided ²³ three zones following the THK concept. ¹

The regional regulation (Perda) of the province of Bali number 16 of 2009 concerning the spatial plan of the province of Bali states that the height of buildings that utilize a ¹ space above the earth's surface is limited to a maximum of fifteen (15) meters or the same as buildings with 4–5 floors. Non-commercial buildings can exceed 15 m, such as temples and public facilities. This is an effort made by the government to limit the population not to exceed the capacity given

Bali's relatively narrow and limited area. Apart from the government, this is the aspiration of the Balinese indigenous people who are very concerned about spatial planning and culture. Figure 3 illustrates the restrictions on building height according to Perda no 16/2009.

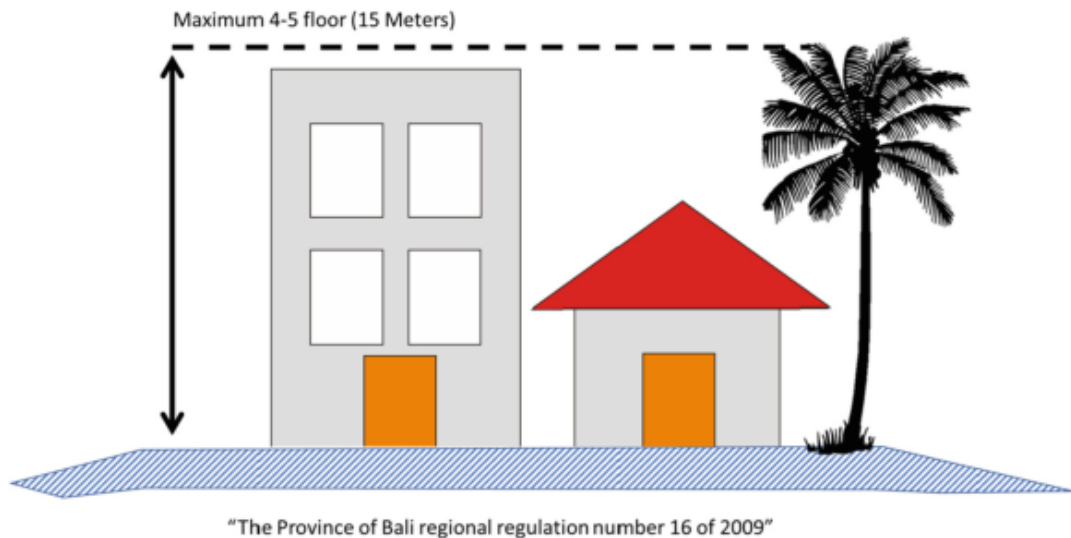


Fig. 3. Illustration of restriction on building height.

Penglipuran Village is a traditional village located in the Kubu Village area, Bangli District, Bangli Regency, Bali Province. The location of this village reaches 112 ha with an altitude of about 500–600 m above sea level. Penglipuran Village is one of the traditional villages well-known as a tourist destination in Bali because of its people who still preserve and practice local wisdom and traditional Balinese culture in their daily lives. The people of Penglipuran Village follow a customary rule known as Awig-Awig. This Awig-Awig embodies local knowledge, which is a strong foundation in good natural resource and environmental management and customary law in the form of regulations or laws drawn up and stipulated by members of the village community, Banjar, and Subak regarding the rules of life. Society in the fields of religion, culture, and socio-economics in Bali.

In the spatial concept of the Penglipuran Traditional Village, the environmental arrangement is oriented towards the north. This is influenced by the old cultural heritage that places the north as the highest and sacred place. In this case, the symbolic orientation is Mount Batur. This mountain is located north of the village of Penglipuran, which they believe has magical and religious powers. So that the pattern of placement of village buildings always crosses from north to south with the north as a sacred part.

Penglipuran Village follows the development procedure according to the architectural rules that exist in Awig-Awig. In addition to the outline of the Penglipuran Village landscape, the Iri Hita Karana concept is also applied in the arrangement of the Penglipuran Village community's house complex. The

idea used is still in the division of Utama, Madya, and Nista zones. These zones also affect community activities, such as the Madya zone, which is the zone where most human activities are carried out, the Utama zone where people worship, and the Nista zone where people carry out activities such as putting livestock. An illustration of the zoning in Penglipuran Village can be seen in [8].

2.2 The Relationship Between Customary Spatial Planning and Customary Cadastre

The regulations governing local wisdom in the province of Bali are local regulations (Perda) No. 5 of 2005 concerning Architectural Requirements for Buildings, Regional Regulation No. 16 of 2009 concerning Spatial Planning for the Province of Bali, and Regional Regulation No. 4 of 2019 regarding Traditional Villages in Bali. These regulations represent all development, management, and living activities that are regulated to create harmony and can implement Tri Hita Karana in life (see Fig. 4).

Then, if it is related to 3D Cadastre and BIM and IFC modeling technology, local wisdom regulations that regulate all development and life activities require using the Tri Hita Karana concept. Where in it there are traditional and modern architecture with the orientation of Tri Mandala, Tri Angga, Sangga Dewata, and Tri Loka [26]. This confirms that in addition to spatial boundaries, there are also rules in life that provide information about mandala zones such as sections passed by guests or the public (Nista), fellow family members or relatives (Madya), and designated places (Utama).

In addition, the above information provides a new semantic inland technology where 2D Cadastre mapping does not provide detailed information regarding the use of the land. So it is necessary to make a transition to 3D Cadastre, which adds information related to 3R to local wisdom on a parcel and the building that is in it. For example, housing or apartments that a local wisdom policy can influence.



Fig. 4. The relationship between regulations, local wisdom and cadastral.

3 Results and Discussions

3.1 The Concept of Dynamic BIM and Sustainable Development Goals

Sustainable development has a positive impact on the Penglipuran Traditional Village. The creation of a prosperous life by reducing poverty and income inequality or unemployment, increasing food security, and improving physical and spiritual health due to the increasing number of tourists who want to visit Penglipuran village. Applying the Tri Hita Karana concept in the Penglipuran traditional village to organize its customary space can create a harmonious life and social welfare. For example, it can overcome various potential conflicts, disputes, and land cases in the future by following the applicable regulations and the existing land management system in the area and, on the other hand, implementing the government's strategic program "Complete Systematic Land Registration" (or known as PTSL) in traditional villages and with the Bali regional regulation No. 4. In 2019 concerning Traditional Villages in Bali, certificates with the subject of traditional villages have the right to have ownership of land rights. This can create an arrangement of life that is just and dignified with legal certainty that it can control, own, use, and utilize the land.

Over time, Penglipuran village has become a unique traditional village because it applies a spatial arrangement with the Tri Hita Karana concept in each of its land divisions and accepts structural and infrastructure modernization because the Penglipuran traditional village becomes a tourist village [4]. However, there is a threat that when fully taking modernization, Penglipuran village will no longer have popularity because it does not maintain its uniqueness. In addition, another impact is that rural communities can experience poverty economically, and residents prefer to work outside their area. From these problems, a liaison is needed to accommodate changes in the function and use of space before and after as well as providing historical and cultural information on ownership, so that it can make efforts to conserve customary space (see Fig. 5)

The image 6 explains the modification of the [11] theory, related to the relationship between land administration and sustainable development. The position in this research is on the application of customary cadastre, which is useful for the conservation of customary space and is carried out in a multipurpose cadastre with the help of a dynamic BIM model with spatial-temporal dynamics information. This is in the provision of land information infrastructure, which is modified with the theory of spatial system administrative unit [1] which supports and is in modern cadastral infrastructure. This customary cadastre is needed to provide legal certainty to indigenous peoples, know their rights, limitations, and responsibilities, and provide historical information on ownership and their traditional buildings and culture.

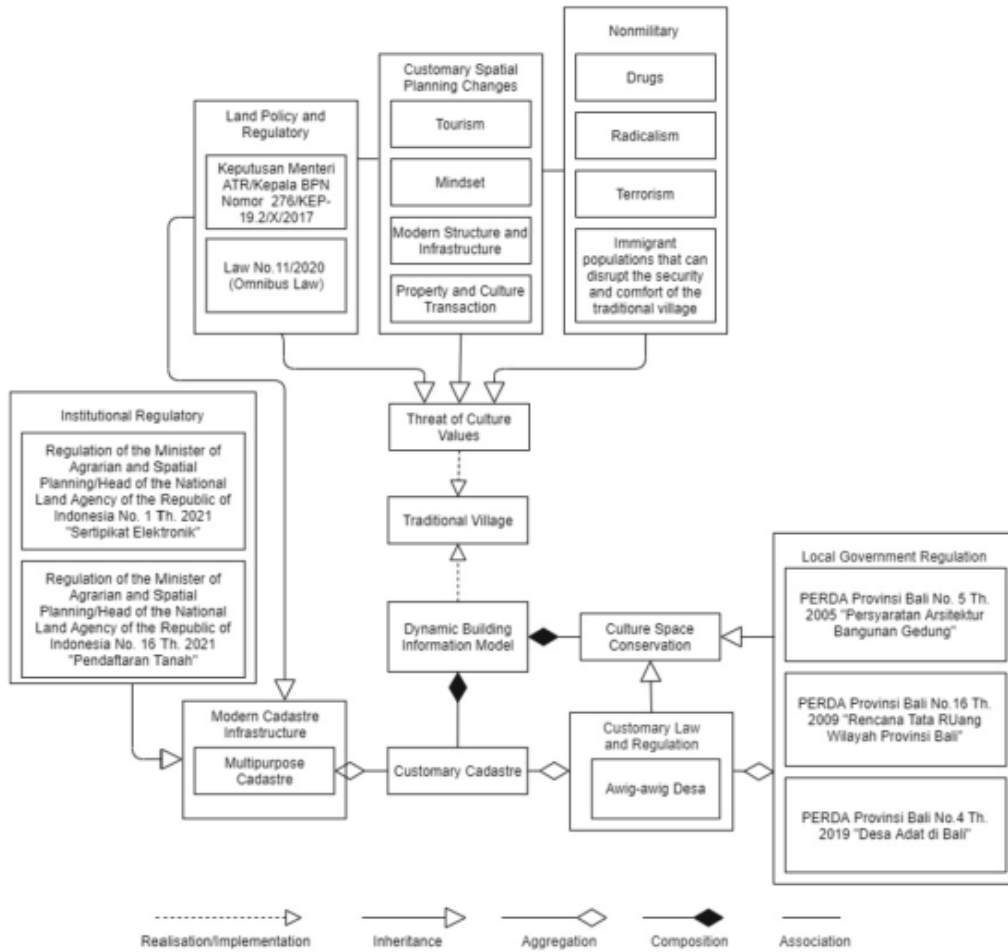


Fig. 5. Threats to the value of the traditional village

3.2 Implementing Dynamic BIM Concept for Customary Cadastre (Restrictions)

Implementing the customary cadastre in Penglipuran village can be done by using the Building Information Modeling approach. BIM can model, manage, and digital inventory data. Future research will implement Dynamic BIM, which adopts the R-tree model to facilitate effective data collection. In addition, it can be integrated with GIS to enable decision-making in giving sanctions to someone who builds a modern building exceeding 15 m. In addition, it can provide a rule that it is not allowed to pass or make on a family temple in the ownership of one plot of land. Figure 7 describes the concept of the process of determining the height limit of space and confirms the zone area in one ownership which contains three zones, namely Utama, Madya, and Nista mandala, with a BIM model that is integrated with R-Tree and GIS. The height of the space from the temple is not limited. The GIS function will provide a height limit of the information so that traditional villages such as Penglipuran village can maintain culture and accept modernization with certain limitations. Thus, Dynamic BIM can accommodate changes in the use and use of space based on applicable customary law and conservation in customary space.

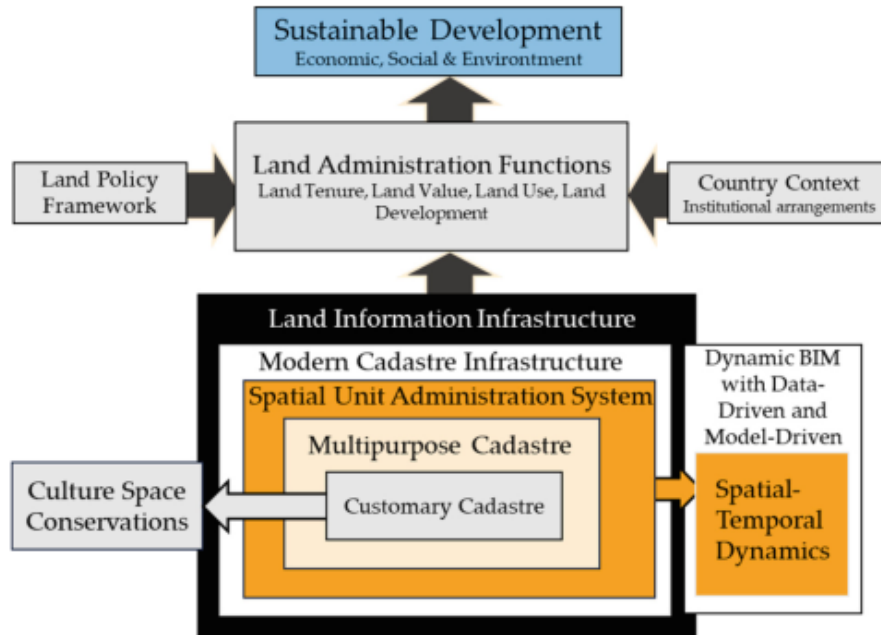


Fig. 6. The concept of dynamic BIM in customary cadastre towards sustainable development ([1, 11, 30] Integrated and Modified by Author)

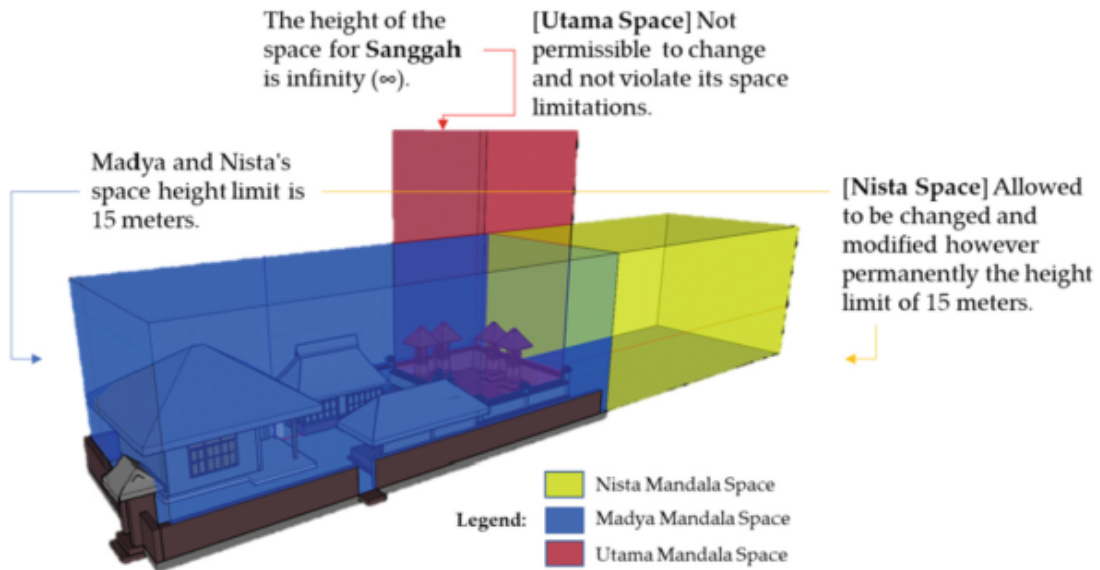


Fig. 7. The concept of setting boundaries related to the construction of structures and infrastructure.

4 Conclusion

Penglipuran traditional village is unique and attractive to tourism because it can maintain its culture and customs by presenting old buildings and accepting modernization in structure (guest-houses, restaurants, souvenir shops) and infrastructure (internet/wifi, modern facilities, and a combination of modern development). However, with this beauty, various potential threats are felt in tra-

ditional villages, such as economic, social, and environmental problems (SDGs) there are changes in modernization. In addition, other threats can be in the form of a different mindset towards cultural heritage buildings and dependence on tourism to avoid financial poverty. On the other hand, there are government policies related to investors and mass certification. Strengthened by local regulations, traditional villages in Bali have legal certainty over their land rights and cannot be contested. Building and implementing the Dynamic BIM model can become a liaison and bridge the existing problems and solutions. The technology it will present can accommodate changes in the use and use of space-based on applicable customary law. The concept can apply customary cadastre and be used as a reference in conservation actions in customary space. Future research will prioritize using existing R-tree models and GIS to be integrated into BIM so that it can be dynamic. The definition of dynamic here is (1) being able to provide information on changes in function and use of space in a customary administration, (2) providing information on land administration related to rights, boundaries, and responsibilities, (3) providing changes in geometric shape after and before using the BRep model, (4) retrieve data quickly and efficiently by adopting the existing R-tree model, (5) make decisions regarding restrictions on the construction of structures and infrastructure under the applicable Customary Law by utilizing GIS technology.

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