



SuperMap

Implementation of Customary Cadastre with Integrating BIM and GIS on SuperMap Software in Bali, Indonesia

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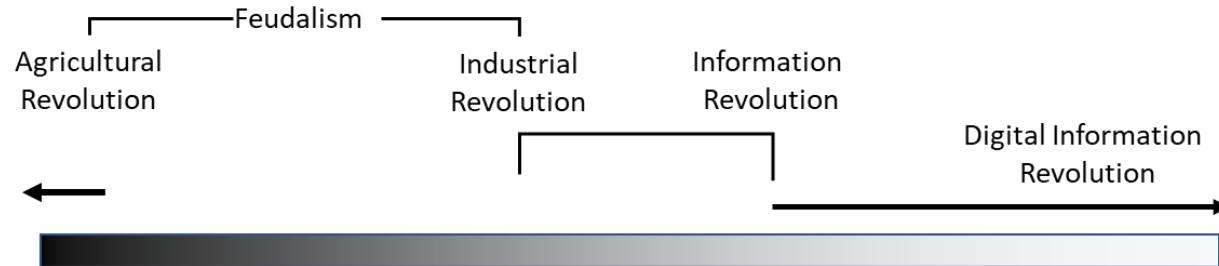
³Department of Survey and Mapping, PT. Amerta Geospatial Indonesia

2021



Contents:

Introduction
BIM & GIS
Spatial Planning of Bali
Methodology
Case Study
Conclusion



BC - 1000

Kingdom
Territorial

Individual
ownership

1700-1900

Land msrkets;
Torrens
System

1960-2000

Agenda 21;
Six Statement of
Cadastre 2014;
Multipurpose
cadastre
Introduction

2005

Land
Administration
Function;
LADM;

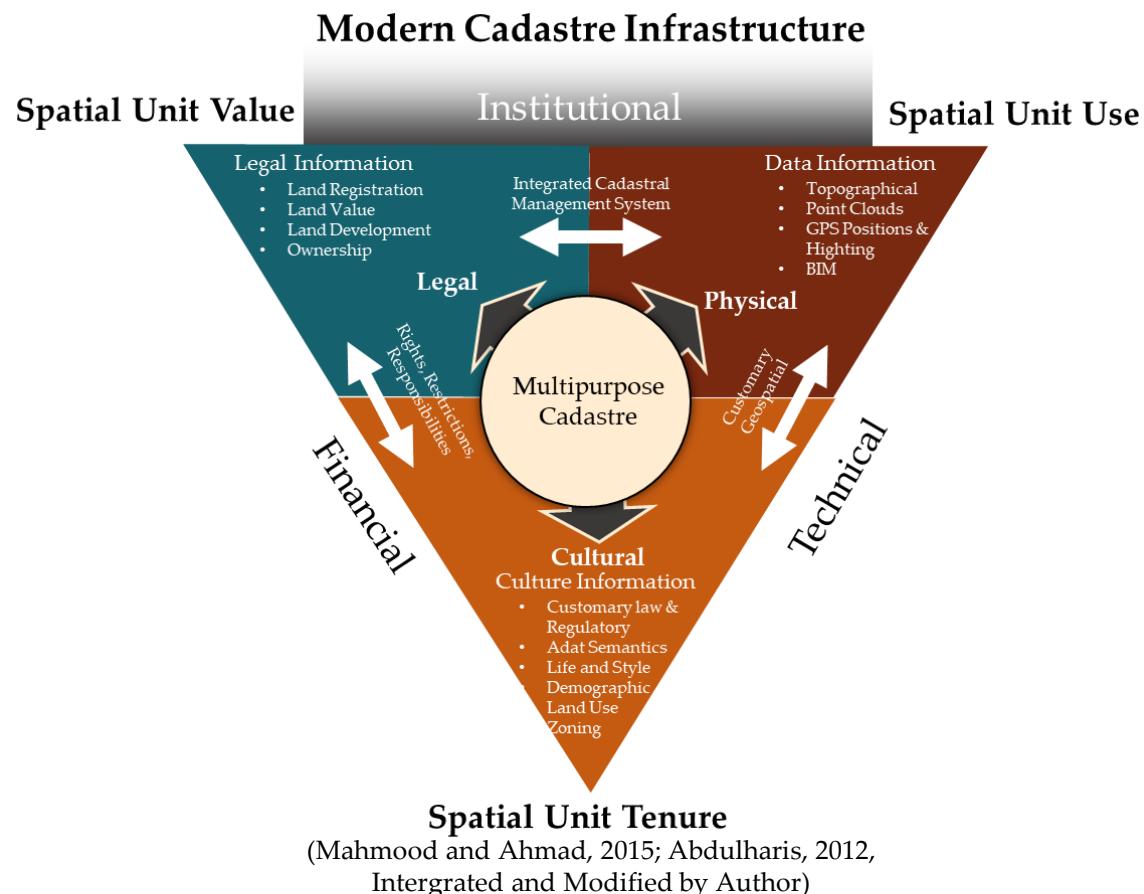
2010-now

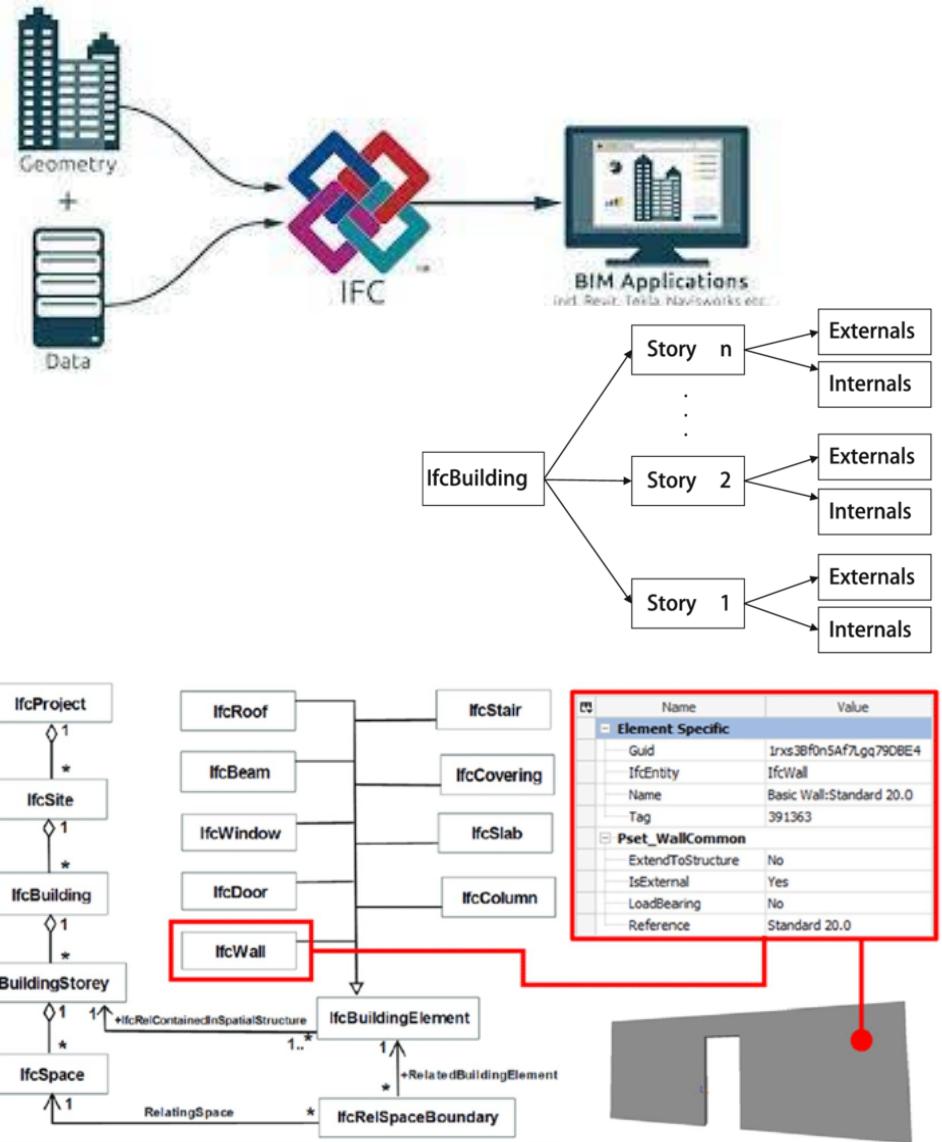
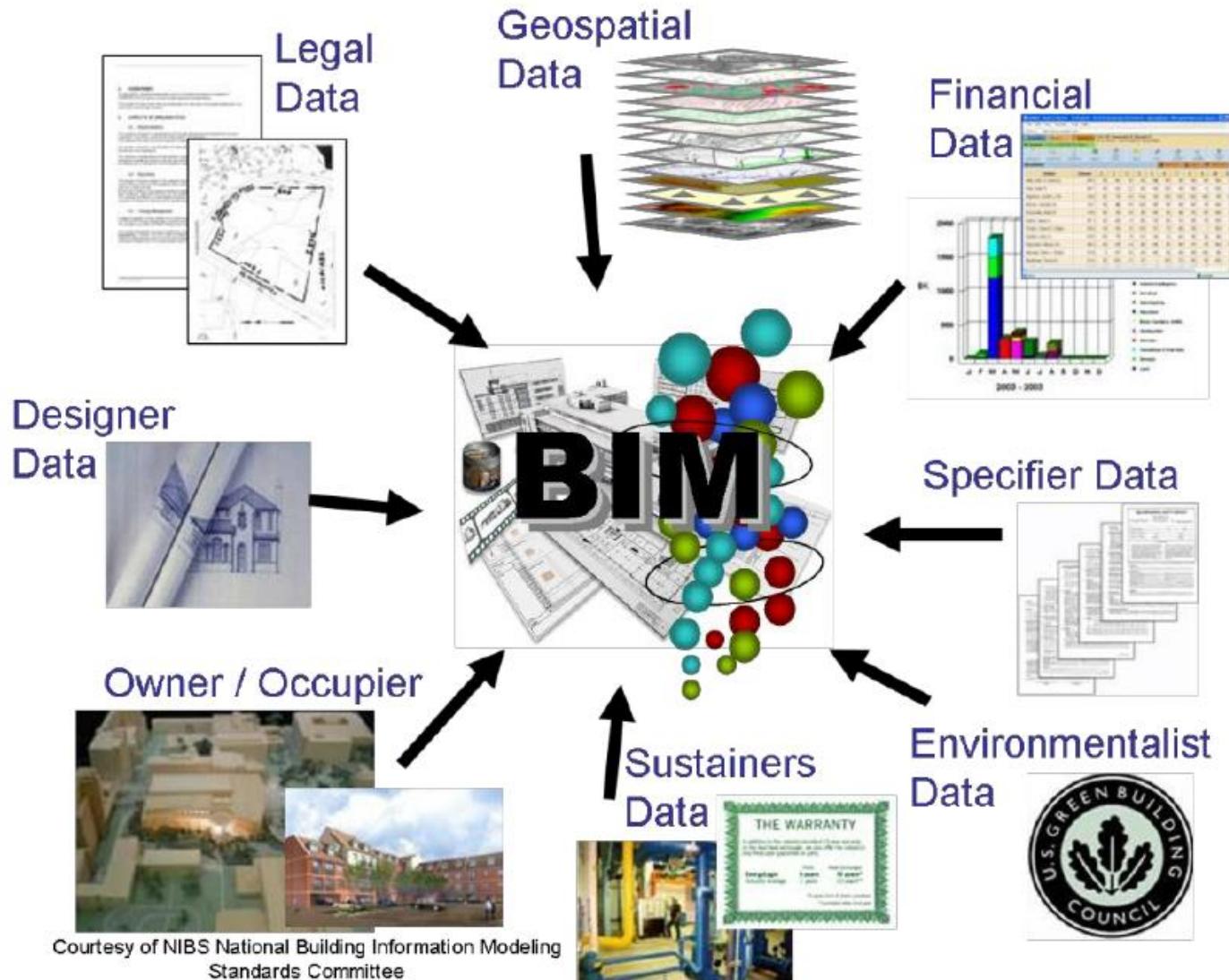
LADM; Cadastre
2034; 3D Cadastre
Implementing –
Concept;
Modern Cadastre
Infrastructure

Multipurpose cadastre is an integrated land information system containing legal (e.g. property ownership or cadastre), physical (e.g. topography, man-made features), and cultural (e.g. land use, demographics).

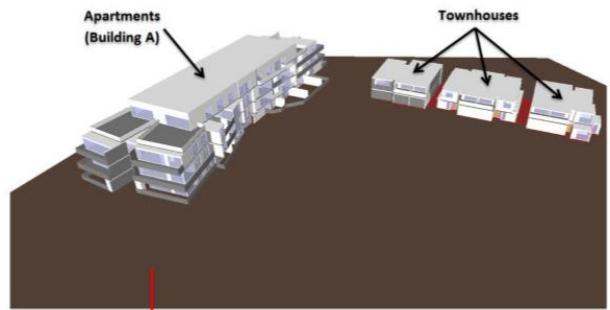
Currently, the application of a multipurpose cadastral system in 3D to support modern cadastre has many technologies. One of them uses BIM and GIS as the perfect approach in providing spatial information related to legal certainty, land assessment, and use of space.

In essence, the cadastre is used as a record of land rights and part of the land administration function towards sustainable development.

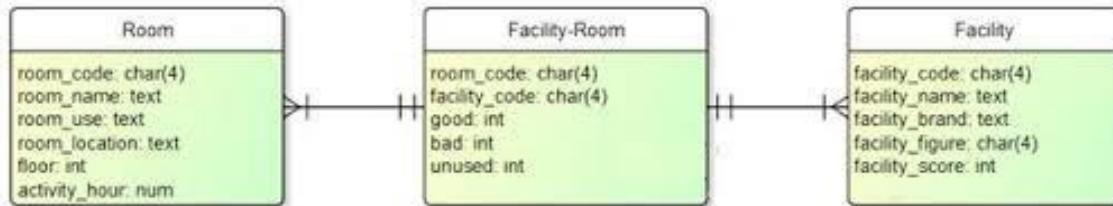
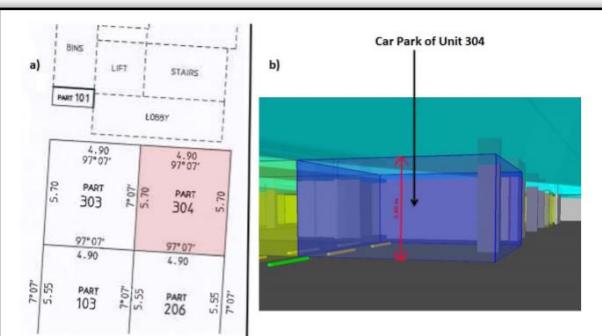
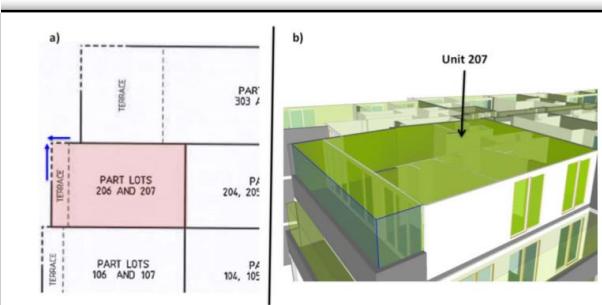
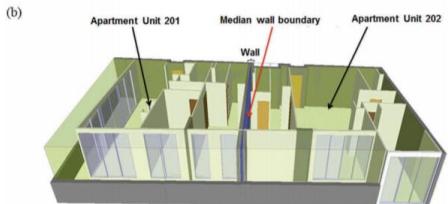
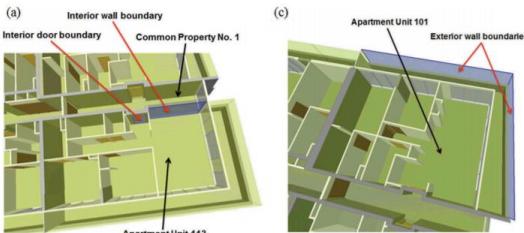




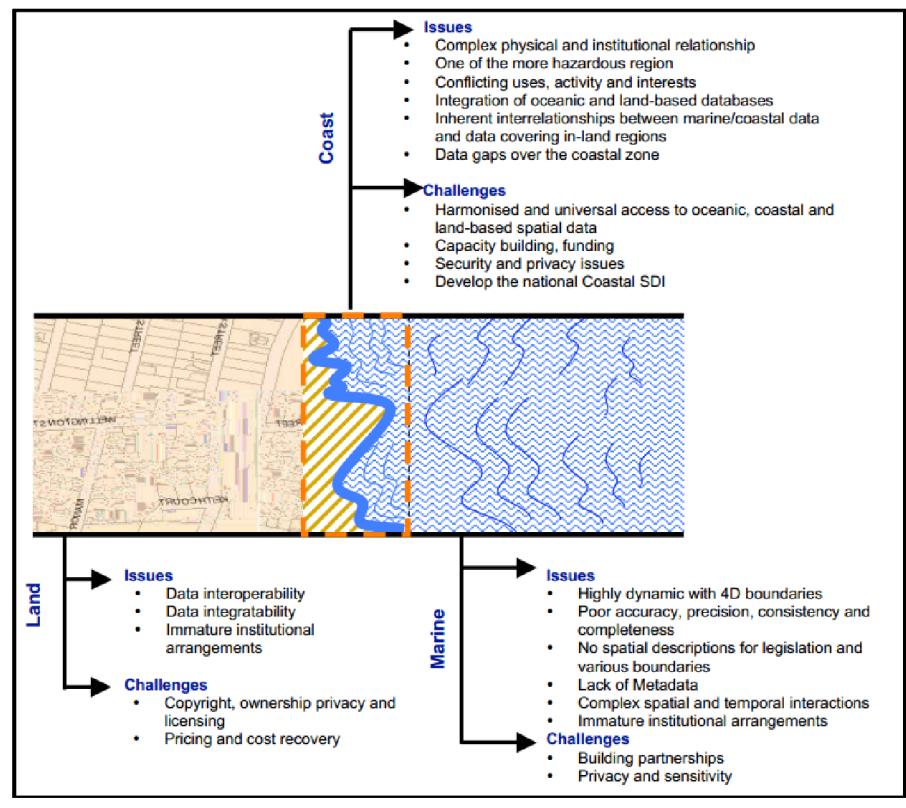
(Herley, 2020)



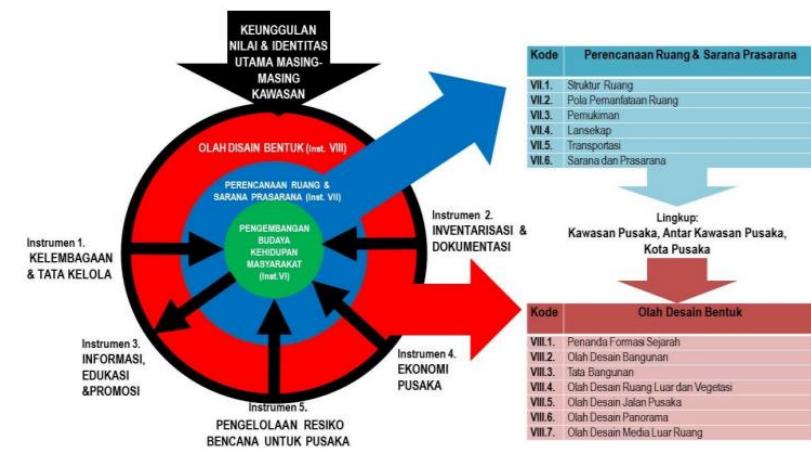
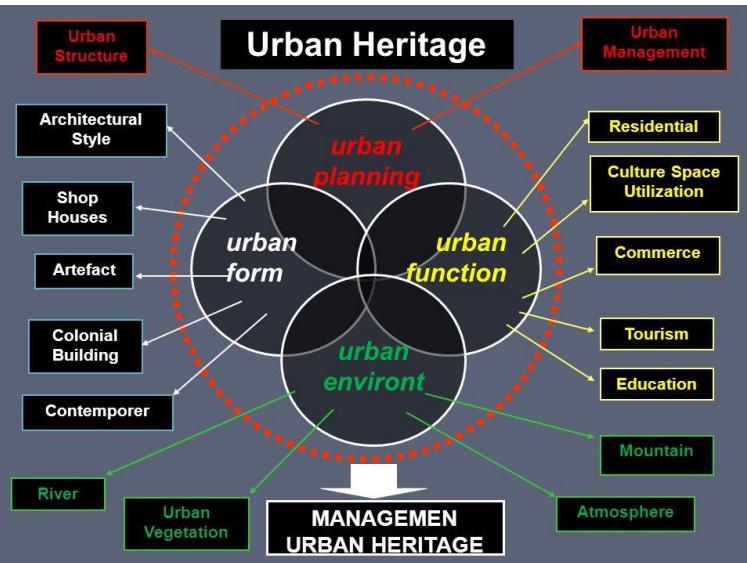
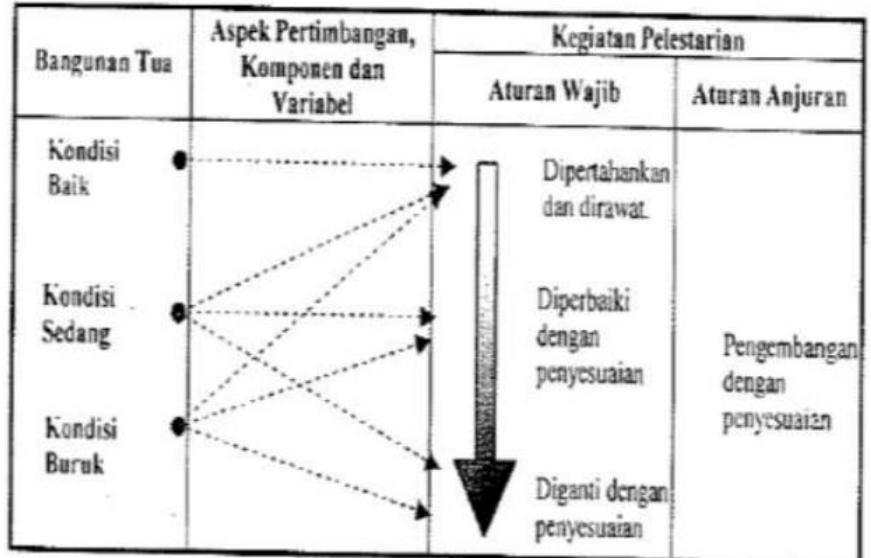
(Atazadeh, 2018)



(alif et al., 2019)

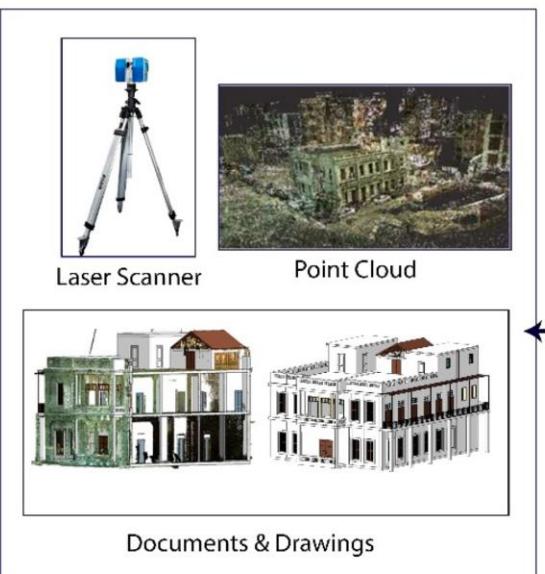
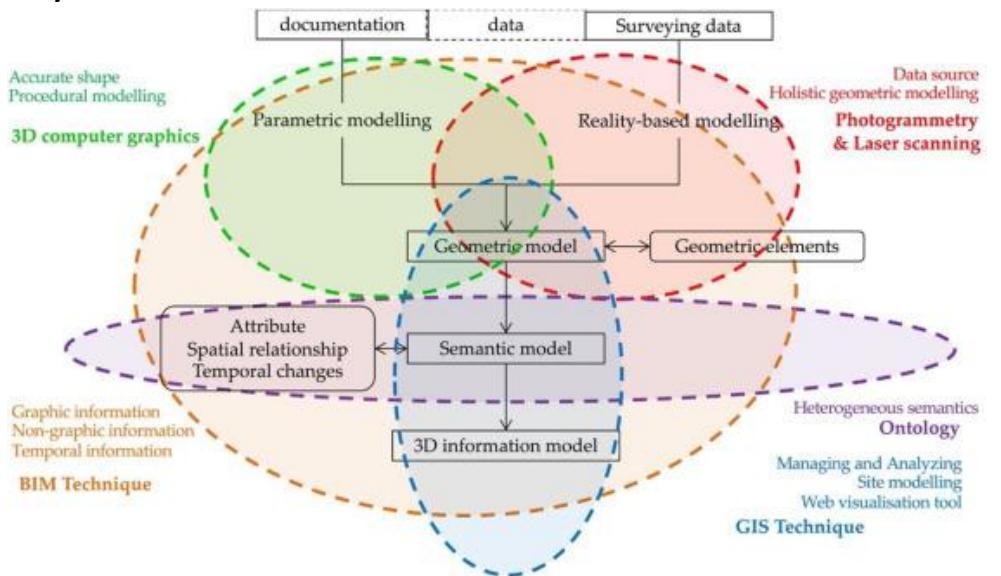


(Rajabifard, 2008)



Adhisakti, 2017

Irwansyah, 2017



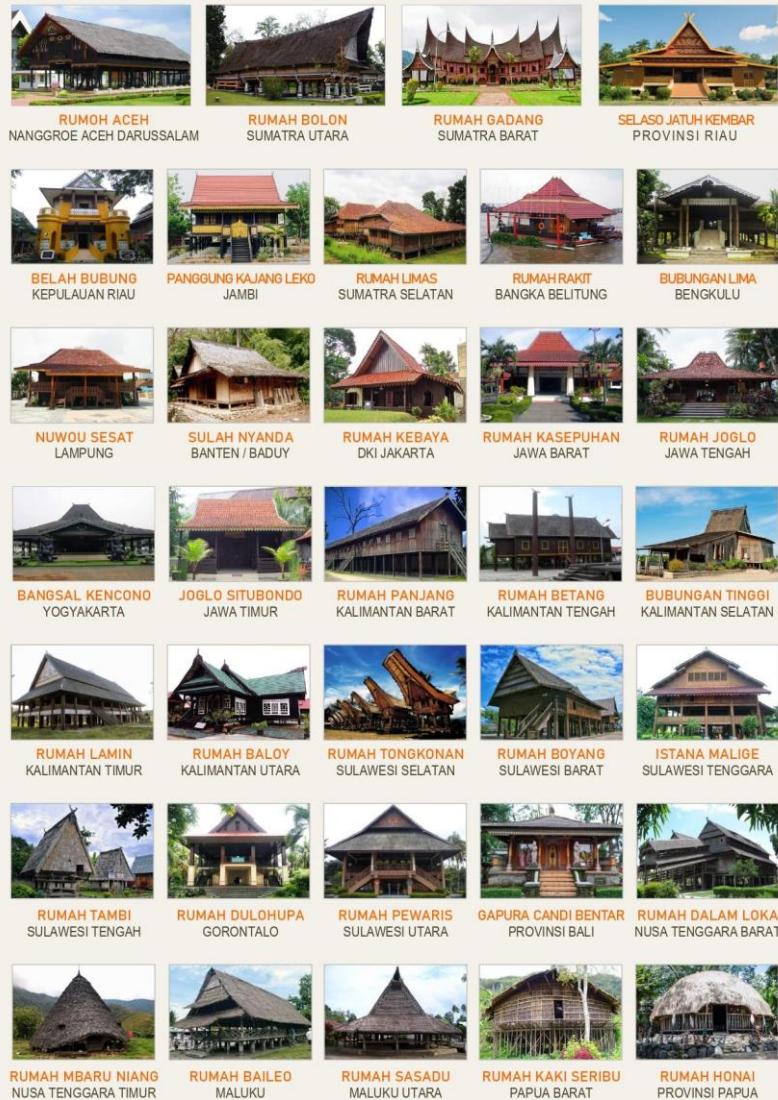
Baik, 2021

How to Implementation of 3D Cadastre in Indonesia?

More of ..
Local Languages?
Culture?
Different of Architecture?



34 RUMAH ADAT INDONESIA



HelpShared.Com

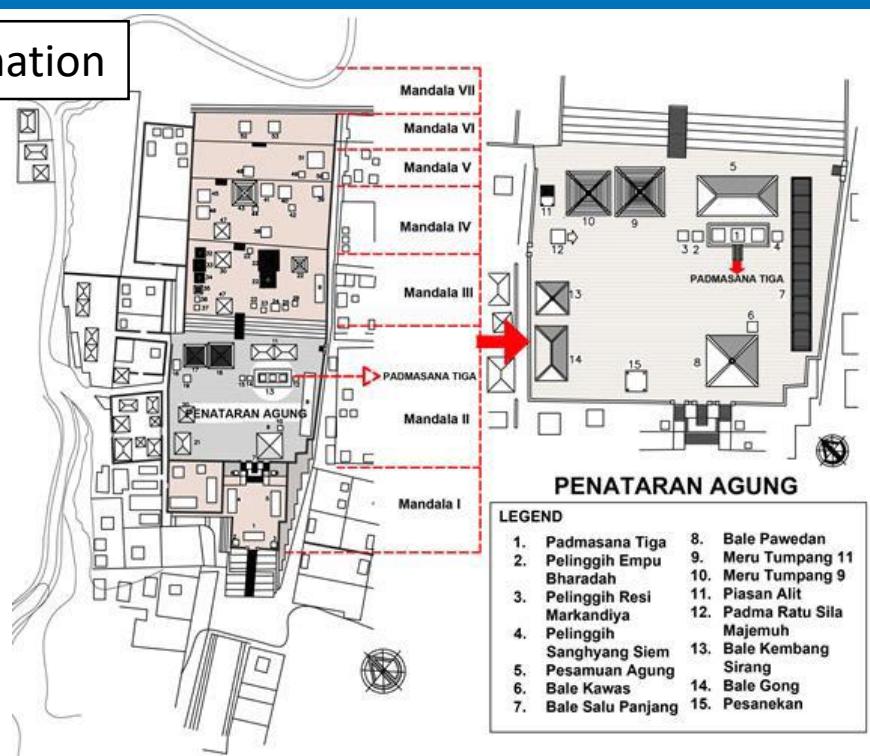
Do you have any knowledge of Bali Island?

What makes Bali a unique location?



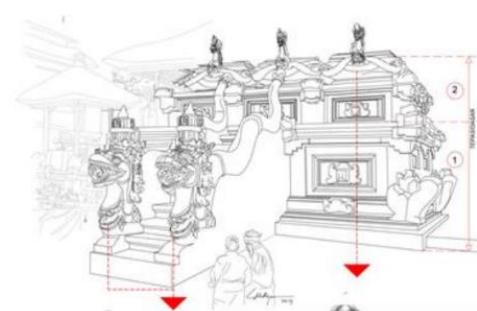
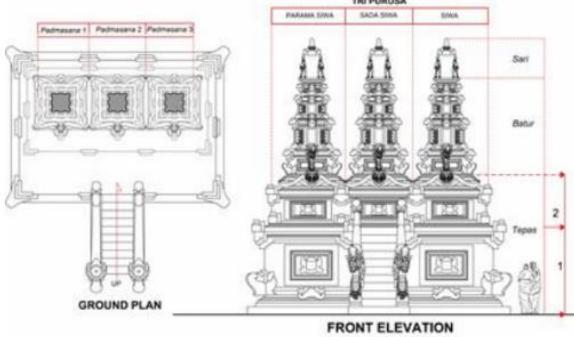
Implementing 3D Cadastre in Bali.

2D Information



Picture in front of the temple

2,5D/3D Drawing Information



Anantabhoga



Basuki and Bedawang Nala

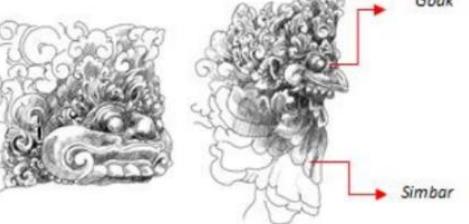
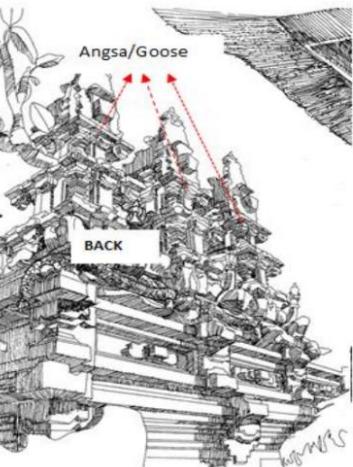


Naga Taksaka



The form of goose if it has been carved
(on the object of research not yet carved)

Goak



Why need implementing 3D Cadastre in Bali.

Complex
Architectural
Patterns and
Adat
Semantics.

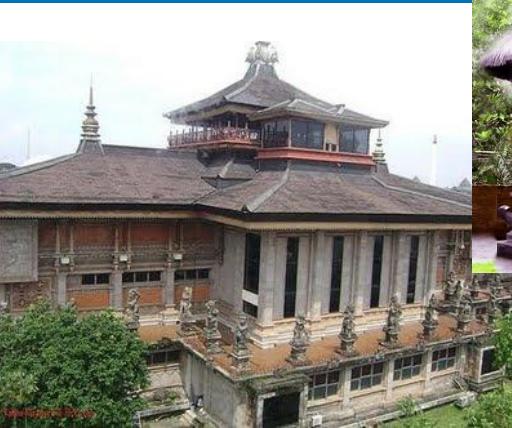




Fig. 1. (a) The traditional gate in the Kesiman Palace, 2013; (b) The Majesty of Ubud Palace, Gianyar Regency, 2009; (c) the Besakih Temple, 2013; (d) the Water Palace Ujung Karangasem, 2013.

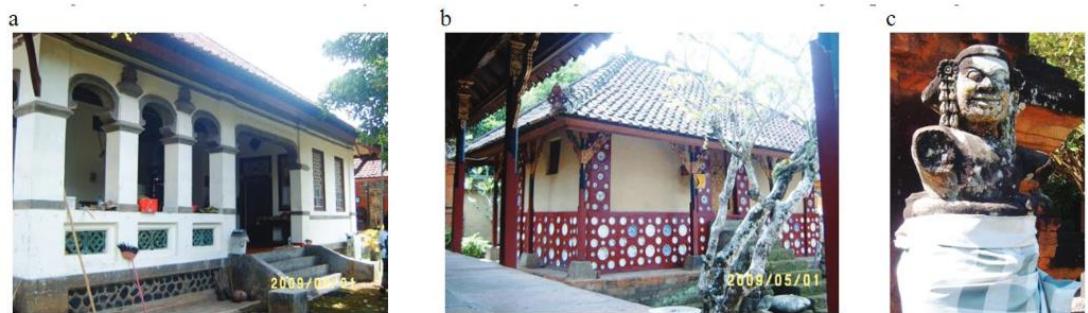


Fig. 7. (a) Colonial building style in Puri Agung Kerambitan, Tabanan Regency, 2009; (b) the using of Chinese plates decorates the traditional building in Puri Agung Kerambitan, Tabanan Regency, 2009; (c) Chinese statue as an evidence of Chinese's influence in Puri Sukawati, Gianyar Regency, 2009.

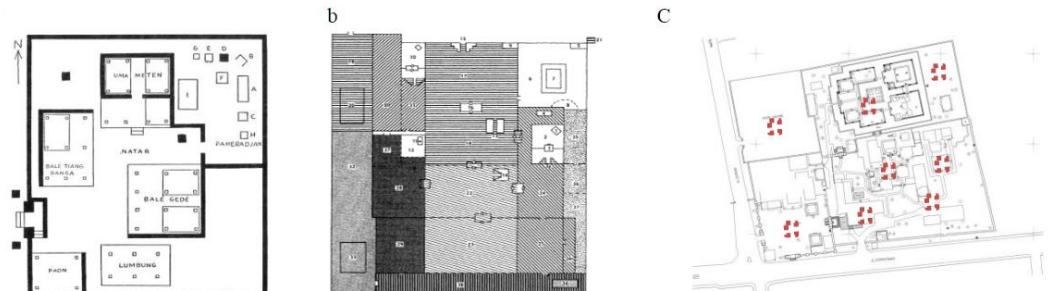


Fig. 2. (a) The palace (*puri*) in the *catuspatha* pattern (Source: Budiharjo, 1995); (b) Meaning of axis and *puri* layout alternative in the *catuspatha* pattern (Source: Putra, 2005).

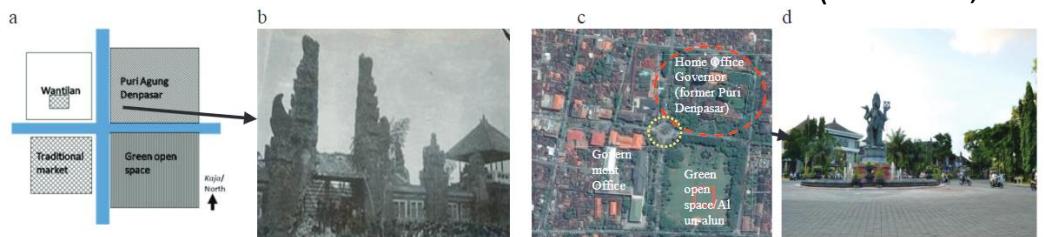


Fig. 5. (a) Cross-road of *catuspatha* pattern in Denpasar with Puri Agung Denpasar was placed in the Northeast direction (Source: Putra, 2005); (b) Puri Agung Denpasar during the Puputan Battle in 1908 (Source: KITLV); (c) the changes of Puri Agung Denpasar into government office in the *catuspatha* pattern (Source: Google Earth, 2014 and processed); (d) the *catuspatha* pattern in Denpasar City with Caturmuka (four faces) statue in the cross-road. 2013.

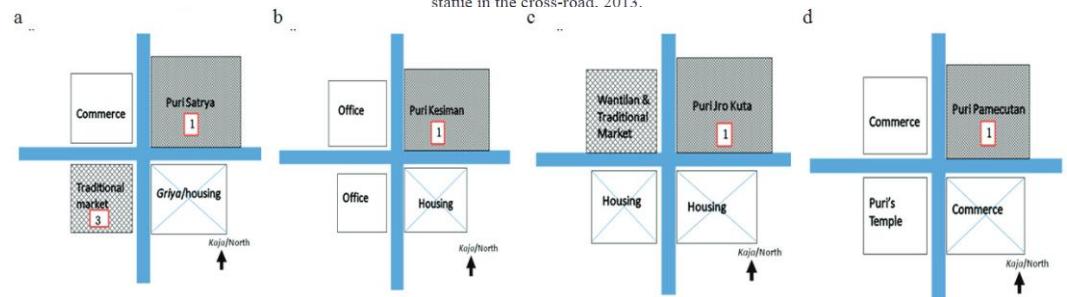


Fig. 6. (a), (b), (c), and (d) the preservation of *puri* position in the northeast as the main value for palace and the changes it's surrounding, 2013.

Since the era of Indonesia's independence in 1945, royal power has diminished but Balinese people still maintain strong ties between aristocratic descendants and their regal associations.

To maintain a harmonious life, Bali establishes the concept of Tri Hita Karana.

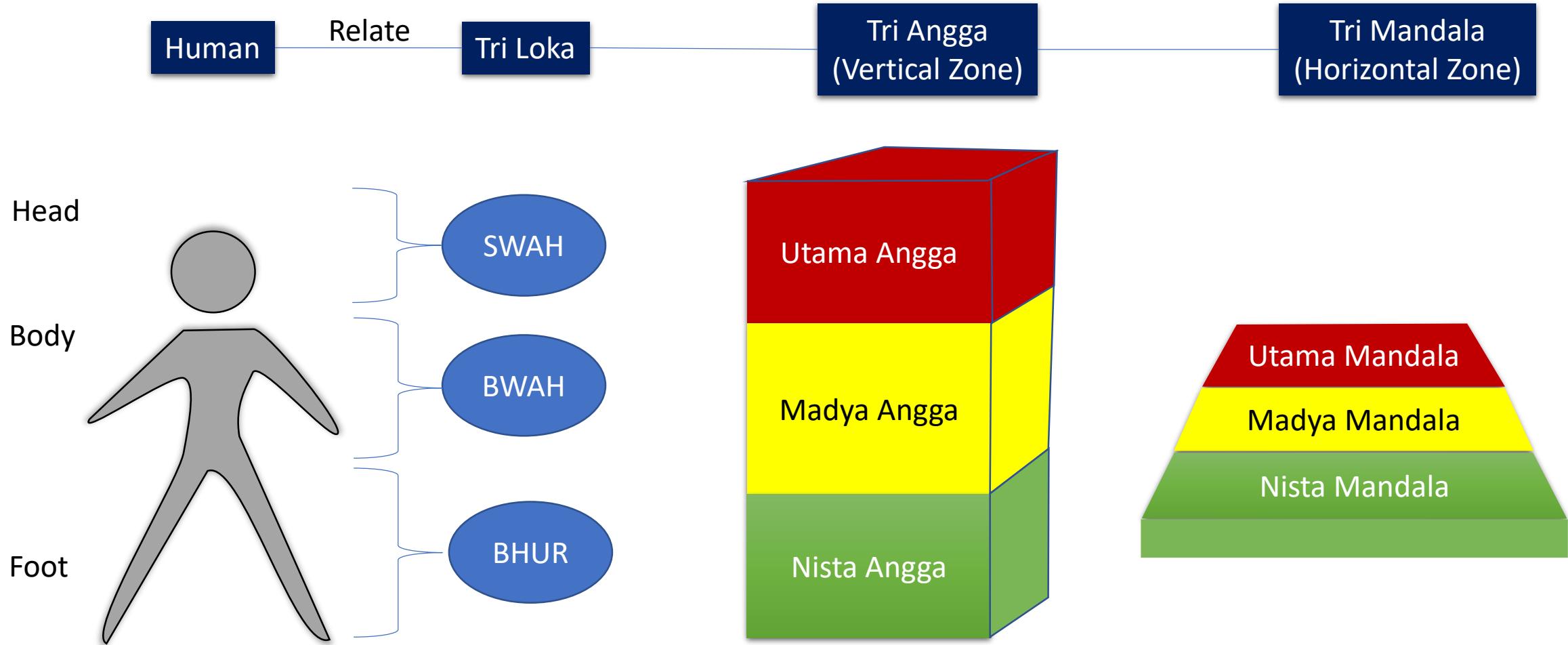


PARHYANGAN

PAWONGAN

PALEMAHAN

Unsur	Atma (Jiwa)	Prana (Tenaga)	Angga (Fisik/jasmani)
Universe (Bhuana Agung)	Paramaatman (The One Almighty God)	The power that moves nature	The Five Elements of Mahabhuta
Village	Kahyangan tiga (Village Temple, Puseh, and Dalem)	Pawongan (Village people society)	Palemahan (Village territory)
Banjar	Parahyangan (Banjar temple)	Pawongan (Banjar people society)	Palemahan (Banjar territory)
House	Pamerajan/ Sanggah	Family members	Ownership boundaries
Human (Bhuana alit)	Atman (human soul)	Sabda Bayu Idep	Human body



TRI MANDALA (ORIENTATION AND RESTRICTION ZONE)

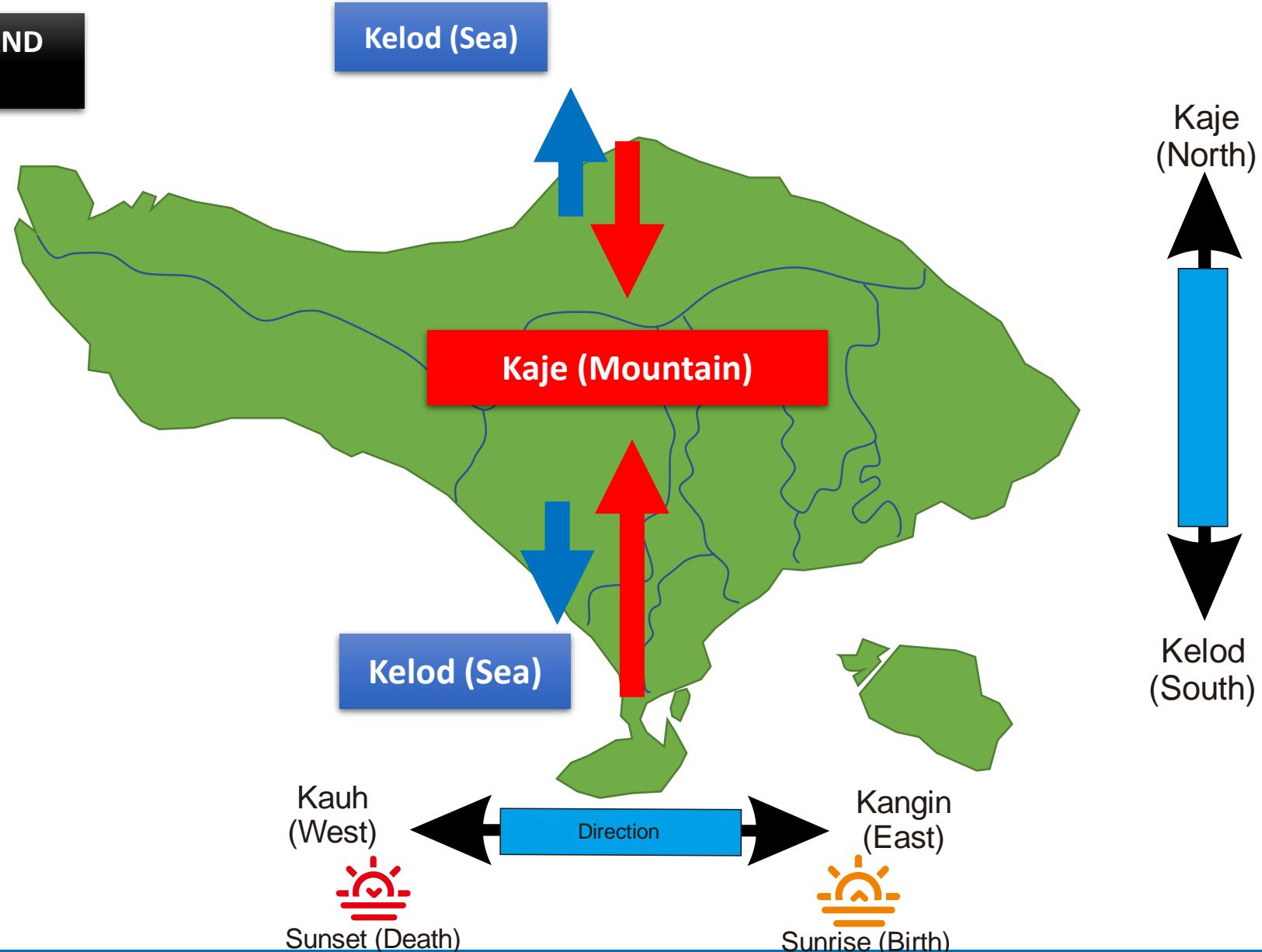
Nista Mandala

Madya Mandala

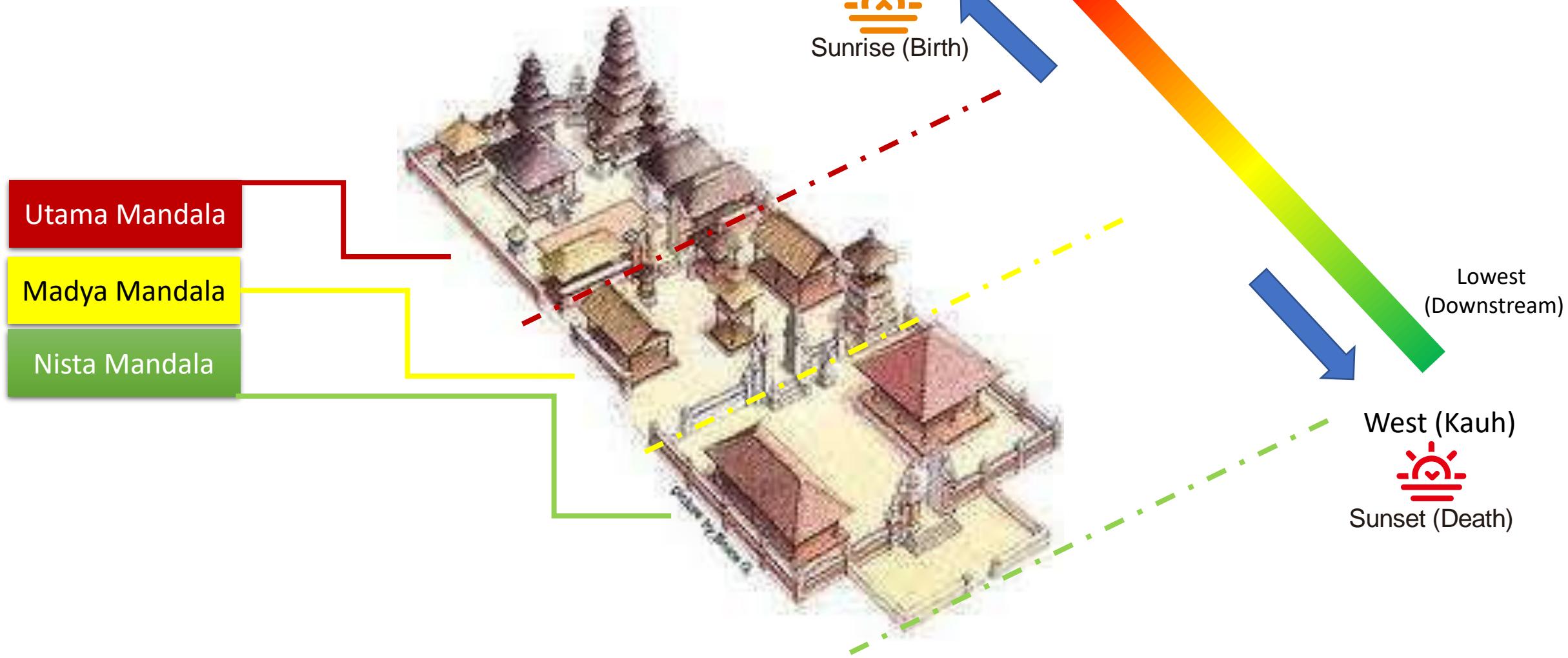
Utama Mandala

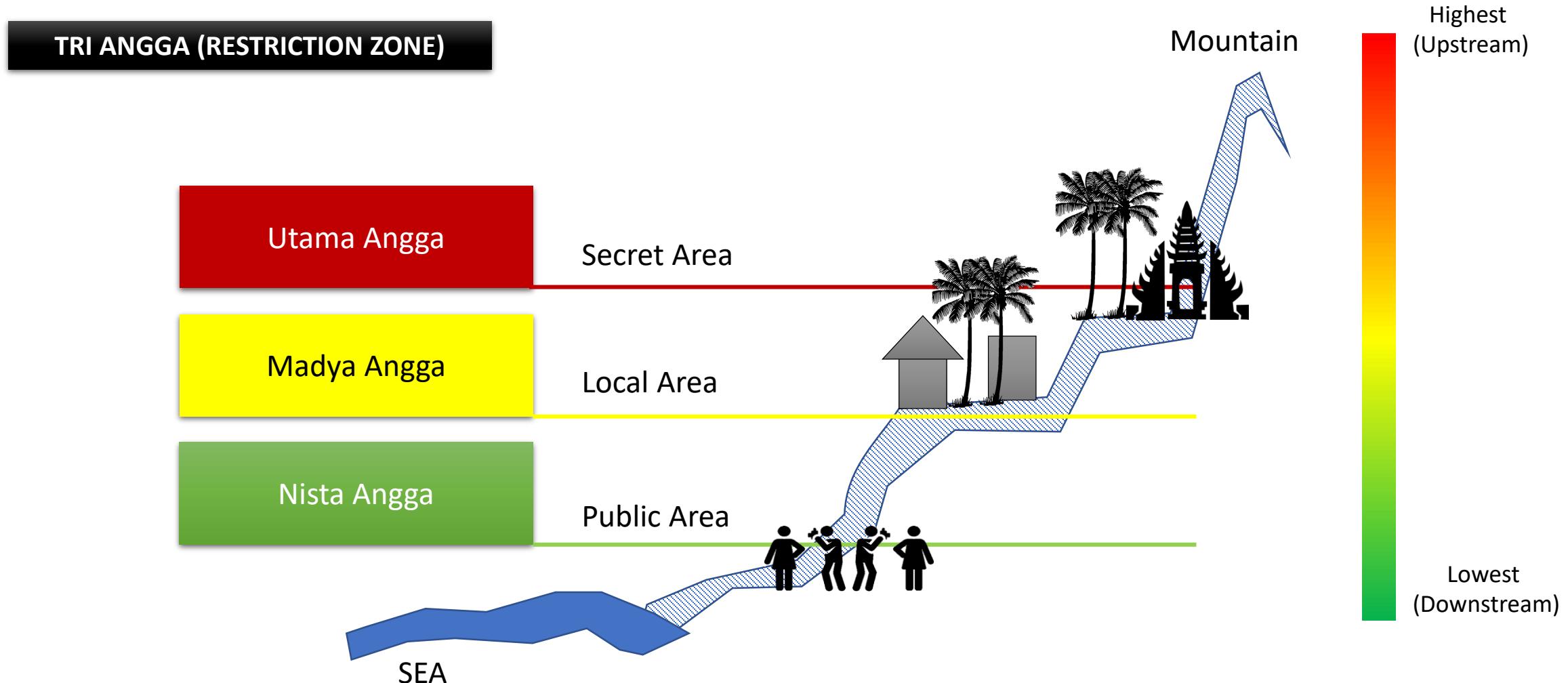
Madya Mandala

Nista Mandala



TRI MANDALA (RESTRICTION ZONE)

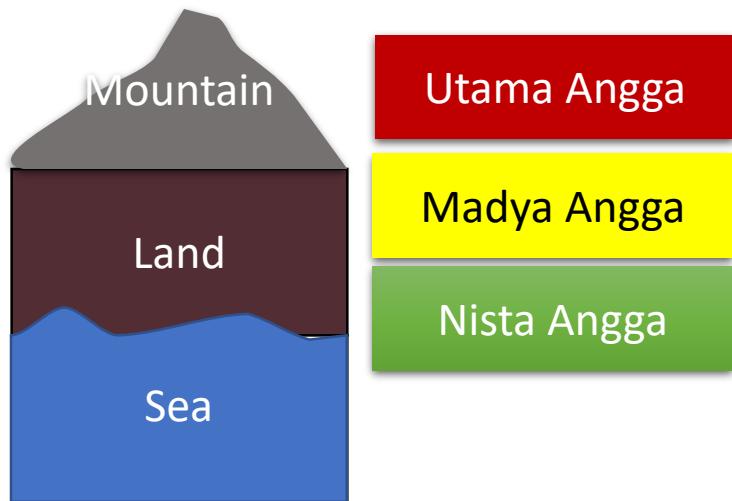




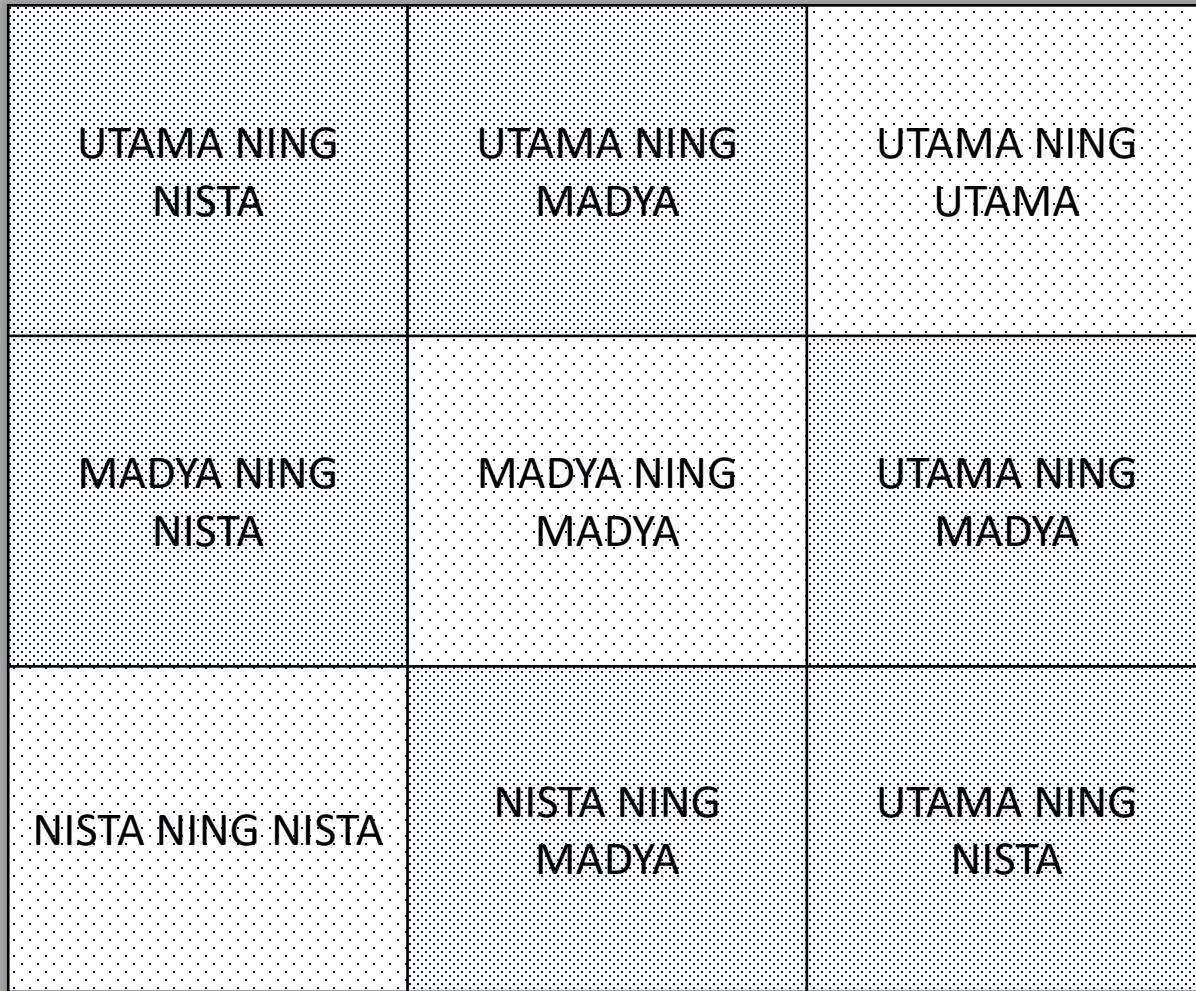
SUNSET



SUNRISE



SANGGA DEWATA (RESTRICTION ZONE)



Highest
(Upstream)



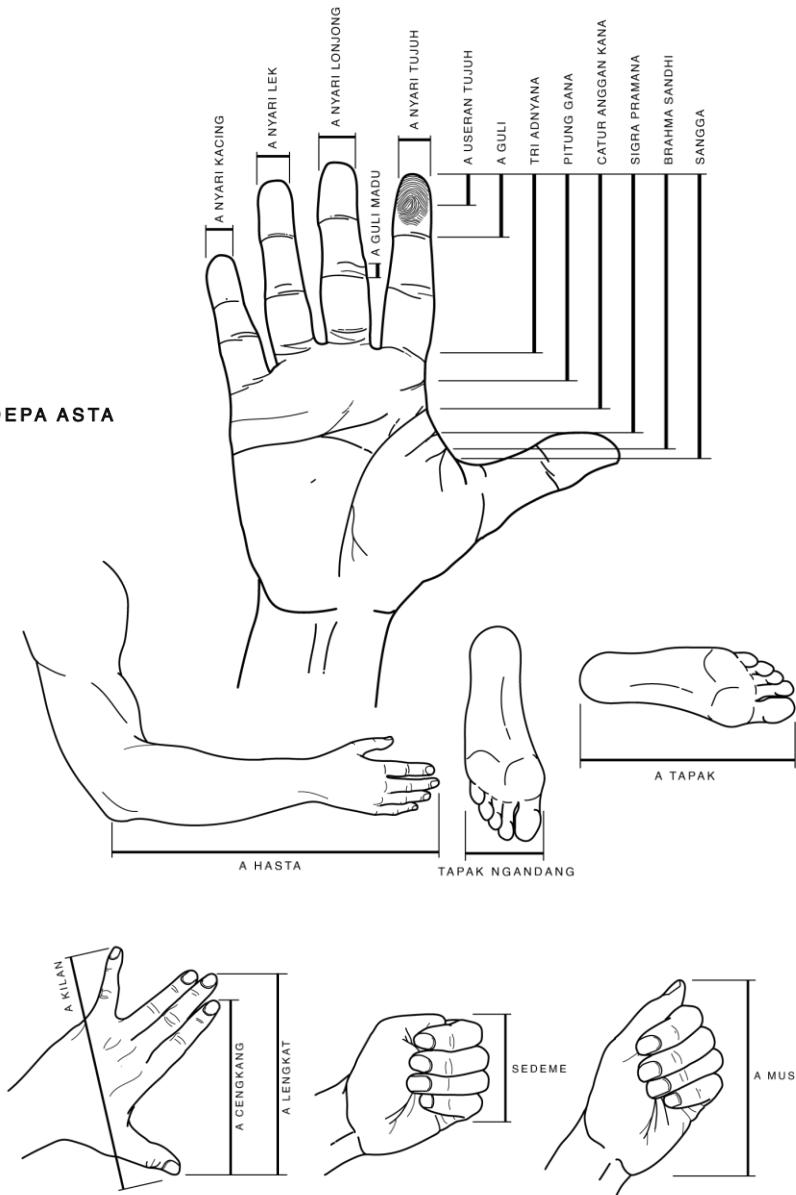
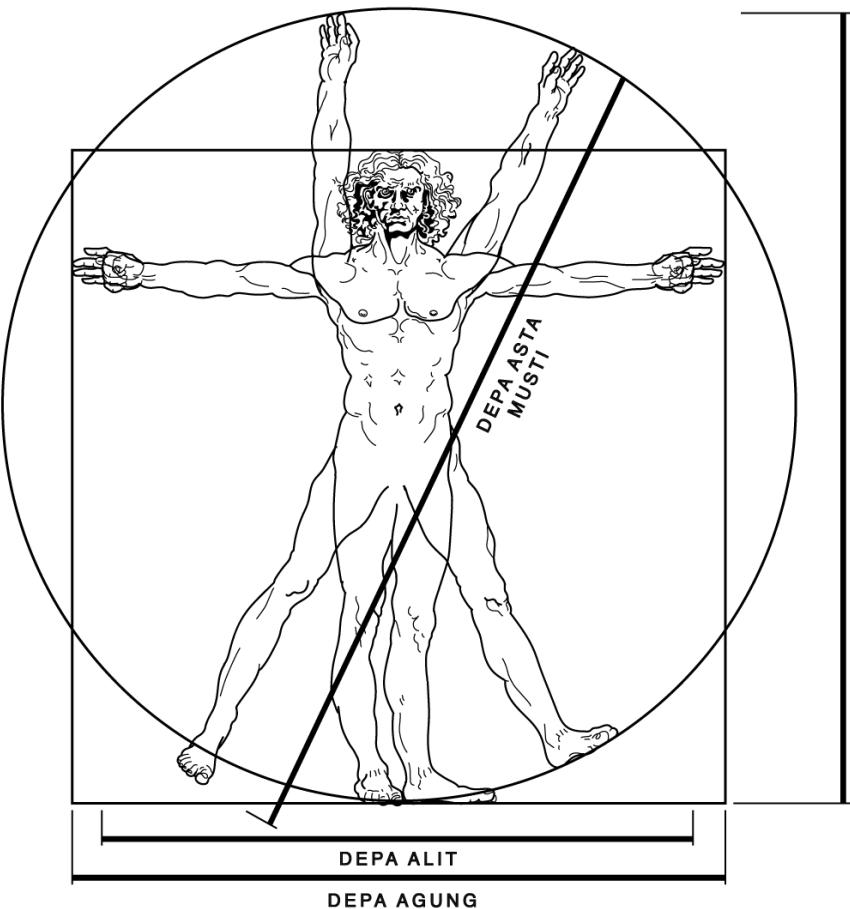
Lowest
(Downstream)

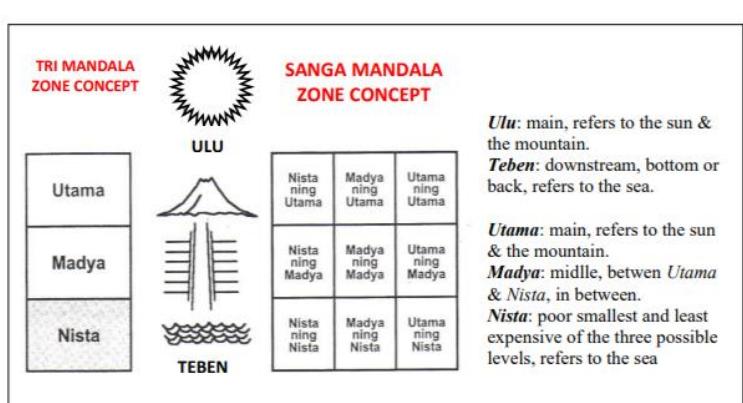
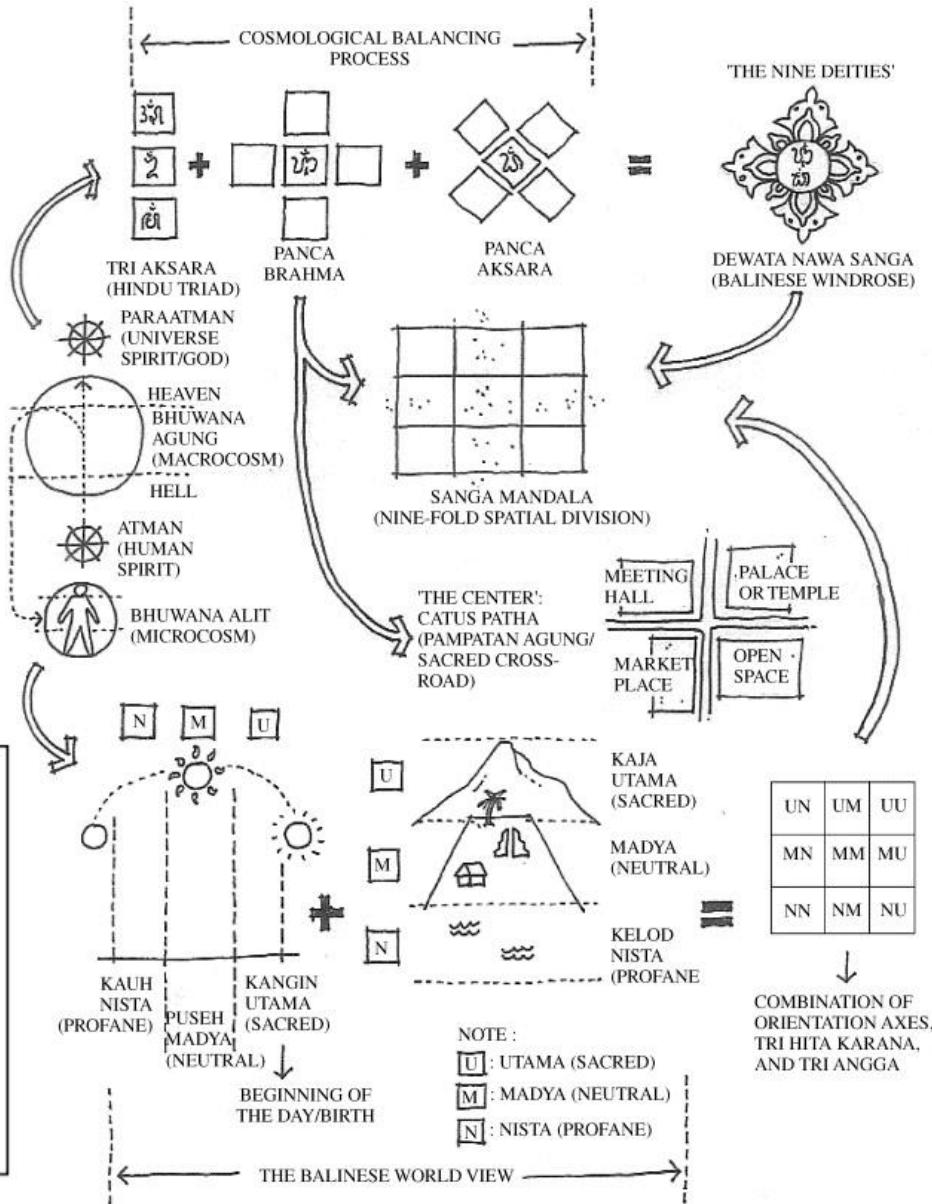
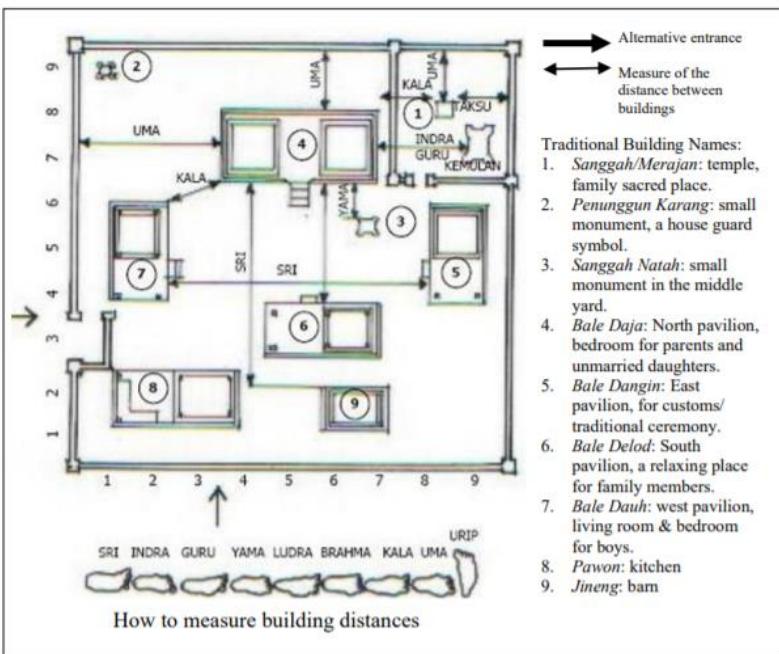
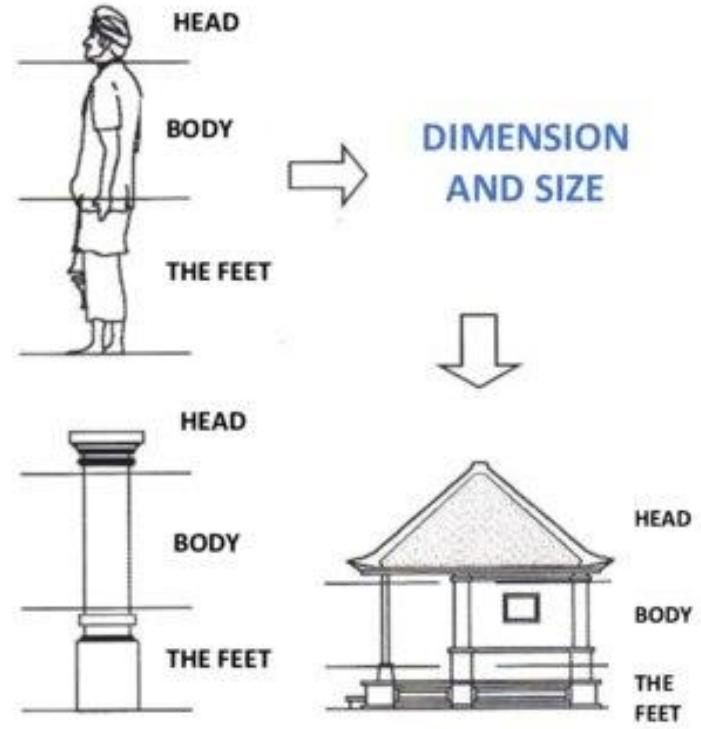
Conventional Measurement with Balinese Traditions.

The basic measurements used in traditional Balinese houses are using **Asta Kosala-Kosali** and **Asta Bumi Iontar** instructions. The basic measurements used are based on the body size of the owner of the house, so that one Balinese house with another Balinese house has different sizes based on the elbow or the size of the owner of the house.

4	Rumah		Asangga	Utama
			Sikut satus solas	Madya
			Sikut satus	Nista

Dimensi Kaki Tiang
Sumber: Putra, J Gt Made. 2014





SANGGA DEWATA (RESTRICTION ZONE)

Utama Mandala

Madya Mandala

Nista Mandala

Kaje



Sanggah (Families Temple)

Natah (Playground)

Bale Dangin (Art's/Life
rites and death rituals
room)

Bale Daja (Parent's Room)

Lumbung Padi / Jineng
(Livestock or storage area
for rice)

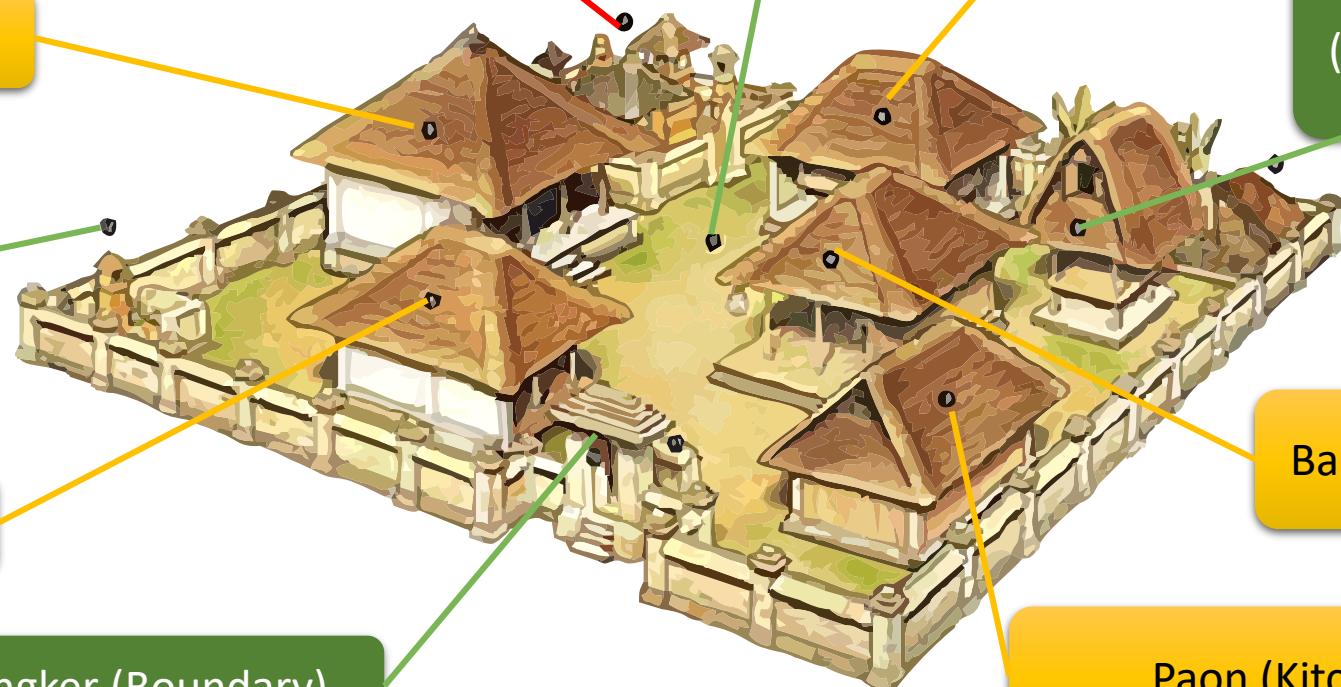
Penunggun Karang
(Guarding of House)

Bale Dauh (Guest's Room)

Bale Delod (Children's Room)

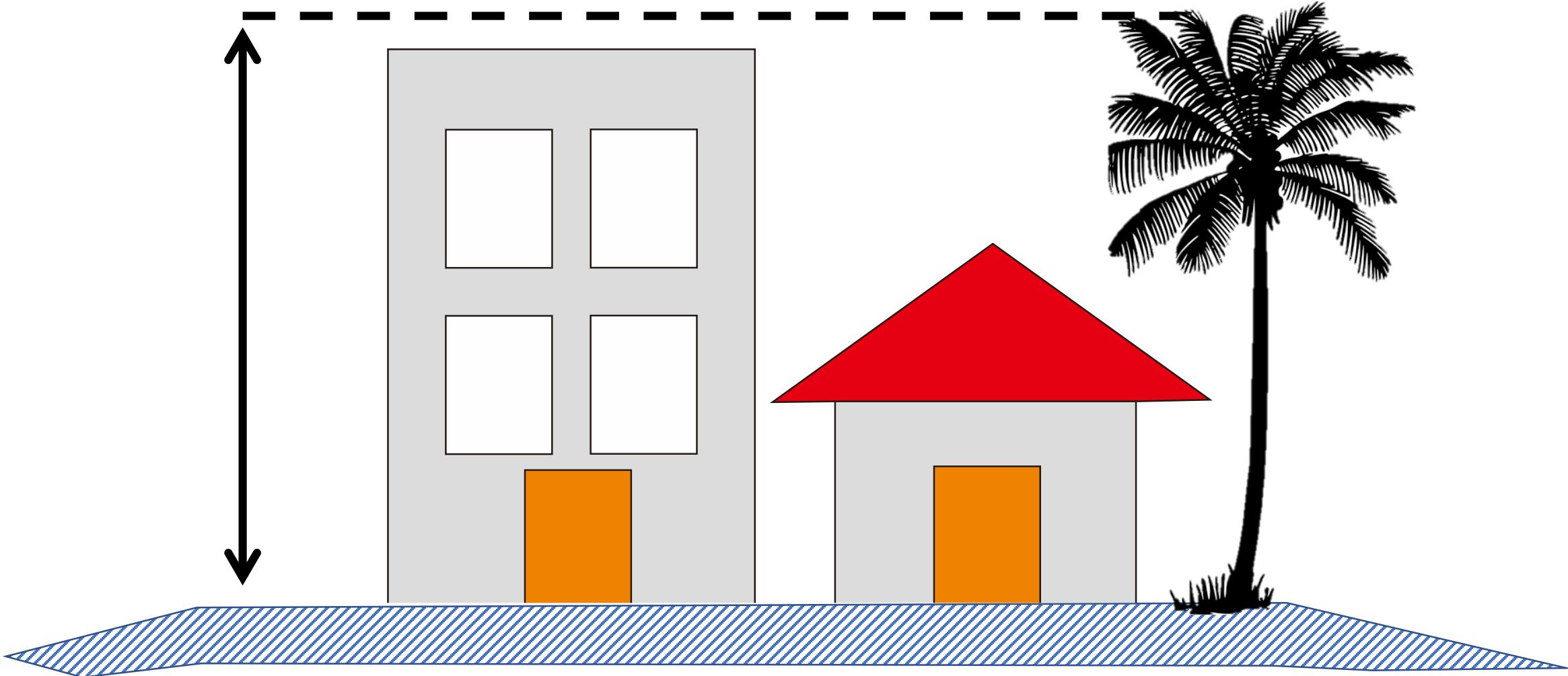
Penyengker (Boundary)

Paon (Kitchen)

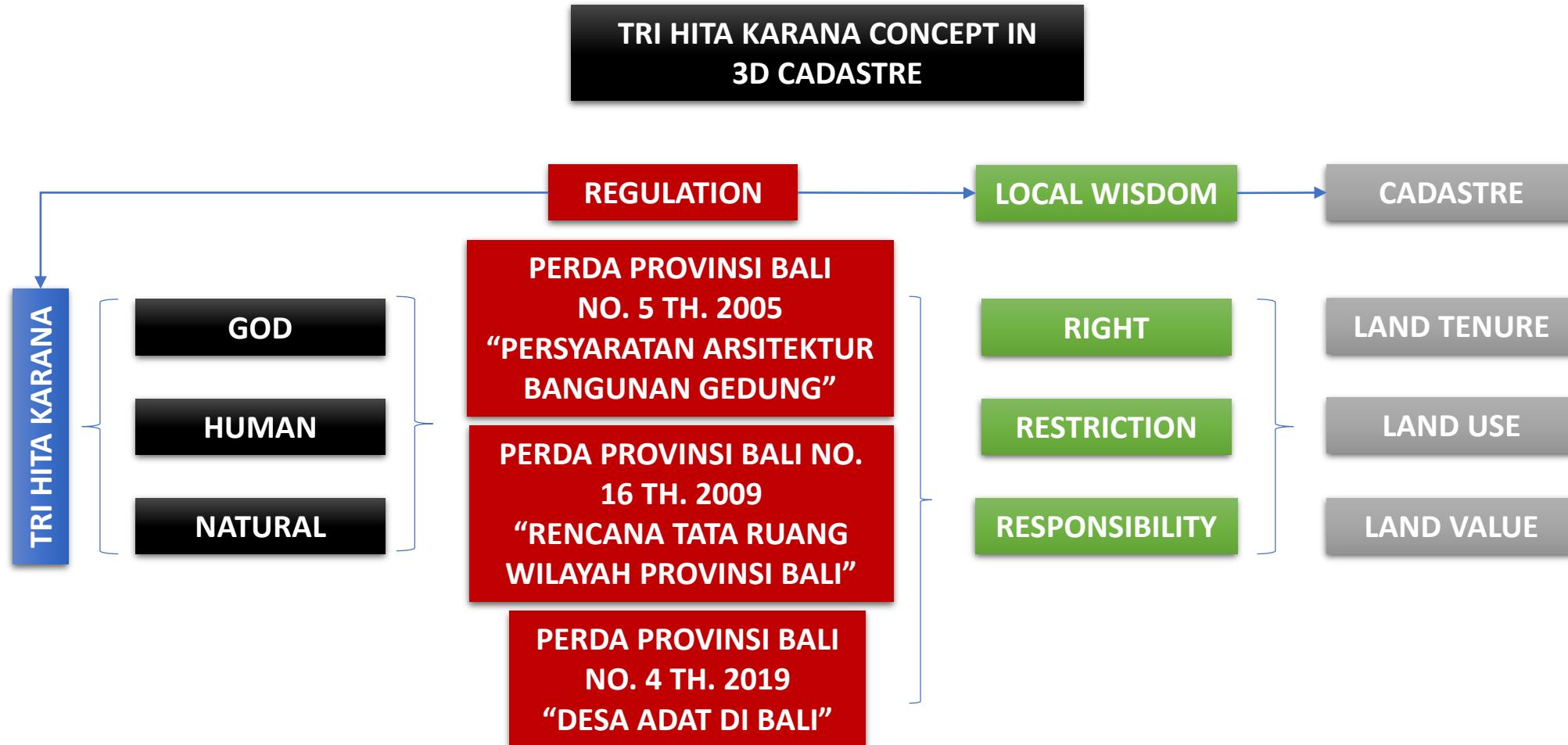


BUILDING HEIGHT (RESTRICTION ZONE)

Maximum 4-5 floor (15 Meters)



“The Province of Bali regional regulation number 16 of 2009”





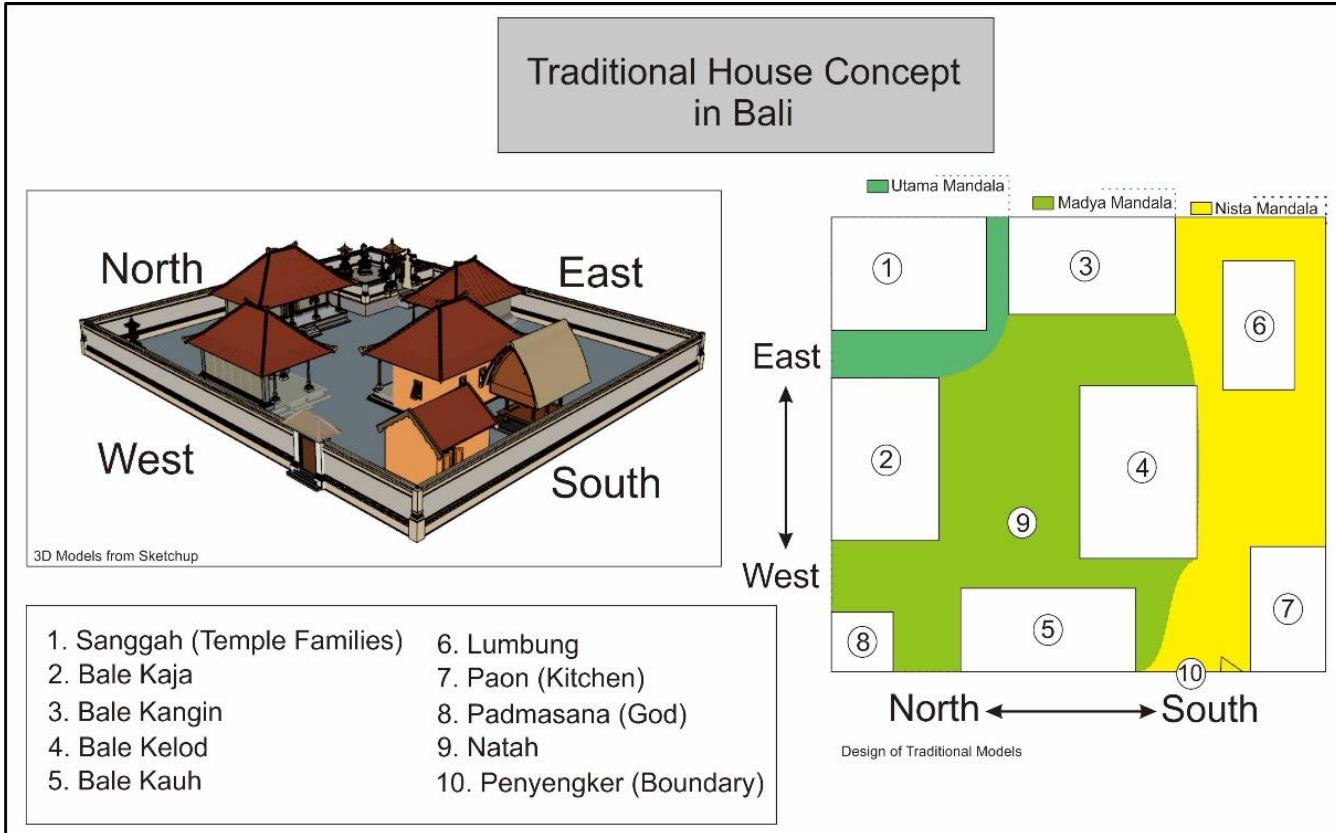
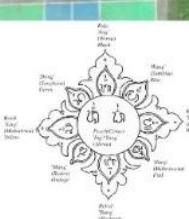
ASTA KOSALA KOSALI

TRADISIONAL LAND USE

Orthophoto in Siangan Village, Gianyar, Bali
Land Use Concept of Tri Hita Karana



- 1. Sanggah (Temple Families)
- 2. Bale Kaja
- 3. Bale Kangin
- 4. Bale Kelod
- 5. Bale Kauh
- 6. Lumbung
- 7. Paon (Kitchen)
- 8. Padmasana (God)
- 9. Natah
- 10. Penyengker (Boundary)



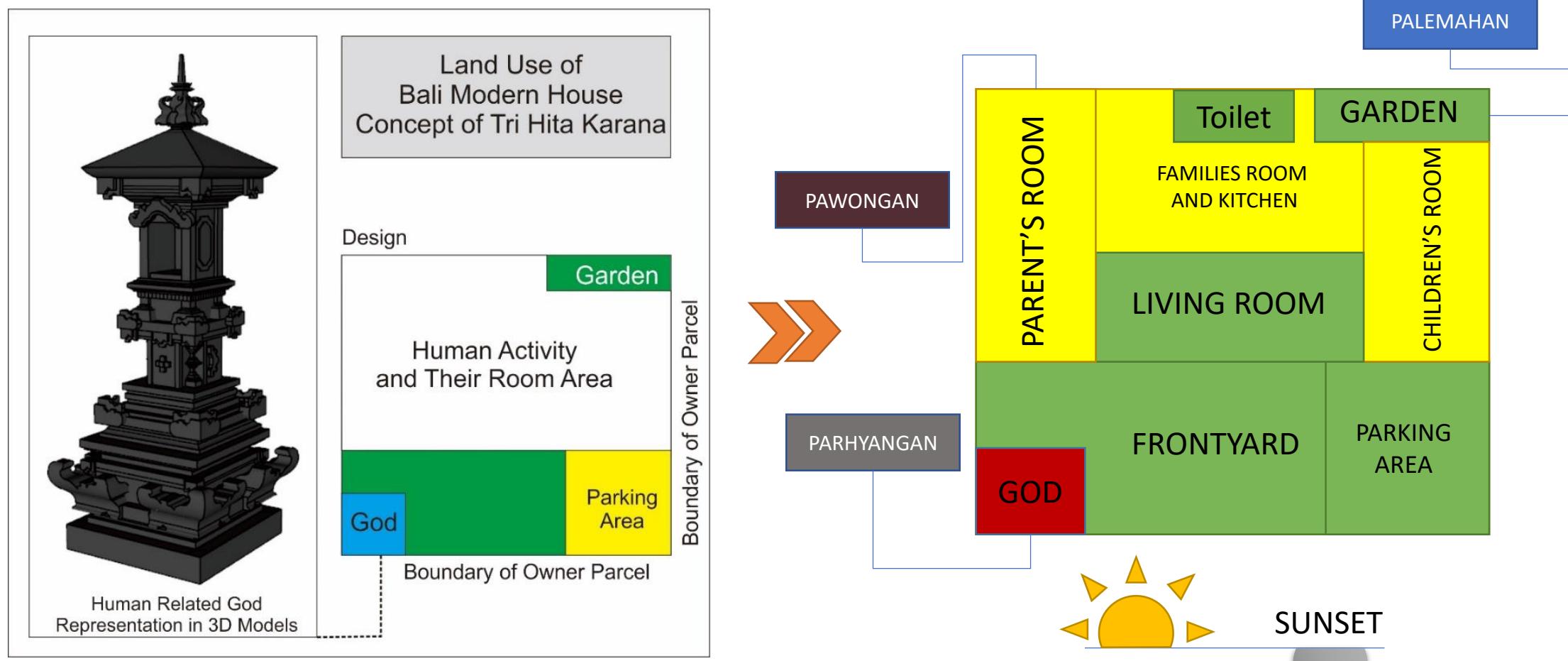
(Suhari et al., 2019)

MODERN MINIMALIST HOUSE LAND USE

Utama Mandala

Madya Mandala

Nista Mandala





The traditional Penglipuran village with its distinctive Penglipuran traditional Balinese spatial layout and building architecture has become a unique tourist destination and has been designated as a tourist village by the Bali Regional Government since 1992 (Astuti, 2002 in the writing of Kasuma and Suprijanto, 2012)





Gnss Observations
(3 hours) – (E=0,3mm,
N=0,3mm, H=1mm)



HLS for detail



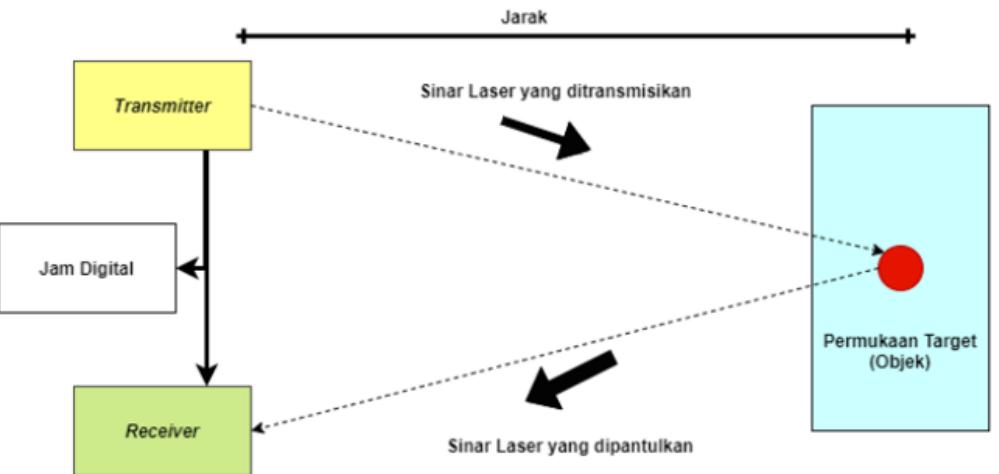
Photogrammetry (3D
Acquisition) H=70m,
FO=75%, SO=65%,
RMSE = 0.196
R=1,89cm/px

High Definition Surveying



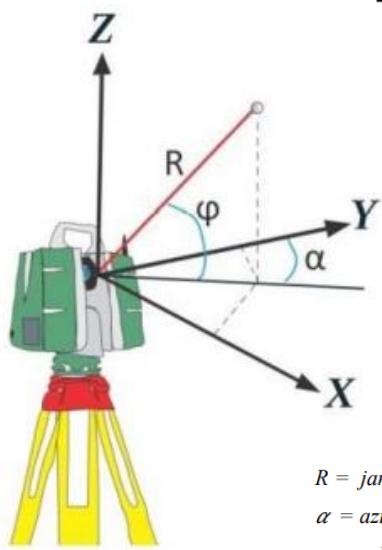
Integration of point clouds from TLS and Orthophoto
RMSE = 0.003m or 3 mm

Reviews: Laser Scanning



$$R = \frac{C \times T}{2}$$

R = Jarak antara sensor dengan setiap objek titik yang diukur (m)
 C = Konstanta kecepatan cahaya (299.792.458 m/s)
 T = Selang waktu tempuh laser (nanosekon)



$$X = R \cdot \cos(\varphi) \cdot \cos(\alpha)$$

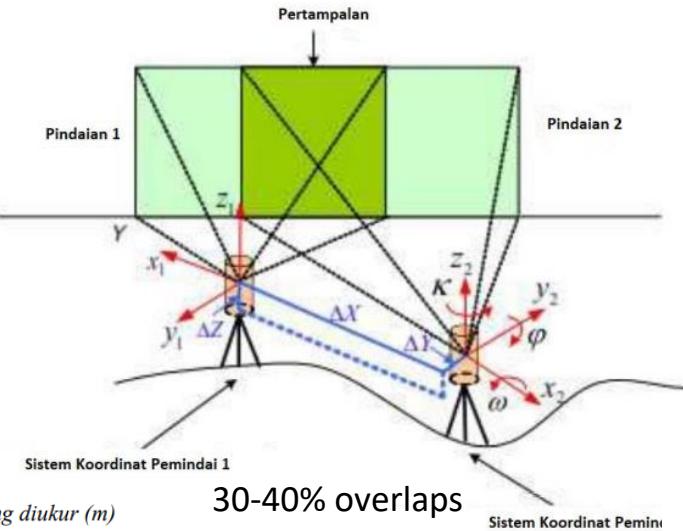
$$Y = R \cdot \cos(\varphi) \cdot \sin(\alpha)$$

$$Z = R \cdot \sin(\alpha)$$

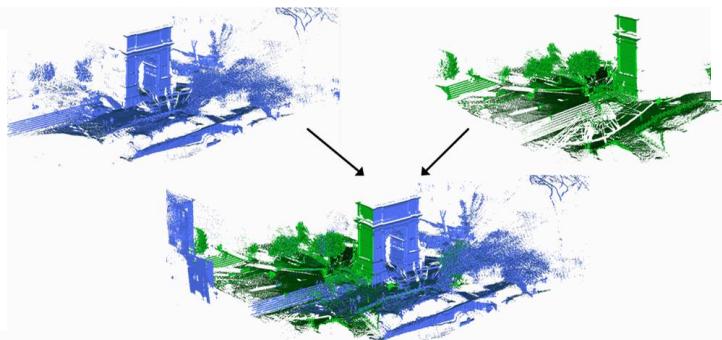
R = jarak dari alat ke titik target (m).

α = azimuth dari alat ke titik target : sumbu Y mengarah ke utara ,

φ = sudut miring yang dibentuk oleh bidang horizontal alat dengan titik target.



Registration of Point Cloud



(Theiler, 2012)

Nilai toleransi kesalahan = $1,96\sigma$
 σ = single point positional accuracy
 (Soeta'at, 2003)

$$RMSE = \sqrt{\frac{\sum(R - R_1)^2}{n}}$$

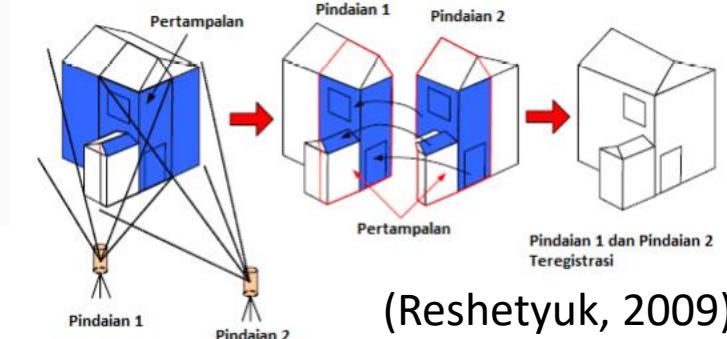
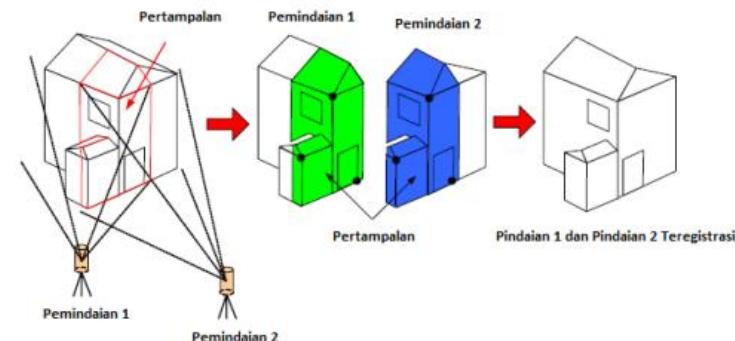
(Wibowo, 2013)

RMSE = Root Mean Square Error

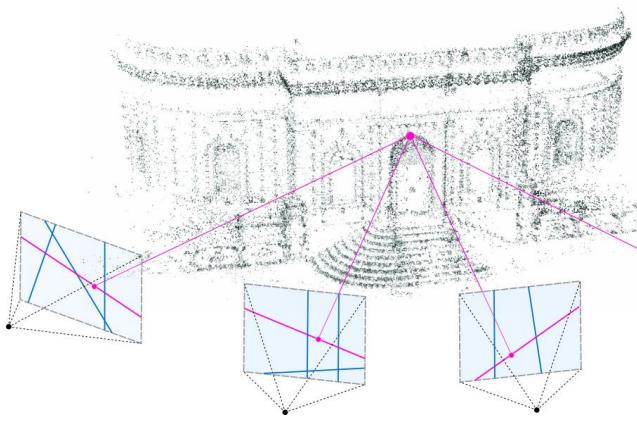
R = Nilai yang dianggap benar

R_1 = Nilai hasil ukuran

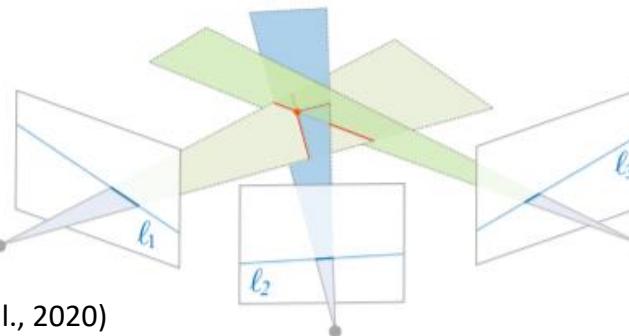
n = Banyak ukuran yang digunakan



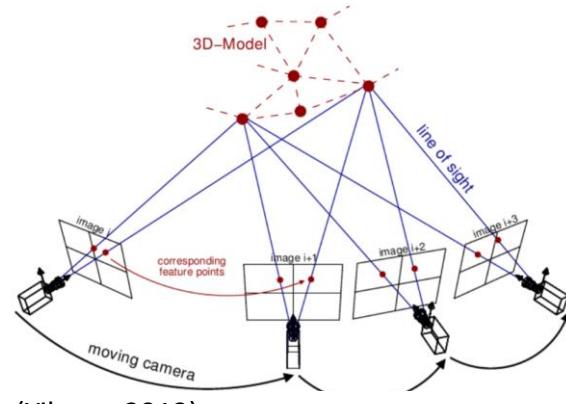
(Reshetyuk, 2009)



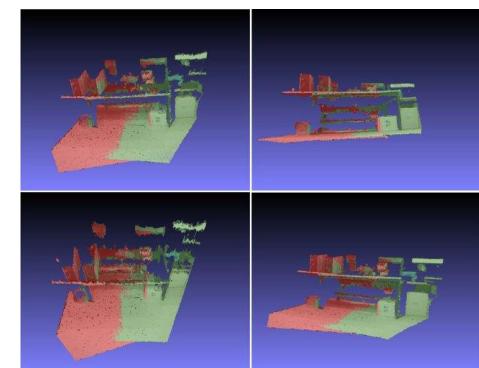
Triangulation



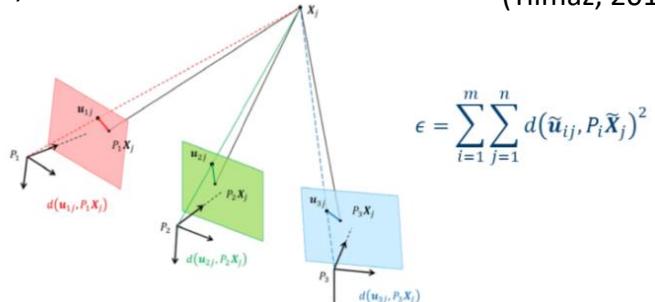
(Geppert et al., 2020)



(Yilmaz, 2013)



(Yilmaz, 2013)



(<https://ai-mrkogao.github.io/vision/structurefrommotion/>)

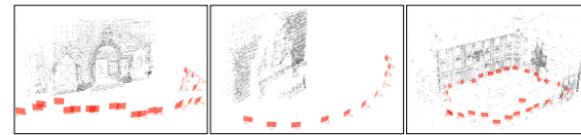
Ketut Tomy Suhari, S.T., M.T. – Institut Teknologi Nasional Malang

Bundle Adjustment:

$$r_{ij}^2 = \frac{(\mathbf{n}^T \pi(R_i \mathbf{X}_j + \mathbf{t}_i) + \alpha)^2}{\mathbf{n}^T \mathbf{n}}$$

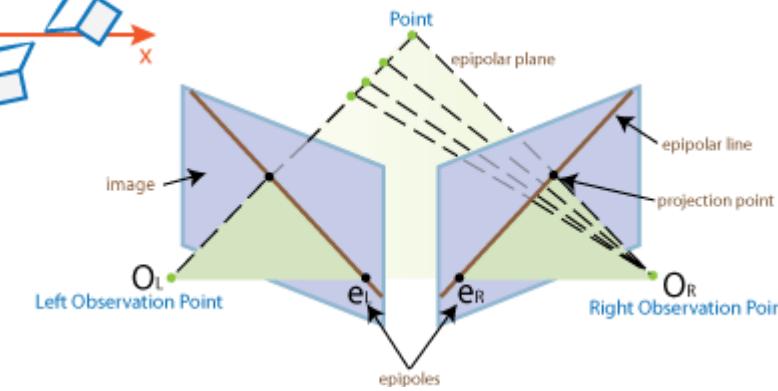
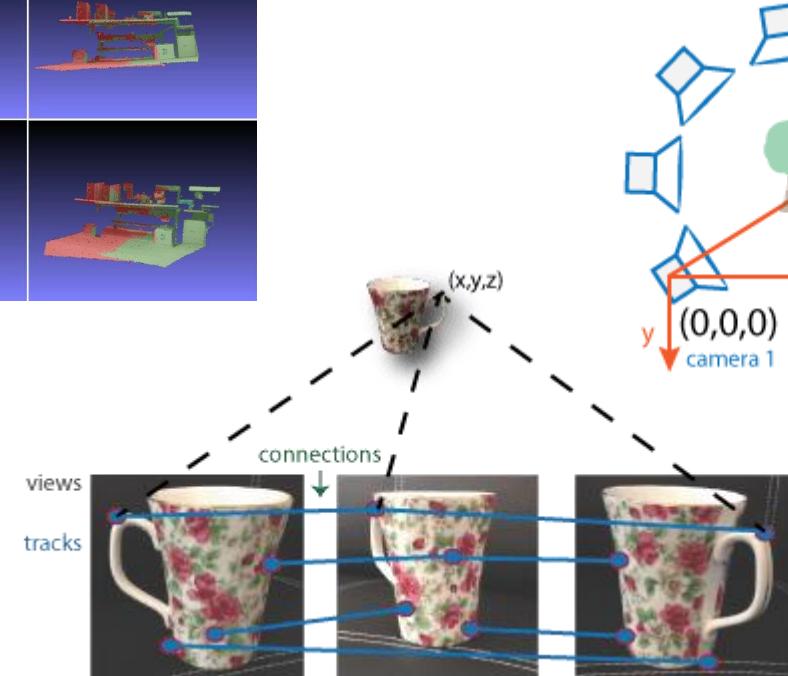
where $\ell_{ij} = (\mathbf{n}, \alpha)^T$

Scene	#Images		#Points		Track Length	Rotation (deg)	Position (cm)	
	Total	Reg.	3D	2D	Mean	Std.	Mean	Std.
castle-P19	19	15	4.3k	24.2k	5.7	0.29	0.20	10.80 17.47
castle-P30	30	30	11.5k	78.7k	6.8	0.08	0.03	4.00 2.73
entry-P10	10	10	4.0k	24.5k	6.1	0.05	0.01	0.71 0.26
fountain-P11	11	11	7.9k	46.2k	5.8	0.03	0.01	0.30 0.14
Herz-Jesu-P8	8	8	3.4k	17.6k	5.2	0.21	0.03	0.53 0.30
Herz-Jesu-P25	25	25	11.1k	86.8k	7.8	0.04	0.02	0.58 0.23



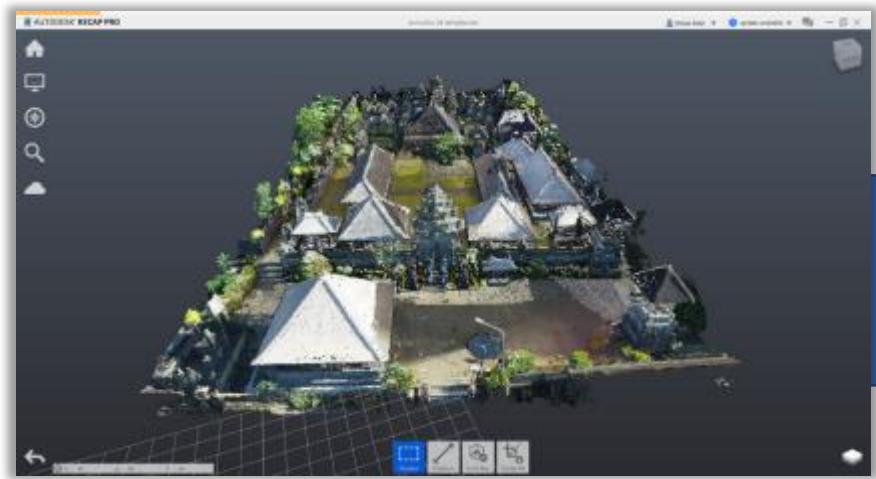
Minimum Error:

$$\min_{\{R_i, t_i\}, \{X_j\}} \sum_{i,j} r_{ij}^2 .$$



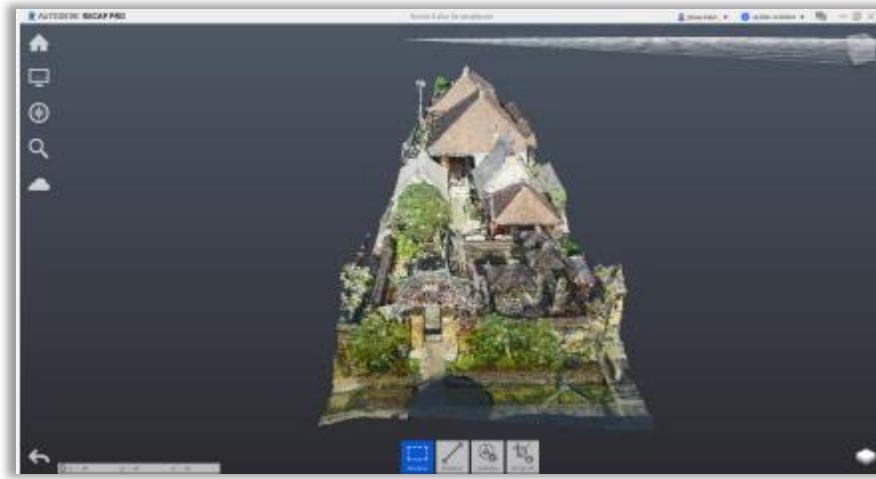
(<https://se.mathworks.com/help/vision/ug/structure-from-motion.html>)

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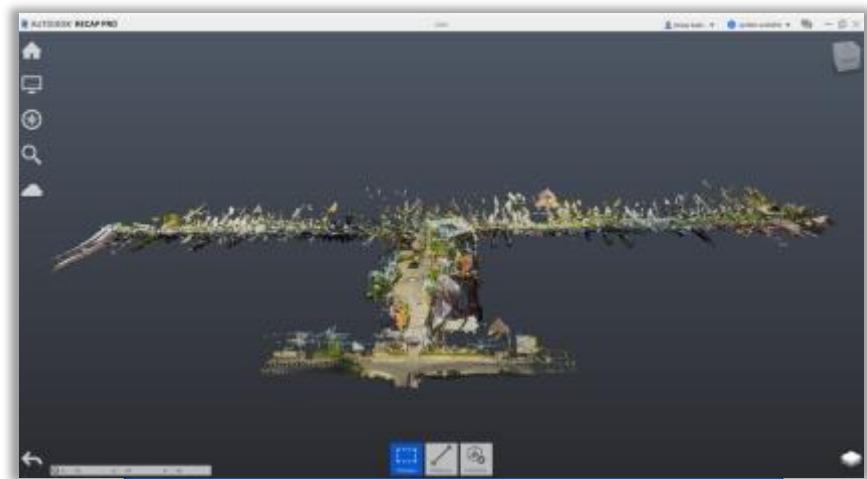


REGISTER POINT CLOUDS INTEGRATION

The Penglipuran Temple segment has an average RMSE of 0.004 m

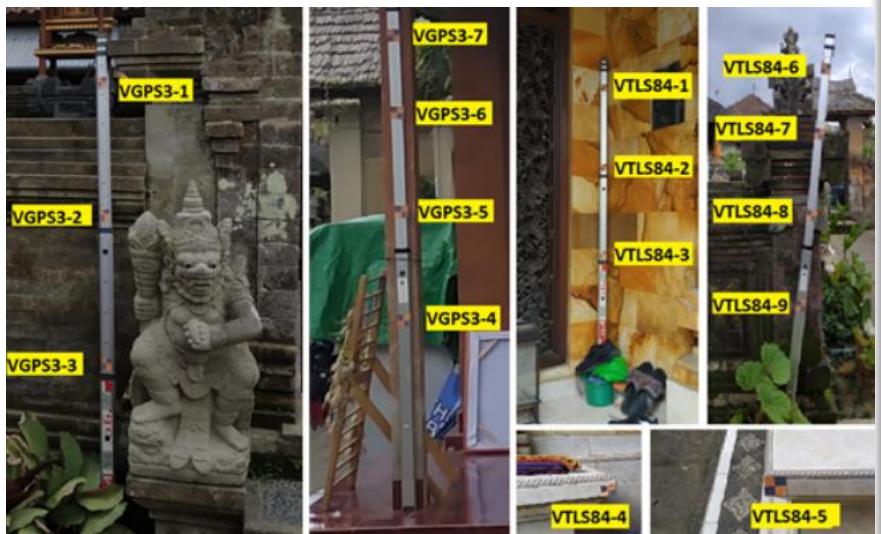
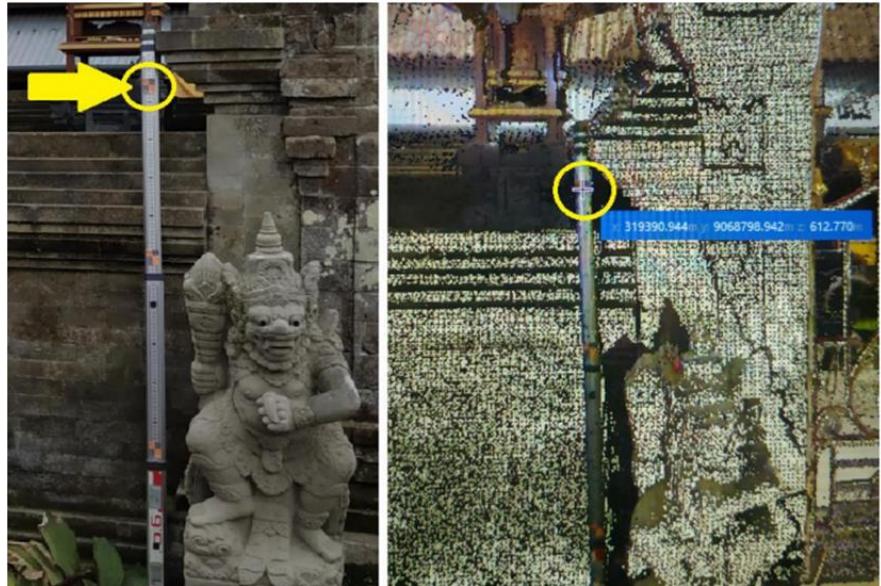


Traditional House
segment no. 8
Average RMSE
0.003 m



Penglipuran Village road
segment with an average
RMSE of 0.006 m

VALIDATION OF POINT CLOUDS RESULTS



Titik	Koordinat pada Point Clouds			Koordinat Hasil Pengukuran ETS			Selisih (Δ Ukuran ETS - Point Clouds)		
	X (m)	Y (m)	Z (m)	X (m)	Y (m)	Z (m)	X (m)	Y (m)	Z (m)
VGPS3-1	319390,94	9068798,94	612,77	319390,95	9068798,939	612,768	0,002	-0,003	-0,002
VGPS3-2	319390,91	9068798,94	612,326	319390,91	9068798,938	612,32	0,002	0,002	-0,006
VGPS3-3	319390,87	9068798,94	611,835	319390,87	9068798,941	611,831	0	-0,001	-0,004
VGPS3-4	319380,92	9068800,39	612,142	319380,92	9068800,397	612,135	0,007	0,012	-0,007
VGPS3-5	319380,91	9068800,4	612,57	319380,92	9068800,402	612,569	0,007	0,007	-0,001
VGPS3-6	319380,91	9068800,4	612,969	319380,91	9068800,397	612,963	0,005	0,002	-0,006
VGPS3-7	319380,89	9068800,39	613,275	319380,91	9068800,393	613,27	0,02	0	-0,005
VTLS84-1	319343,39	9068806,24	613,023	319343,39	9068806,243	613,024	0	-0,001	0,001
VTLS84-2	319343,4	9068806,24	612,579	319343,4	9068806,231	612,575	0,001	-0,004	-0,004
VTLS84-3	319343,42	9068806,22	612,081	319343,41	9068806,213	612,085	-0,005	-0,004	0,004
VTLS84-4	319344,92	9068806,2	611,279	319344,92	9068806,192	611,277	-0,002	-0,004	-0,002
VTLS84-5	319343,42	9068802,46	611,284	319343,42	9068802,461	611,282	-0,003	0,003	-0,002
VTLS84-6	319354,61	9068799,36	612,645	319354,61	9068799,355	612,651	-0,003	-0,001	0,006
VTLS84-7	319354,62	9068799,4	612,352	319354,61	9068799,393	612,347	-0,011	-0,009	-0,005
VTLS84-8	319354,62	9068799,44	611,956	319354,62	9068799,433	611,956	-0,005	-0,011	0
VTLS84-9	319354,62	9068799,51	611,533	319354,62	9068799,509	611,527	-0,004	-0,004	-0,006
						Rata-rata Selisih	0,0007	-0,001	-0,002

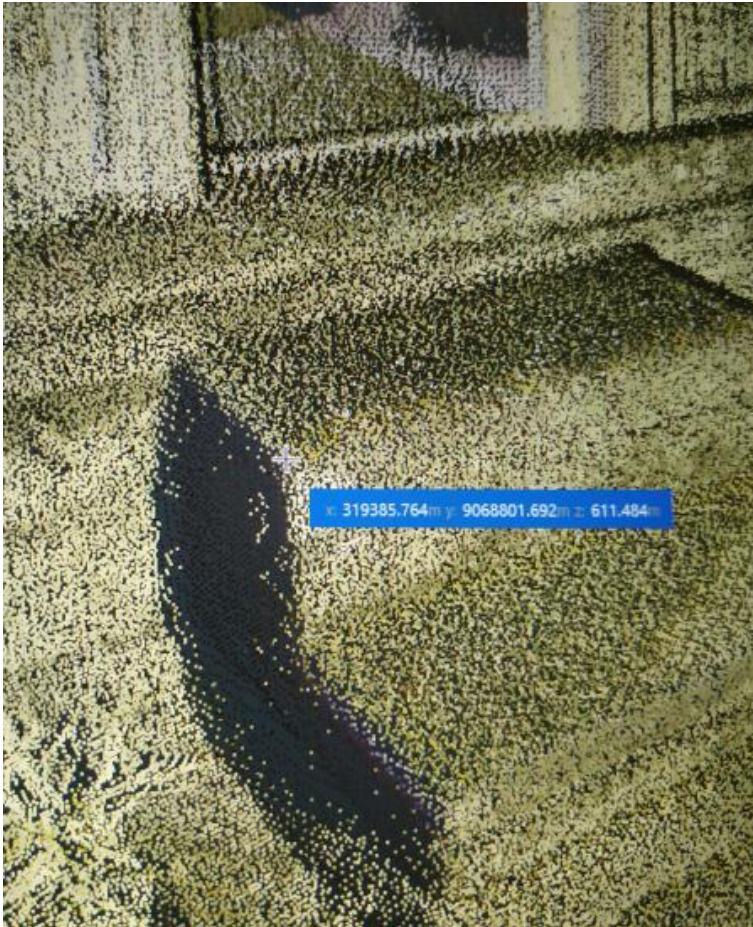
The difference between the coordinates of the point clouds and the coordinates of the ETS measurement results.

The difference in model validation results is below 0-2 mm



Verification of Modeling Results

Calculating the difference between the coordinate values of the points on the model and the point coordinates of the point clouds



MODEL VERIFICATION



Objek	Titik	Koordinat pada Model			Koordinat pada Point Clouds			Selisih (Δ) = Koord. Point Clouds - Koord. Model		
		X (m)	Y (m)	h (m)	X (m)	Y (m)	h (m)	ΔX (m)	ΔY (m)	Δh (m)
Angkul-angkul	Angkul-1	319371,337	9068800,686	611,007	319371,467	9068800,486	610,991	0,130	-0,200	-0,016
	Angkul-2	319371,990	9068800,505	614,577	319371,989	9068800,345	614,586	-0,001	-0,160	0,009
Rumah 5.1	Rumah 5.1-1	319379,033	9068804,203	616,736	319378,965	9068804,290	616,712	-0,068	0,087	-0,024
	Rumah 5.1-2	319381,286	9068799,469	611,223	319381,323	9068799,487	611,179	0,037	0,018	-0,044
Paon	Paon-1	319385,763	9068801,702	611,484	319385,764	9068801,692	611,484	0,001	-0,010	0,000
	Paon-2	319389,084	9068800,368	612,850	319388,826	9068800,600	612,804	-0,258	0,232	-0,046
Bale Sakenem	BSakenem-1	319382,324	9068799,300	613,214	319382,444	9068799,044	613,153	0,120	-0,256	-0,061
	BSakenem-2	319388,378	9068796,956	611,663	319388,416	9068796,784	611,690	0,038	-0,172	0,027
Sanggah	Sanggah-1	319389,634	9068798,963	611,130	319389,673	9068798,971	611,120	0,039	0,008	-0,010
	Sanggah-2	319390,140	9068794,866	612,901	319390,206	9068794,884	612,908	0,066	0,018	0,007
Rumah 5.2	Rumah 5.2-1	319402,379	9068790,568	611,462	319402,487	9068790,775	611,458	0,108	0,207	-0,004
	Rumah 5.2-2	319400,856	9068793,462	616,142	319400,946	9068793,609	616,158	0,090	0,147	0,016
Rumah 5.3	Rumah 5.3-1	319407,880	9068790,468	611,699	319407,999	9068790,688	611,523	0,119	0,220	-0,176
	Rumah 5.3-2	319418,882	9068788,141	612,061	319418,990	9068788,488	611,891	0,108	0,347	-0,170
						RMSE	0,106	0,181	0,071	

Dimensions

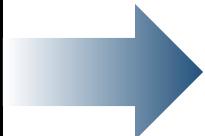


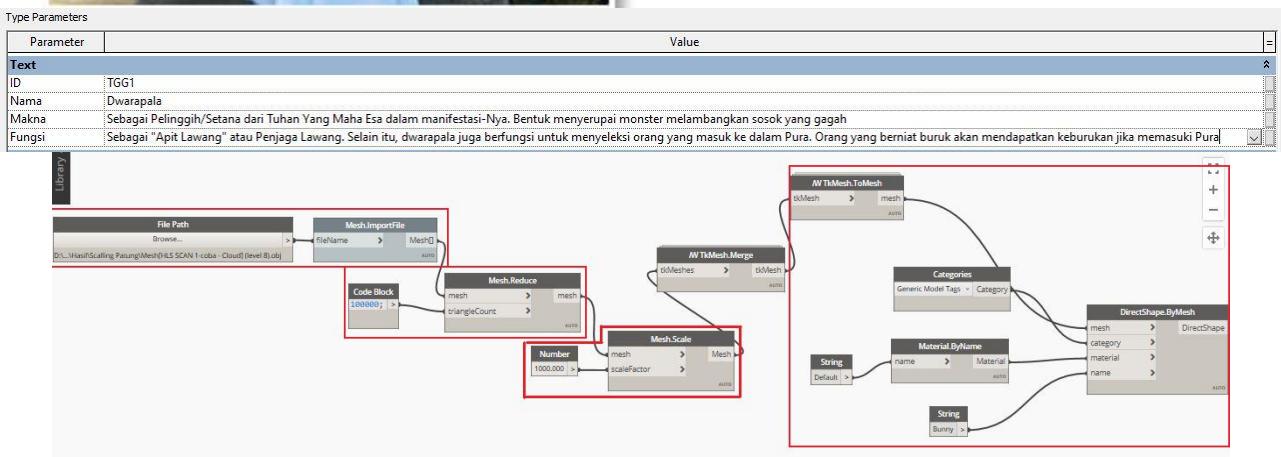
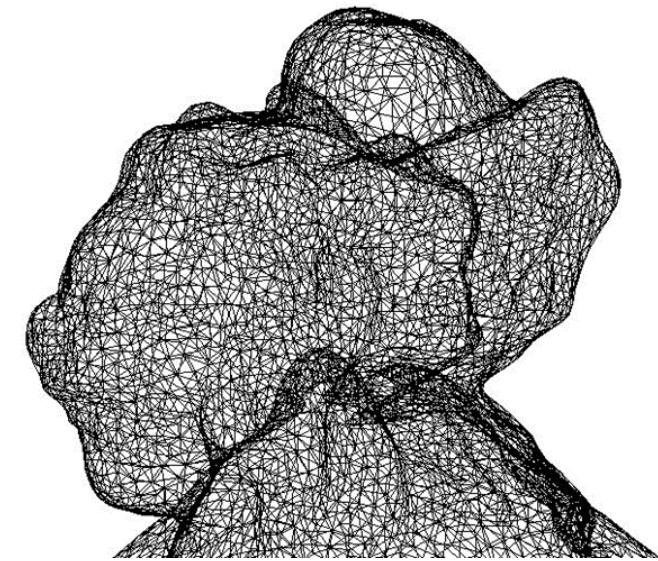
Objek	Nama Pengukuran	Model (m)	Point Cloud (m)	Selisih (Δ) = Point Clouds - Model (m)
<i>Angkul-angkul</i>	Ver1	2,648	2,646	-0,002
	Ver2	2,289	2,271	-0,018
<i>Rumah 5.1</i>	Ver3	8,449	8,390	-0,059
	Ver4	1,976	1,972	-0,004
<i>Paon</i>	Ver5	5,296	5,310	0,014
	Ver6	0,976	0,971	-0,005
<i>Bale Sakenem</i>	Ver7	4,464	4,471	0,007
	Ver8	5,453	5,445	-0,008
<i>Sanggah</i>	Ver9	0,686	0,687	0,001
	Ver10	1,040	1,028	-0,012
<i>Rumah 5.2</i>	Ver11	2,718	2,716	-0,002
	Ver12	5,008	5,031	0,023
<i>Rumah 5.3</i>	Ver13	12,700	12,705	0,005
	Ver14	3,826	3,808	-0,018
				RMSE
				0,019

Point Cloud



BIM



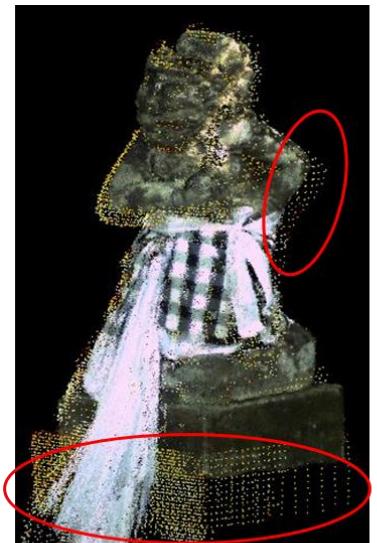

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Hasil Overlay Metode Helmert

Metode Transformasi Helmert	
RMSx (m)	0.04222755814
RMSy (m)	0.1575584548
RMSz (m)	0.04292241062
RMSe (m)	0.168671772

Hasil Overlay Metode Affine

Metode Transformasi Affine	
RMSx (m)	0.00360551275
RMSy (m)	0.002516611478
RMSz (m)	0.002516611478
RMSe (m)	0.005066228051



Hasil Overlay Metode Helmert



Hasil Overlay Metode Affine

Hamdani, 2020





IfcBuilding

IfcBuildingStorey

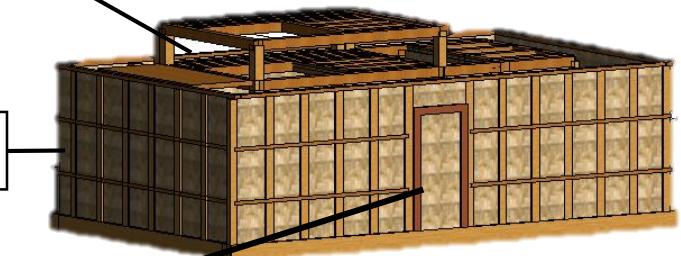
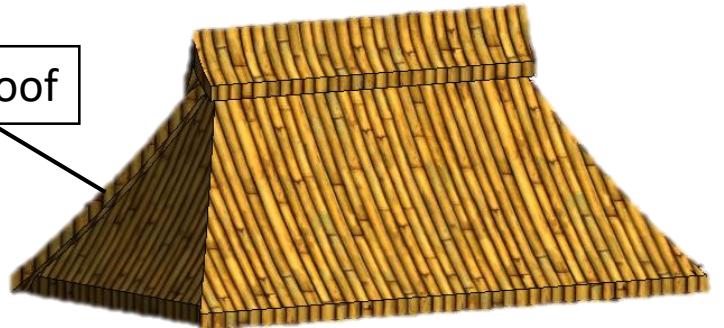
IfcRoof

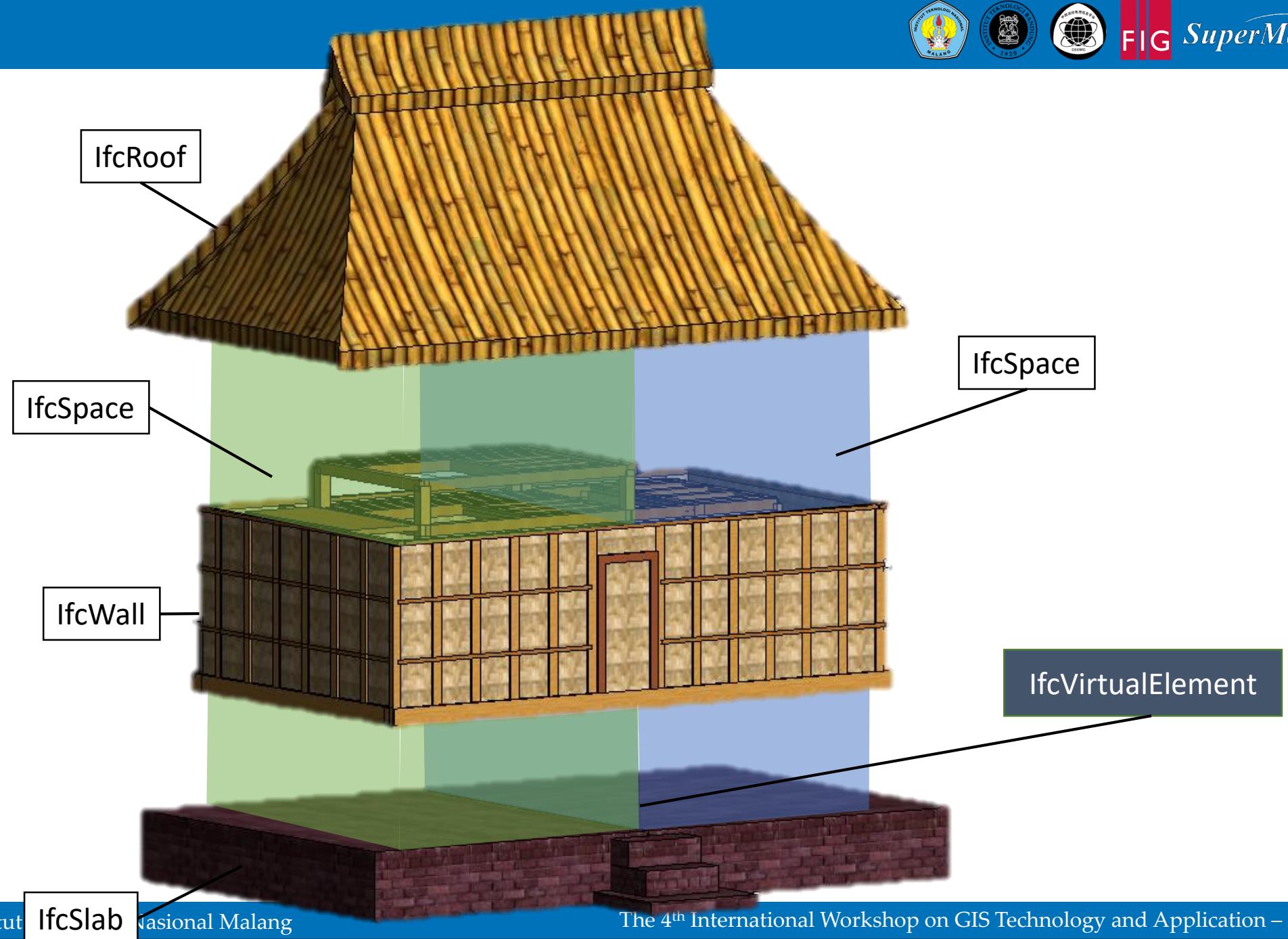
IfcSpace

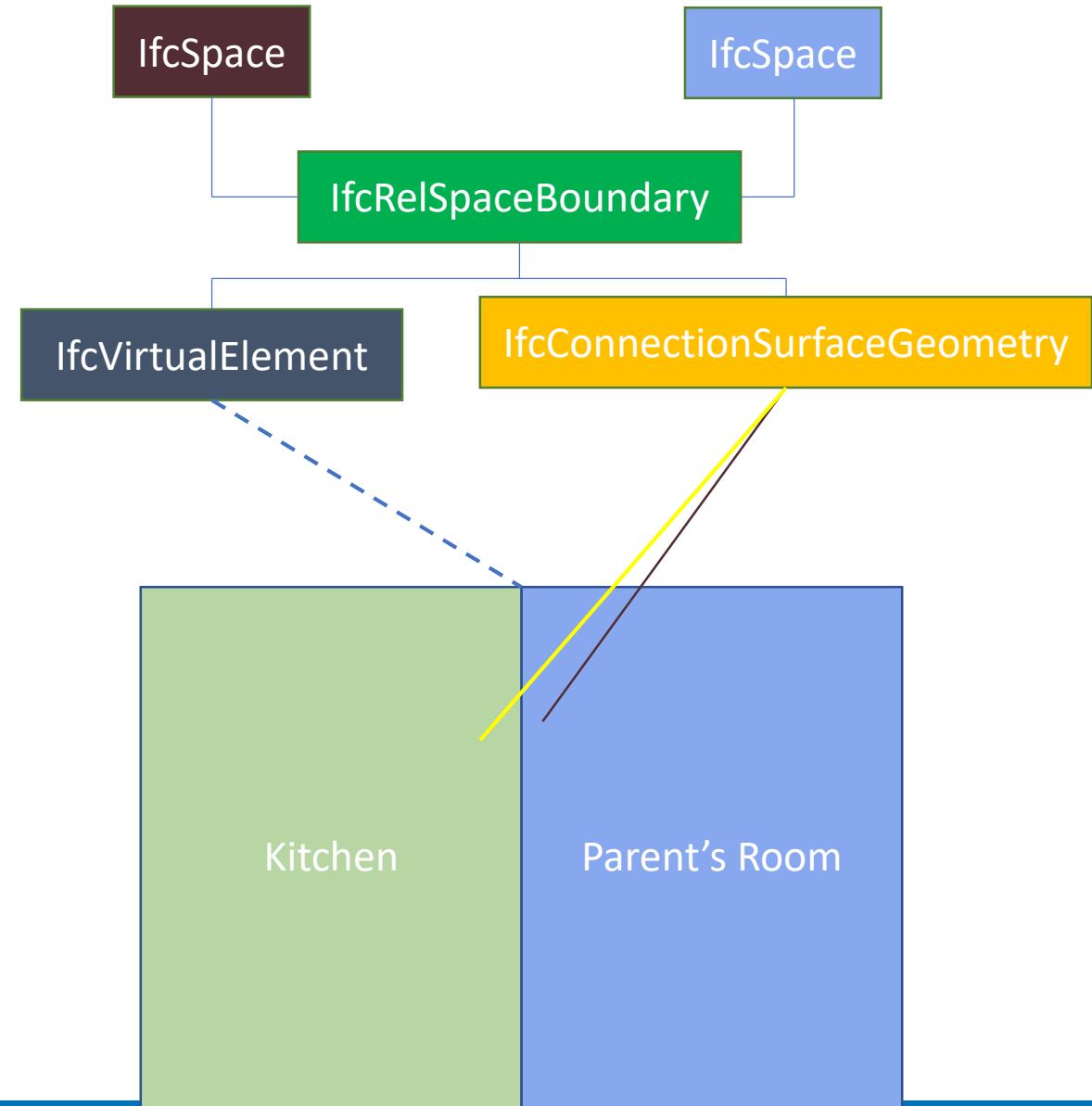
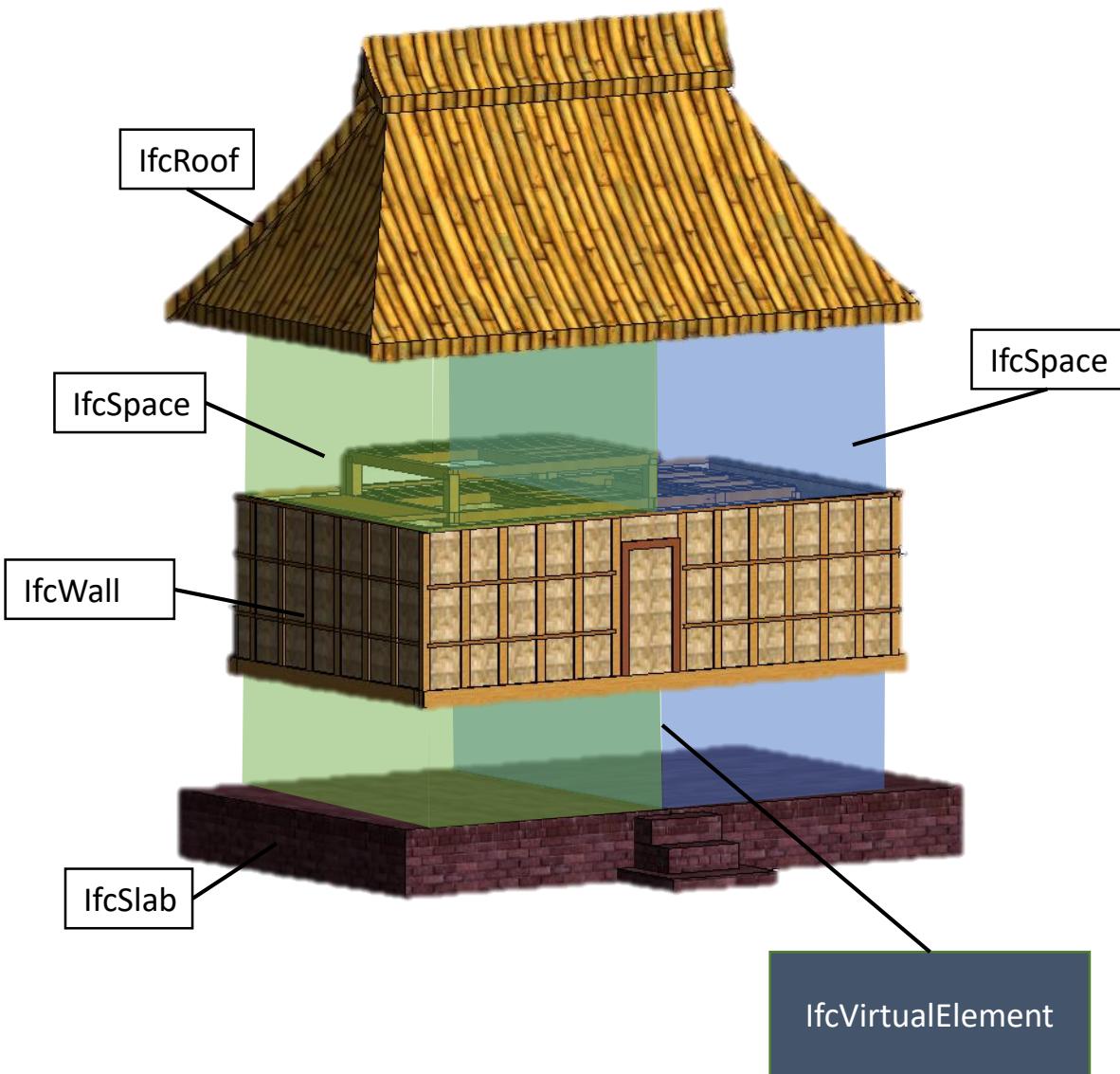
IfcWall

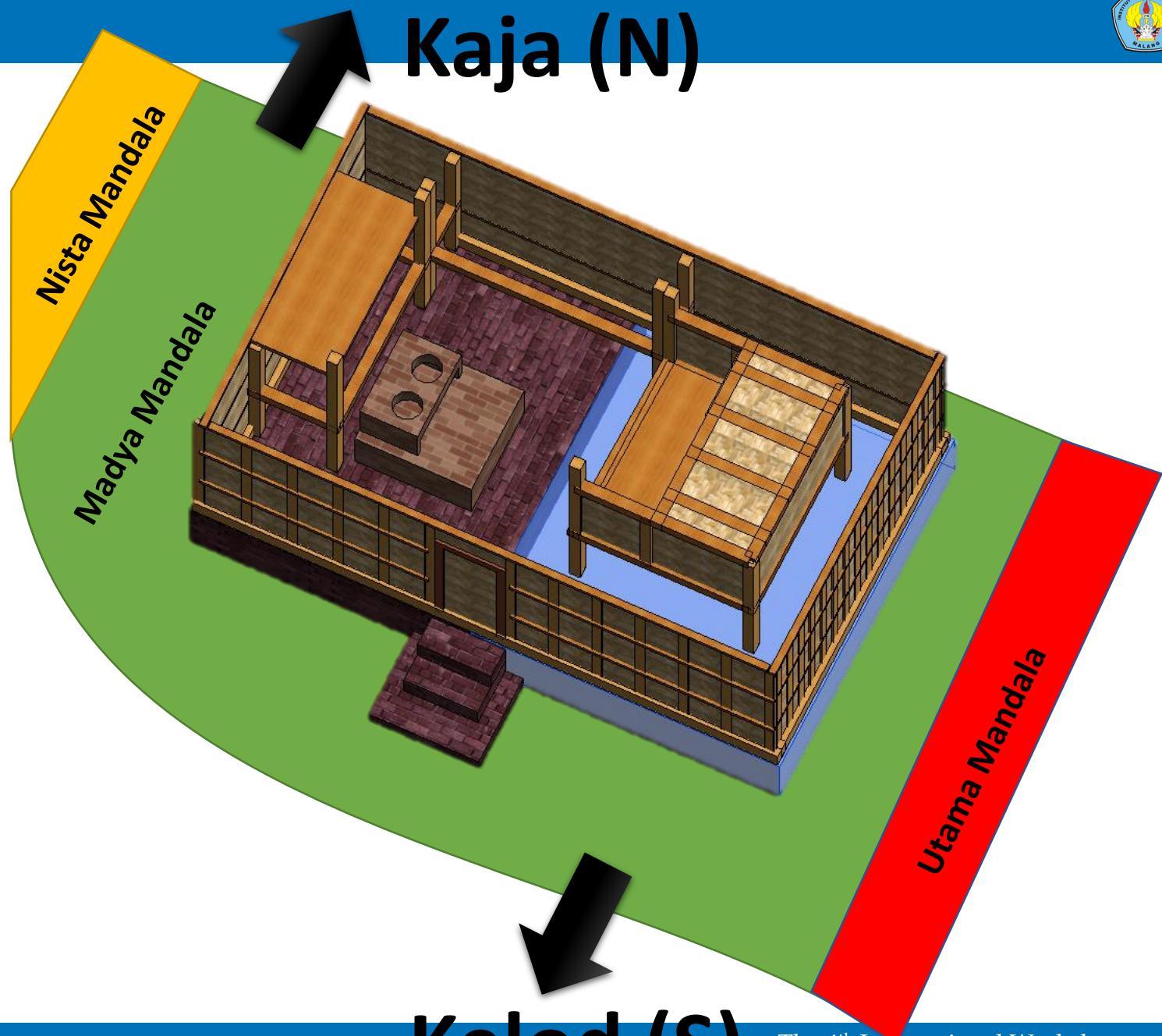
IfcDoor

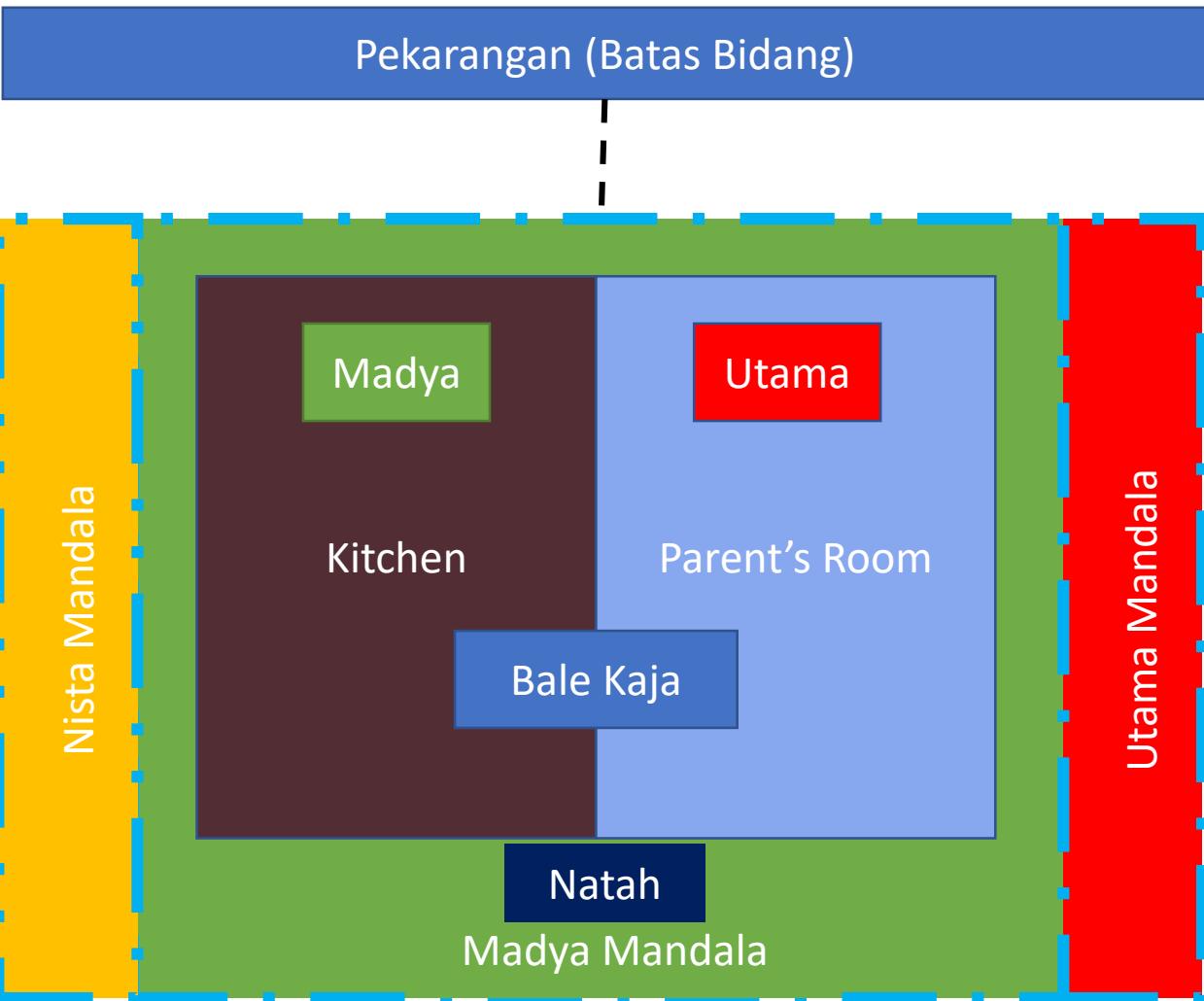
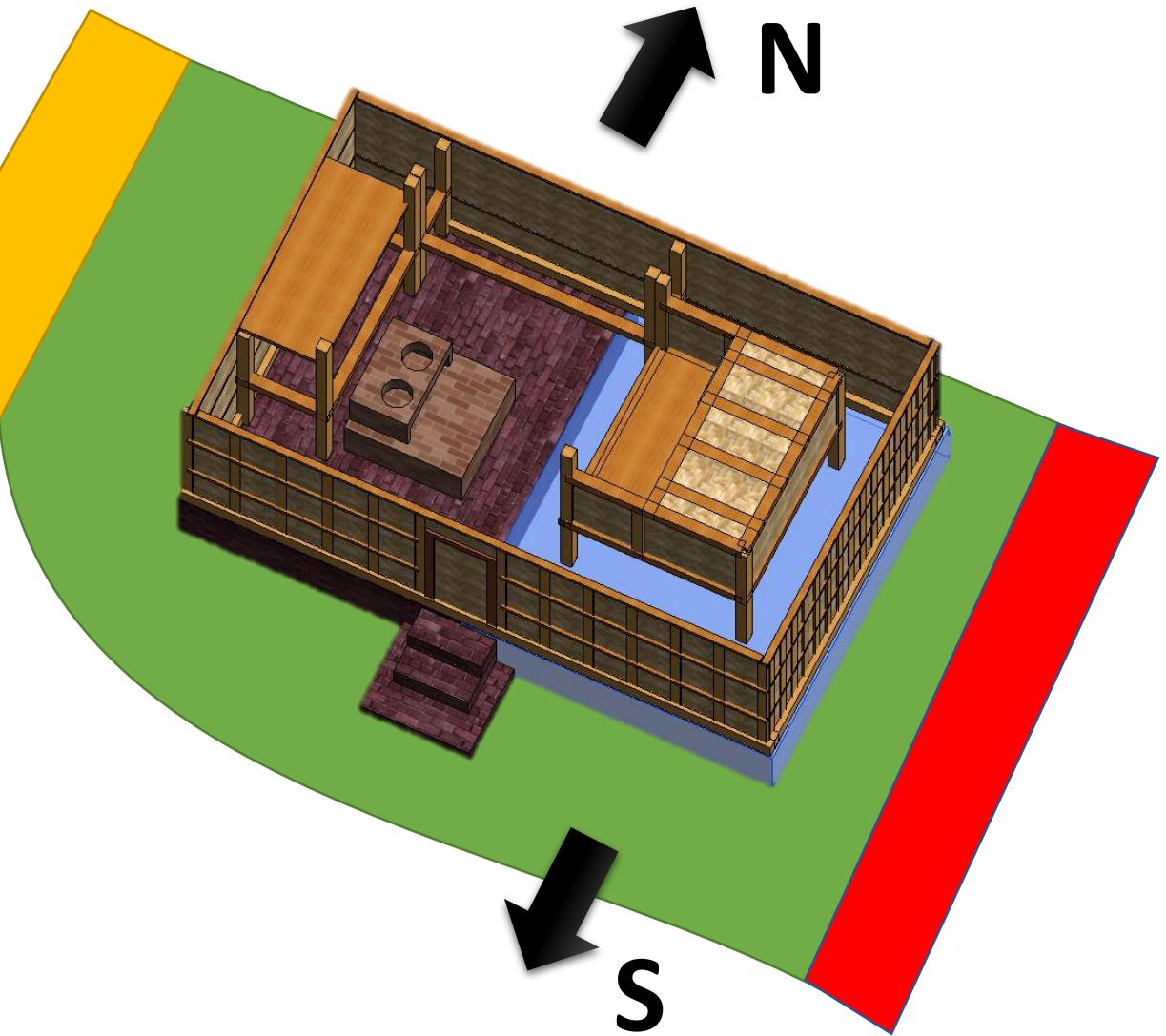
IfcSlab





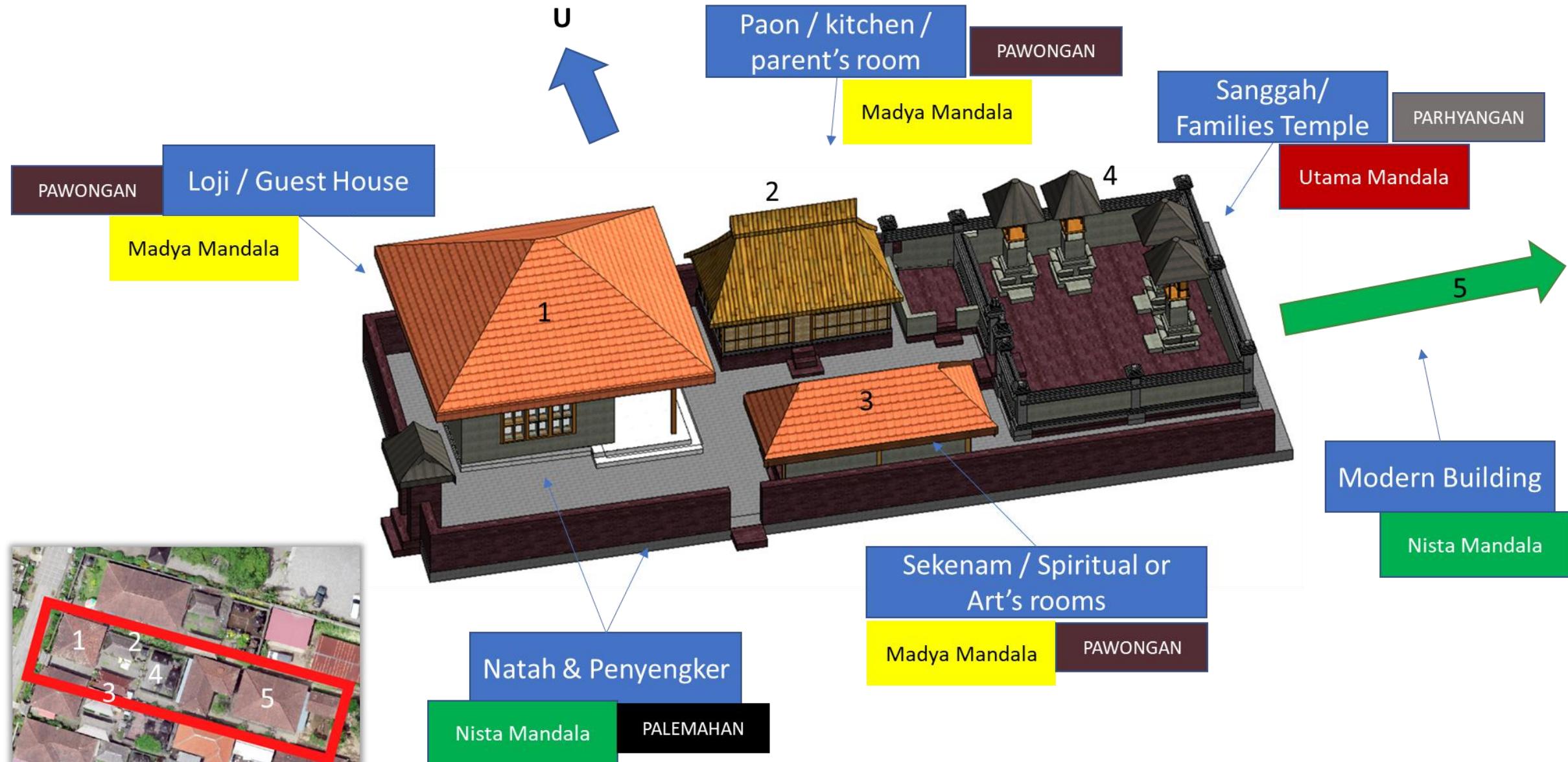






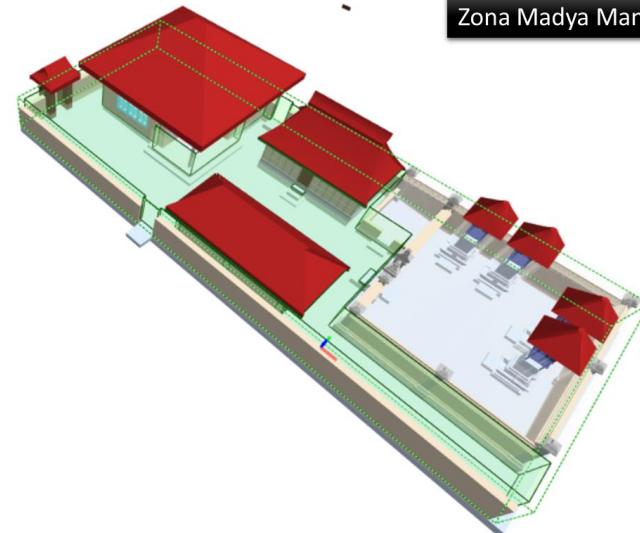


Results



Results

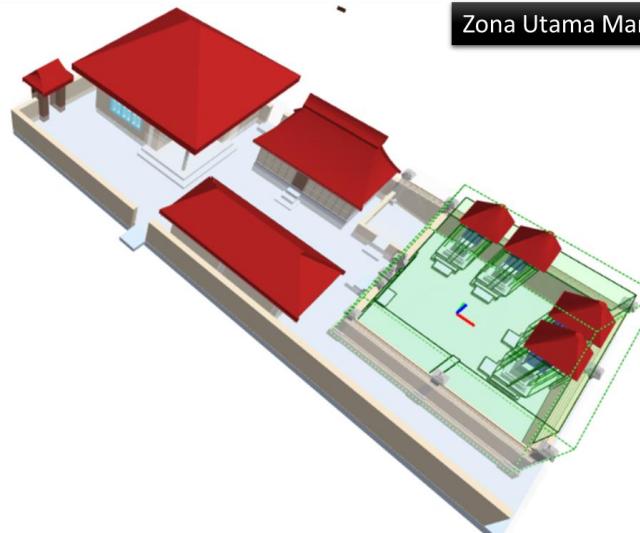
Zona Madya Mandala



IFC Structure			
Active	Type	Name	Description
<input checked="" type="checkbox"/>	Space	2	Children's Room
<input checked="" type="checkbox"/>	Space	3	Living Room
<input checked="" type="checkbox"/>	Space	1	Utama
<input checked="" type="checkbox"/>	Space	2	Madya
<input checked="" type="checkbox"/>	Space	3	Madya
<input checked="" type="checkbox"/>	Space	4	Nista
<input checked="" type="checkbox"/>	Space	4	Parent's Room
<input checked="" type="checkbox"/>	Space	5	Paon (Kitchen)
<input checked="" type="checkbox"/>	Space	9	Ritual Room
<input checked="" type="checkbox"/>	Space	10	Sanggah
<input checked="" type="checkbox"/>	Space	11	Sanggah
<input checked="" type="checkbox"/>	Space	12	Guest's Room
<input checked="" type="checkbox"/>	Space	13	Natal / Local Area
<input checked="" type="checkbox"/>	Space	13	Madya

Properties			
Name	Value	Unit	
Element Specific			
Legal Document			
Approved By	Kepala BPN Kab. Bangli		
Luas Bidang	119,917747	m ²	
Luas Volume	191,303782	m ³	
NIB	819		
Nilai Pajak	Rp. 0,-		
Pemilik	Desa Pakraman Penglipuran		
Register By	Ketut Tomy Suhari, ST		
Status	Approved		
Status Hak	Hak Milik		
Wilayah	Kelurahan Kubu, Kecamatan Bangli, Kabupaten Bangli, Provinsi Bali		
Tri Mandala Zona			
Zona	Madya		

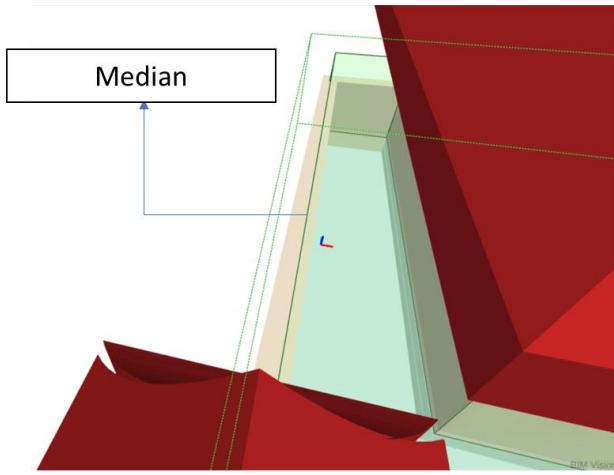
Zona Utama Mandala



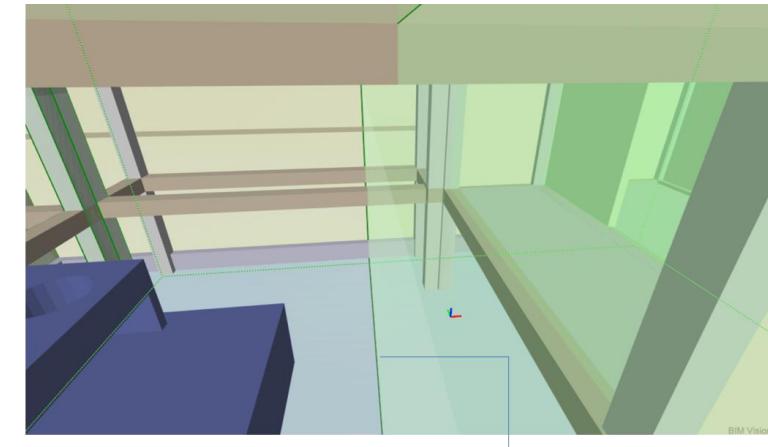
IFC Structure			
Active	Type	Name	Description
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<input checked="" type="checkbox"/>	Space	3	Living Room
<input checked="" type="checkbox"/>	Space	1	Utama
<input checked="" type="checkbox"/>	Space	2	Madya
<input checked="" type="checkbox"/>	Space	3	Madya
<input checked="" type="checkbox"/>	Space	4	Nista
<input checked="" type="checkbox"/>	Space	4	Parent's Room
<input checked="" type="checkbox"/>	Space	5	Paon (Kitchen)
<input checked="" type="checkbox"/>	Space	9	Ritual Room
<input checked="" type="checkbox"/>	Space	10	Sanggah
<input checked="" type="checkbox"/>	Space	11	Sanggah
<input checked="" type="checkbox"/>	Space	12	Guest's Room
<input checked="" type="checkbox"/>	Space	13	Natal / Local Area
<input checked="" type="checkbox"/>	Space	13	Madya

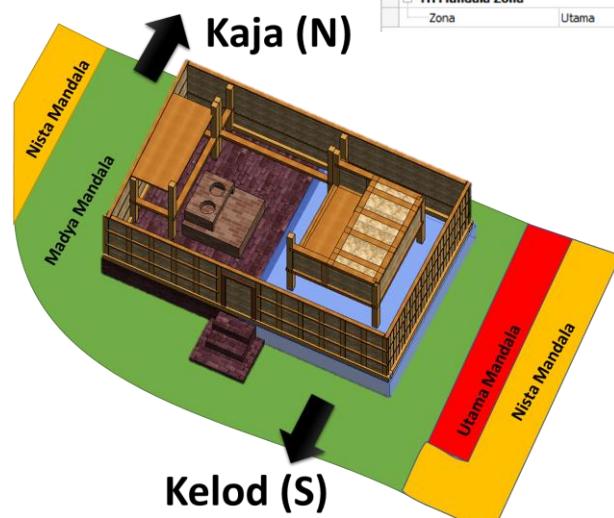
Properties			
Name	Value	Unit	
Element Specific			
Legal Document			
Approved By	Kepala BPN Kab. Bangli		
Luas Bidang	52,850875	m ²	
Luas Volume	114,543494	m ³	
NIB	819		
Nilai Pajak	Rp. 0,-		
Pemilik	Desa Pakraman Penglipuran		
Register By	Ketut Tomy Suhari, ST		
Status	Approved		
Status Hak	Hak Milik		
Wilayah	Kelurahan Kubu, Kecamatan Bangli, Kabupaten Bangli, Provinsi Bali		
Tri Mandala Zona			
Zona	Utama		

Median



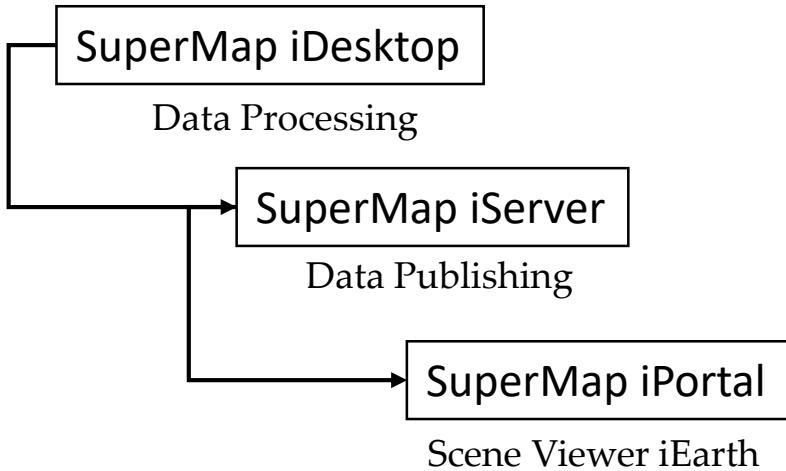
Virtual Boundary



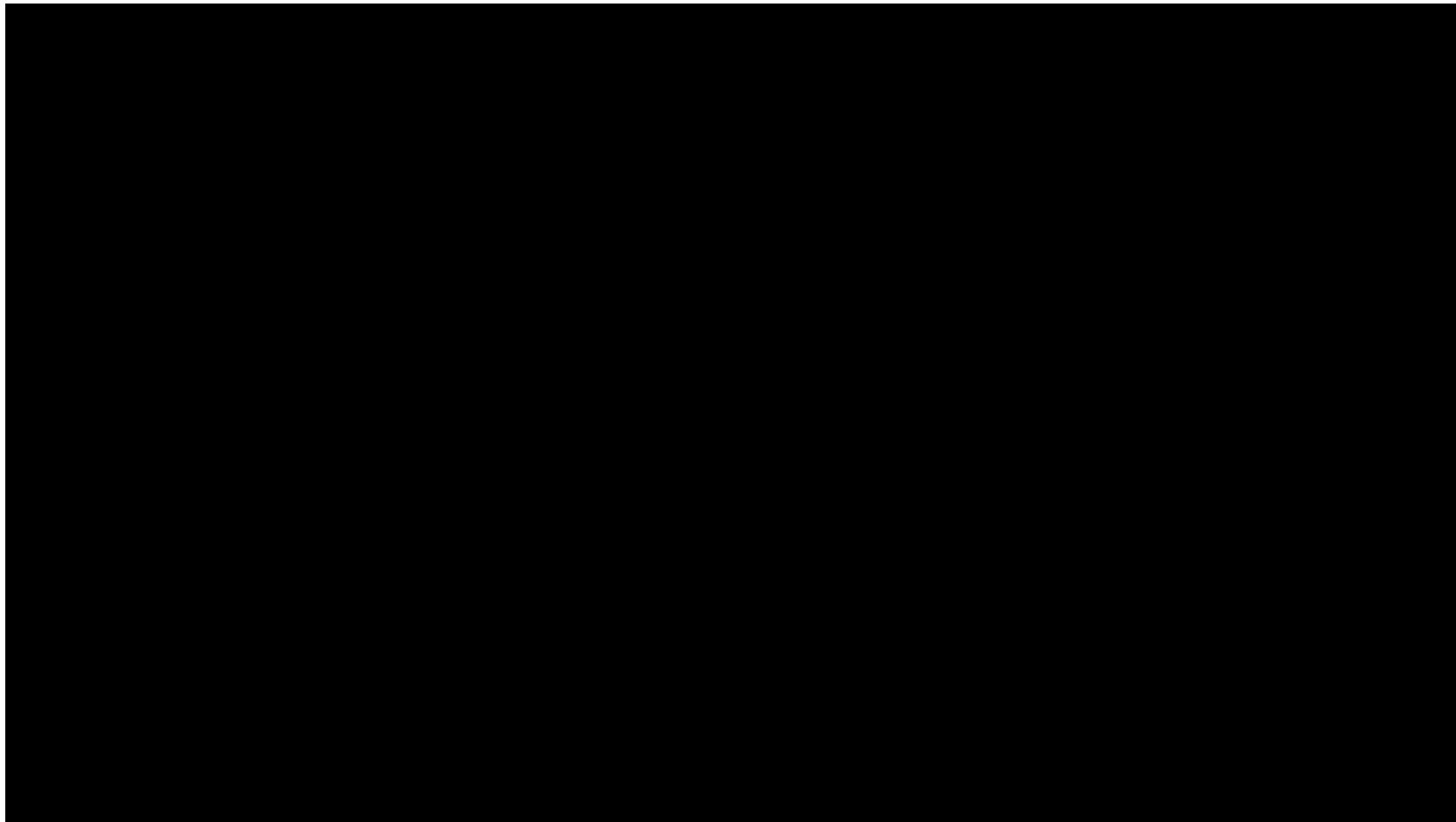


Implementing Customary Restrictions in Penglipuran Village In SuperMap Software

Method:



The integration of BIM and GIS can provide an overview of customary law and restrictions that apply in one customary village. This integration makes it easier for stakeholders to decide on modernization restrictions to maintain their traditional buildings.



Collaboration with Indonesian SuperMap Team



Customary/Adat Cadastre is important to be implemented in Indonesia. Because this activity will be socially related, considering that Indonesia has thousands of traditional villages scattered throughout Indonesia. A customary cadastre is not simply depicted in 2D; a registration system or recording in 3D is required. Thus, to identify customary adat (Right, Restriction, Responsibility) can use this 3D cadastre integration in various jobs (multipurpose cadastre) to support the function of the land registration.

Integrating BIM and GIS makes it possible to follow up on Bali regional regulations regulating building heights and modernization zones restrictions. It is an initial effort in the conservation of customary space in Bali. Likewise, that can apply in several other villages or even other countries that require the conservation of these customary spaces.

Thank You
Matur Suksma

If you would like to connect with me:



ksuhari@lecturer.itn.ac.id

or



Ketut Tomy Suhari