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A study on the transformation and succession of a historical environment a case study in Cakranegara, Indonesia

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ABSTRACT

This study sought to clarify the transformation and succession of the historical environment of Cakranegara, a historical Indonesian city based on the following viewpoints: 1) transformation of building lots and their uses; 2) utilization of space on the streets; and 3) proposing appropriate indices to evaluate the historical environment of Cakranegara. The major findings were: 1) the transformation of the spatial structure of the city can be evaluated by analyzing the relationship between the change of building lots and their uses. The tendency of splitting or consolidating lots varies depending on land use type and location; however, almost half of the building lots have retained their original size; 2) the utilization of public space in Cakranegara can be analyzed and evaluated using seven categories of objects, three time scales, three types of ownership, and five categories of open space; 3) usage of Tagtagan, which is a space installed along both sides of a street, has transformed from a space for religious activities and planting trees to a space with multiple uses for daily living activities; and 4) public space is characterized by a dualistic spatial structure – space for commercial/transportation uses and space for residential uses – based on road hierarchies.

Introduction

The aim of this study was to clarify the historical characteristics of Cakranegara, a historical city developed in the early 18th century in the south-western part of Lombok Island, and to analyze its transformation and succession based on the city planning philosophy of Hinduism (Funo et al. 1992). Lombok Island is located in eastern Bali Island, Indonesia (figure 1).

Cakranegara has a latticed street plan with the main streets called Marga Sanga, which cross at the center of the city where the Pura Meru (Meru Temple) and Mayura water palace are located. These main streets form the backbone of the city (figure 2). City blocks are referred to as Karang, which are in turn each composed of four strips of small blocks called Kriang (Funo et al. 1992).

Previous studies have reported several basic characteristics regarding the planning philosophy of the city, and these are as follows: 1) one strip was originally split into 20 building lots, 2) 20 building lots were grouped into one unit together with another line of lots at their rear; 3) the lots were all residential, except for those containing temples in each Karang; 4) each lot has a shrine called a Sanggah at its northeastern corner, which expresses the worship of sunrise from the east and of the holy mountain called Rinjani located in the northern part of Lombok Island; 5) there is a hierarchy of streets that differ from each other by their width. The largest are the Marga Sanga (approx. 36 m wide), followed by the Marga Dasa (approx. 18 m wide), and then the Marga (approx. 8 m wide) as illustrated in figure 3; and 6) spaces along the streets are referred to as Tagtagan, which are intermediate between private and public spaces. The Tagtagan provide residents with space for growing food and ornamental plants, and for living activities (Funo et al. 1995).

Cakranegara has unique spatial characteristics, such as its grid-like street plan and building lots designed with a focus on faith. The lots are surrounded by a lattice pattern of 300-year-old streets. The existing forms and functions of building lots and streets are affected by the spatial conditions formulated in the past centuries (Nakatani 2011). Cakranegara is thus well suited to investigating the spatial and functional transformation and succession of a city due to its homogeneous spatial characteristics.

Previous research

Most of the architectural research focusing on the spatial characteristics of major Indonesian cities was conducted in Java Island. (de Haan 1922) outlined the overall history of Batavia (now called Jakarta) and (Funo, Yamada, and Yamamoto 2005) described the establishment of the city based on historical maps commissioned by the Dutch.

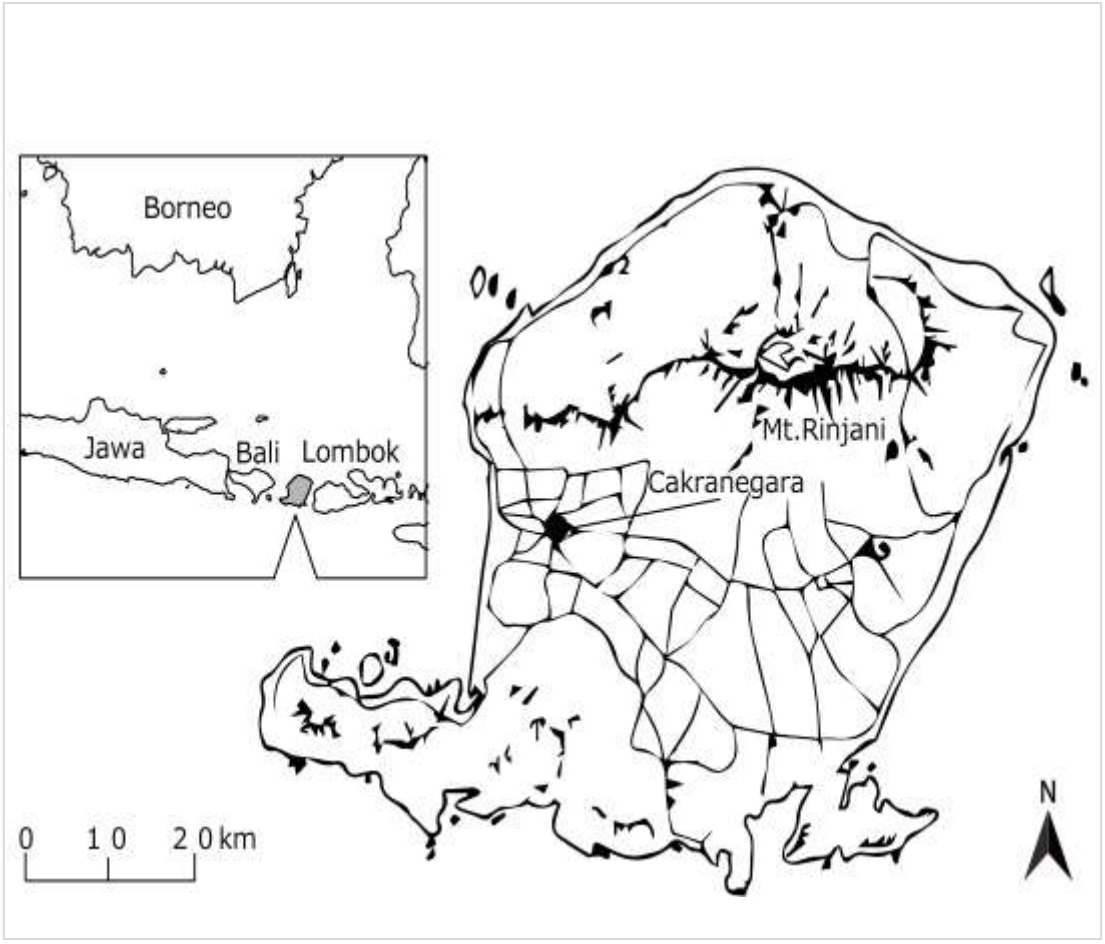

Figure 1. Study area and city blocks included in the survey

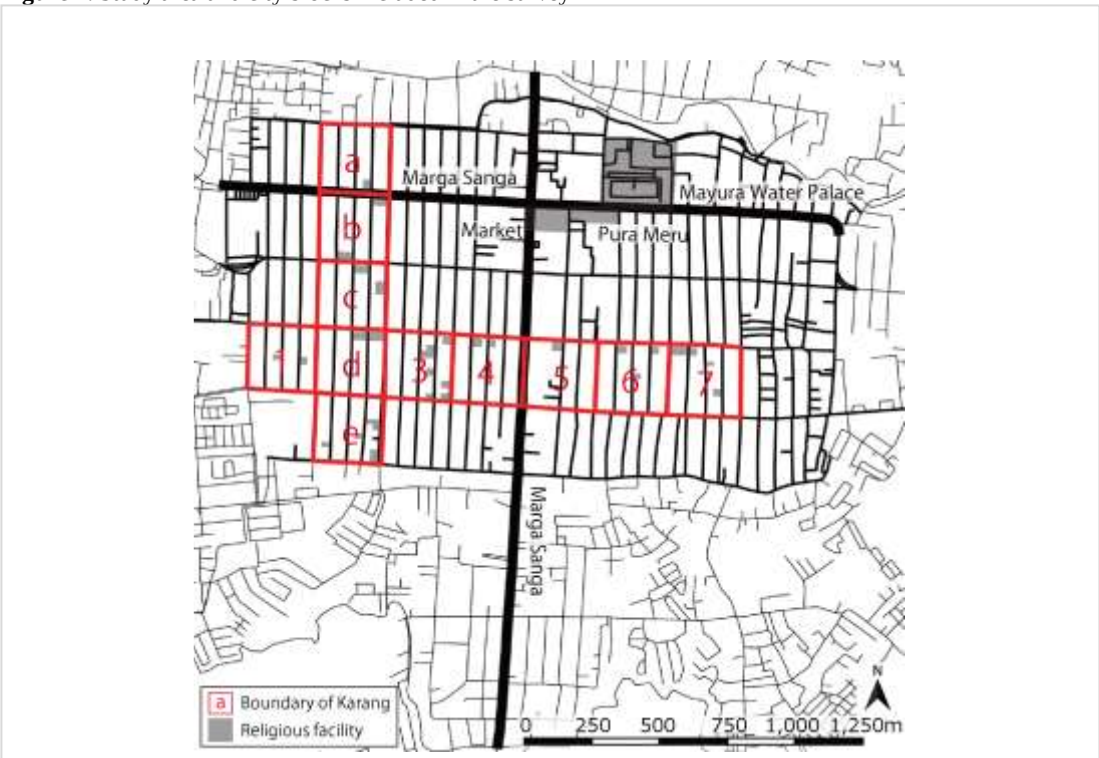

Figure 2. Map of study area and city blocks included in the survey

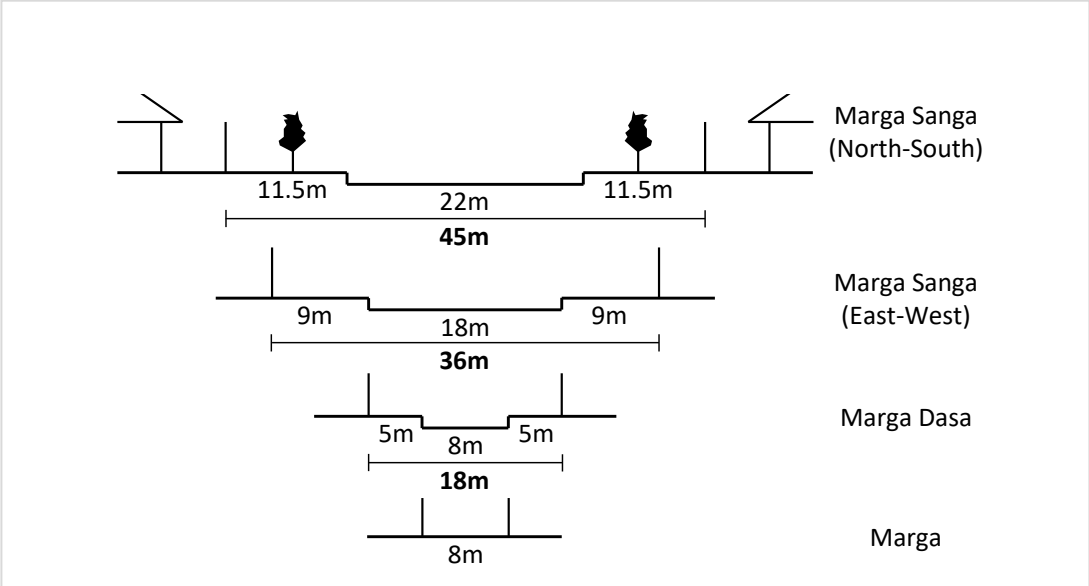

Figure 3. Hierarchy of roads in Cakranegara

East India Company. (Silas 1989) outlined the establishment of the city of Surabaya and (Yamamoto and Funo 2002) investigated the spatial transformation of Surabaya based on historical maps (Ikaputra 1995) and (Bagoes and Wiryomartono 1995) extracted Hindu and Islamic cosmologies based on the layout of public urban facilities in Surakarta and Jogjakarta and (Rukayah, Vania, and Abdullah 2023) examined the development of the city of Semarang.

As for studies conducted near Lombok Island, (Salija 1975) and (Budihardjo 1986) examined the spatial structure of cities and villages on Bali Island to clarify the sense of direction of Balinese Hinduism, which was reflected in the layout of public facilities. However, because of its lattice layout, Cakranegara is considered to be well suited for use as a case study on the succession and spatial and functional transformation of city spaces.

Several studies have been conducted on Cakranegara to date. Funo undertook a series of studies to reveal the basic spatial structure of Cakranegara in the 1990s. The first study clarified the spatial structure of Cakranegara, focusing on street patterns and building lots (Funo et al. 1997). The second study focused on the neighborhood unit called the *Karang*, revealing its relationship with *Pura Meru* (Funo et al. 1998a). The third study clarified the relationship between segregation and the spatial development of building lots and streets (Funo, Maki, Wakita, Yamamoto, et al. 1998b).

Recent studies have investigated the cosmological foundations of Balinese traditions. (Wakita et al. 1996) and (Mulyadi 2014) compared similarities and differences in the orientation of holy places, city structure, and settlements of Balinese and the Sasak people on Bali Island and Cakranegara. (Yamamoto et al. 2005) also compared city structures of Cakranegara and Gianyar on Bali Island.

This study aimed to clarify the spatial and functional aspects associated with the transformation and success of Cakranegara, based on the spatial characteristics identified in previous studies. The findings of this study may provide insights on the preservation of historical city blocks.

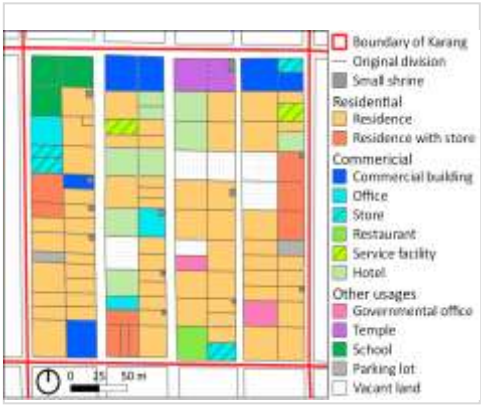

Figure 4. Example of land use in block C

Method

Data on building lots, lot usage, and street space were collected during a series of field surveys that were undertaken from august 7 to 14, 2017 and from august 16 to 23, 2019 (i.e., a total of 16 days). The target city blocks and streets were selected from a set of blocks (a, b, c, d and e) along a north-south axis and others on an east-west axis (1, 3, 4, 5, 6 and 7), which still retain traditional characteristics. These blocks and streets were selected to consider possible regional differences (figure 1).

To confirm the status of spatial transformation of building lots, their subdivision and consolidation, and the relationships among these factors, 1,037 building lots were selected from the field surveys[2].

The distribution of Sanggah, which are small shrines in the northeastern corner of each lot, was also analyzed to confirm the succession of Balinese cosmology which places Sanggah at the North-East corner in the land lot. The distribution of Sanggah was confirmed only for the lots located along the eastern side of strips of small blocks, as these could most easily be seen and surveyed from the road.

Regarding street spaces, functional transformation was analyzed based on the usage of items in street spaces, including the Tagtagan, and relationship between the items and the type of street. Appropriate indices were also considered prior to the analyses.

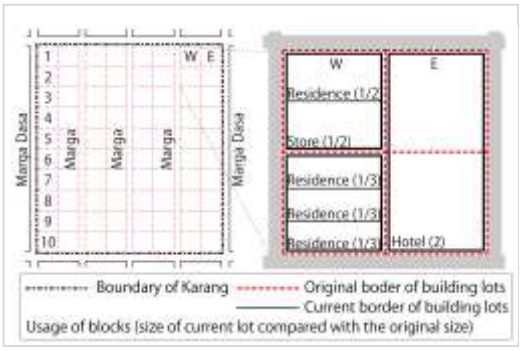

Figure 5. Structure, subdivision, and consolidation of building lots in Karang

Findings
Example of a specific block

An example of lot subdivision and changes in land use is illustrated in figure 4. The land use was classified into six categories based on the results of field surveys. The original 80 building lots selected for the analysis were comprised of 45.5 (56.9%) residences, 20.0 (25.0%) commercial buildings, 4.5 (5.6%) public facilities, 4.5 (5.6%) religious facilities, and 5.5 (6.9%) vacant areas/houses. Schools, commercial buildings and a temple were located on the consolidated building lots at the northern or southern edge of the Kriang. Stores, schools and offices were located at the lots on the eastern or western sides of the Kriang along Marga Dasa. Major parts of residences, accounted for 40.5 of 45.5 (89.0%) residential lots, located inside the Kriang (i.e., the lots except for the northern and southern ends of the Kriang). Vacant areas/houses were all located inside the Kriang.

Due to the subdivision and consolidation of building lots, the number of lots in Karang C increased from 80 to 103 lots. A total of 42 (52.5%) lots retained their original size, 27 (33.8%) lots were subdivided, and 11 (13.8%) were consolidated, which means that over half of the lots are their original size. The 26 subdivided lots (out of 27; 96.3%) are located within the *Kriang*, which implies that subdivision is progressing inside the *Kriang*. On the other hand, all consolidated lots (four commercial buildings, four vacant areas/houses, and three public facilities) are located at the northern or southern sides of the *Kriang*.

These instances of subdivision and consolidation follow the borders of the original lots, which implies the succession of the original lots layout.

Land use of building lots

The distribution of land use in different building lots is shown in table 1. Among the five different lot use types, residential areas are still the most abundant (56.9%), followed by commercial use (26.6%). The remaining 16.5% is composed primarily of vacant areas/houses (7.8%), religious facilities (4.7%), and public facilities (3.8%), indicating a slight increase in the number of vacant areas/houses.

The spatial distribution of land use is shown in table 2. The share of residents at the northern and southern ends of the Kriang (E1, E2, W1 and W2) was higher than residents at the center of the Kriang (E2 to E9 and W2 to 9), with 64.1% of residents residing at the edges and only 28.4% in the center of the Kriang. The share of commercial buildings is relatively high at the northern and southern ends of each Kriang, with 30.1%, 45.5%, 50.0% and 50.0% of E1, W1, E10 and W10 dedicated to commercial activities, respectively. Contrary to the findings of a previous study (Funo et al. 1997), which reported that Chinese residents lived primarily along Marga Sanga and were engaged in commercial activities, current land use indicates that commercial uses are spread along Marga Dasa in an east-west direction, whereas the center of the Kriang is still used as residential land.

A high proportion of lots at the northern end of each Kriang were used for religious facilities (E1 = 17.0% and W1 = 19.3%, see table 2 and gray areas in figure 1 above). The concentration of religious facilities at the northern end of each Kriang reflects the Balinese reverence for the mountains to the northeast of Mataram city.

The percentage of vacant areas/houses is higher near the center of each Kriang, with 8.3% of such lots located in E/W2 to 9 compared to 5.8% in E/W 1 and 10.

Table 1. Lot characteristics

Usage	No. of Lots	Lot size		
		Total	Share	Average
1. Residance	657	501.0	56.9%	0.8
2. Commercial building	261	233.9	26.6%	0.9
3. Public facility	21	33.5	3.8%	1.6
4. Religious facility	37	41.7	4.7%	1.1
5. Vacant land/house	70	68.9	7.8%	1.0
6. Unknown	1	1.0	0.1%	1.0
Total	1,047	880.0	100.0%	0.8

Table 2. Spatial distribution of lots and lot uses

Original location	Usage 1 Residence	2 Commercial	3 Public facility	4 Religious facility	5 Vacant land/house	6 Unknown	Total
W1	8.0	20.0	5.0	8.5	2.5	0.0	44
	18.2%	45.5%	11.4%	19.3%	5.7%	0.0%	100%
W2	31.2	6.5	3.0	0.3	3.0	0.0	44
	70.8%	14.8%	6.8%	0.8%	6.8%	0.0%	100%
W3	30.5	9.5	0.5	1.0	2.5	0.0	44
	69.3%	21.6%	1.1%	2.3%	5.7%	0.0%	100%
W4	29.7	11.0	0.0	0.3	2.0	1.0	44
	67.4%	25.0%	0.0%	0.8%	4.5%	2.3%	100%

Original location	Usage						Total
	1	2	3	4	5	6	
	Residence	Commercial	Public facility	Religious facility	Vacant land/house	Unknown	
W5	29.8	10.2	0.0	0.5	3.5	0.0	44
	67.8%	23.1%	0.0%	1.1%	8.0%	0.0%	100%
W6	29.0	8.5	2.0	0.5	4.0	0.0	44
	65.9%	19.3%	4.5%	1.1%	9.1%	0.0%	100%
W7	26.0	11.0	1.0	0.5	5.5	0.0	44
	59.1%	25.0%	2.3%	1.1%	12.5%	0.0%	100%
W8	26.0	13.5	1.0	0.0	3.5	0.0	44
	59.1%	30.7%	2.3%	0.0%	8.0%	0.0%	100%
W9	26.7	9.0	2.0	0.0	6.3	0.0	44
	60.6%	20.5%	4.5%	0.0%	14.4%	0.0%	100%
W10	14.5	22.0	4.0	1.0	2.5	0.0	44
	33.0%	50.0%	9.1%	2.3%	5.7%	0.0%	100%
E1	16.0	13.3	4.0	7.5	3.3	0.0	44
	36.4%	30.1%	9.1%	17.0%	7.4%	0.0%	100%
E2	30.0	8.5	2.5	0.5	2.5	0.0	44
	68.2%	19.3%	5.7%	1.1%	5.7%	0.0%	100%
E3	32.0	8.5	0.5	1.0	2.0	0.0	44
	72.7%	19.3%	1.1%	2.3%	4.5%	0.0%	100%
E4	26.0	11.0	0.0	2.0	5.0	0.0	44
	59.1%	25.0%	0.0%	4.5%	11.4%	0.0%	100%
E5	28.2	7.5	2.0	4.5	1.8	0.0	44
	64.0%	17.0%	4.5%	10.2%	4.2%	0.0%	100%
E6	29.2	9.8	0.0	2.5	2.5	0.0	44
	66.3%	22.3%	0.0%	5.7%	5.7%	0.0%	100%
E7	28.8	10.2	0.0	2.5	2.5	0.0	44
	65.5%	23.1%	0.0%	5.7%	5.7%	0.0%	100%
E8	23.0	9.0	1.0	2.0	9.0	0.0	44
	52.3%	20.5%	2.3%	4.5%	20.5%	0.0%	100%
E9	25.0	13.0	1.5	1.5	3.0	0.0	44
	56.8%	29.5%	3.4%	3.4%	6.8%	0.0%	100%
E10	11.5	22.0	3.5	5.0	2.0	0.0	44
	26.1%	50.0%	8.0%	11.4%	4.5%	0.0%	100%
Total	501.0	233.9	33.5	41.7	68.9	1.0	880
	56.9%	26.6%	3.8%	4.7%	7.8%	0.1%	100%

Subdivision and consolidation of lots

Half of building lots have retained the original lot size (50.9%), while some have been subdivided (27.6%) and others have been consolidated (21.5%), as shown in table 3.

This tendency for subdivision or consolidation varies as function of the location of lots, as shown in table 4. The share of consolidated lots at the northern and southern ends of the *Kriang* is higher than the ones in the center of the *Kriang*, with 31.3% (E/W1) and 28.4% (E/W10) at the edges and 19.5% (E/W2 to E/W9) in the center of the *Kriang*. Conversely, the share of subdivided lots at the northern and southern ends of the *Kriang* are 14.8% (E/W1) and 18.8% (E/W10), respectively, whereas the share of subdivided lots at the center was 30.3%. These results show that there is a tendency towards subdivision of building lots in the center and consolidation at the ends of the *Kriang*.

This tendency of subdivision and consolidation of building lots was related to their uses (table 5). Almost half of the residential have remained at their original lot size (263, 52.5%), followed by subdivided lots (170, 33.9%) and consolidated lots (68, 13.6%).

Approximately half of the commercial lots have retained their original size (122, 52.2%) whereas the shares of the subdivided lots and consolidated lots are similar; the former comprises 58 (24.6%) and the latter 54 (23.3%). The tendency of subdivision and consolidation differs from the scale of commercial facilities. Commercial facilities with a single story show higher share of subdivision (15.7%) whereas those with multiple stories show a higher share of consolidation (40.9%), as shown in table 6.

The percentage of consolidation is relatively high in temples (60.9%), which implies that the temples originally occupied two lots, and this has been retained to the present[4].

Among the different types of public facilities, the extent of consolidation has been high among educational (93.3%), medical (75.0%) and banking (40.0%) facilities, whereas 90.9% of administrative facilities have retained their original lot structure. Modern facilities, such as educational and medical facilities, can require relatively large areas of land and tend to consolidate lots. However, most administrative facilities do not require large areas as villas are used for these facilities.

Table 3. Subdivision and consolidation of lots

Type	No. of lots	Lot size	Share (lot size)
No change	448	448	50.9%
Subdivision	508	243	27.6%
Consolidation	91	190	21.5%
Total	1,047	880	100.0%

Table 4. Subdivision and consolidation of lots by location

Original location	No change	Subdivision	Consolidation	Total
E/W1	47.5	13.0	27.5	88
	54.0%	14.8%	31.3%	100%
E/W2	46.0	24.7	17.3	88

Original location	No change	Subdivision	Consolidation	Total
	52.3%	28.0%	19.7%	100%
E/W3	43.0	31.5	13.5	88
	48.9%	35.8%	15.3%	100%
E/W4	52.0	18.5	17.5	88
	59.1%	21.0%	19.9%	100%
E/W5	41.5	30.0	16.5	88
	47.2%	34.1%	18.8%	100%
E/W6	46.5	25.7	15.8	88
	52.8%	29.2%	18.0%	100%
E/W7	42.0	30.7	15.3	88
	47.7%	34.8%	17.4%	100%
E/W8	44.0	26.0	18.0	88
	50.0%	29.5%	20.5%	100%
E/W9	39.0	26.0	23.0	88
	44.3%	29.5%	26.1%	100%
E/W10	46.5	16.5	25.0	88
	52.8%	18.8%	28.4%	100%
Total	448.0	242.5	189.5	880
	50.9%	27.6%	21.5%	100%

Table 5. Subdivision and consolidation of lots

Usage of Building Lots	No. of lots				Share			
	No change	Subdivision	Consolidation	Total	No change	Subdivision	Consolidation	Total
1 . Residence	263	170	68	501	52.5 %	33.9 %	13.6 %	100 %
2 . Commercial	122	54	58	234	52.2 %	23.3 %	24.6 %	100 %
3 . Public facility	10	2	22	34	29.9 %	4.5%	65.7 %	100 %
4 Religious facility	10	7	25	42	24.0 %	16.0 %	60.0 %	100 %
5 Vacant land/house	42	10	17	69	60.9 %	14.4 %	24.7 %	100 %
6 . Unknown	1	0	0		100 %	0.0%	0.0%	100 %
Total	448	243	190	880	50.9 %	27.6 %	21.5 %	100 %

Table 6. Subdivision and consolidation of commercial buildings by number of floors

No. of Floors	No change	Subdivision	Consolidation	Total
Single story	80	46	24	150
	53.4%	30.9%	15.7%	100%
Multiple stories	41	8	34	83
	49.3%	9.8%	40.9%	100%
Total	121	54	58	233
	51.9%	23.4%	24.7%	100%

Definition of objects located in street spaces

All of the objects observed in the public space adjacent to the streets that traverse the target blocks of the city in a north-south direction were recorded to assess the extent of utilization of these areas. The following four types of attribute information were collected: 1) category, 2) location, 3) time scale and 4) owner. Location was used to analyze the distribution of objects among Tagtagan and other public and private spaces. Time scale refers to whether the public spaces were used constantly or temporarily; many countries in Southeast Asia make common use of such spaces. Owner refers to the traditional commons associated with the public space. The definitions of these indices are shown in figure 6 and table 7 to table 9.

Table 7. Definition of street objects

Large Groups	Medium Groups	Small Groups
Living	Rest/chat	Chair, wooden balcony, lodge
	Cook	Kitchen utensil, washing place
	Living utensil	Cleaning tool, furniture
	Laundry	Laundry, cloth
	Garbage	Trash bin, garbage dump
	Eave/terrace	Eave, terrace, gate, wall
Commercial	Signboard	Signboard, advertisement
	Food stall	Goods, food stall
	Store	Store
Work	Material/ equipment	Woodwork, workbench, machine tool
Decoration	Plant	Plant, tree pit, roadside tree
	Statue/sculpture	Stone pillar, sculpture
	Pavement	Decorative pavement
	Flag	Flag
Event	Religious item	Praying pole
	Cockfighting basket	Cockfighting basket
Public	Signboard, pole	Signboard, electric pole, traffic light
	Gate pillar	A pair of pillars at the entrance of Marga
Transport	Curb, fence	Curb, fence
	Vehicle	Car, motorcycle, bicycle
	Bridge	Bridge crossing waterway

Figure 6. Definition of different locations of space

Table 8. Definition of time scales

Time Axis	Definition	Example
Permanent	Cannot be moved structurally	Electricity pole, street tree, gate
Semi-Permanent	Movable but left in place	Plant, bench
Temporary	Tentatively placed	Car, motorcycle

Table 9. Definition of object ownership

Owner	Definition	Example
Public	Publicly owned	Electricity pole, streetlight
Community	Commonly owned	Wooden stand, garbage dump
Private	Individually owned	Motorcycle, sculpture

Distribution of shrines (Sanggah)

The number of Sanggah observed in the lots on the eastern side of the Kriang was divided by the total number of lots (table 10). A total of 40.4% of lots have Sanggah, and the highest proportion (51.2%) was observed in residential areas. In cases where lots have been subdivided, it was expected that the percentage of lots with Sanggah would be less than half of the original percentage of undivided lots; however, the percentage of subdivided lots with Sanggah (46.6%) is just 9.6% lower than that in the unchanged lots (56.2%). This result indicates that Sanggah were newly installed in the subdivided lots, and reflects the importance of Sanggah for religious activities in Cakranegara.

Table 10. Distribution of shrines in different types of blocks

	#	Usage	No change	Sub-division	Consoli-dation	Total
A. No. of	1	Residence	82	81	8	171
	2	Commercial	20	7	2	29
	3	Public facility	1	0	3	4
	4	Vacant land/house	0	0	1	1
		Total	103	88	14	205
B. No. of Building Lots	#	Usage	No change	Sub-division	Consoli-dation	Total
	1	Residence	146	174	14	334
	2	Commercial	61	46	20	127
	3	Public facility	3	2	7	12
	4	Vacant land/house	21	11	3	35
		Total	231	233	44	508
Ave. Shrines per Building Lots (A/B)	#	Usage	No change	Sub-division	Consoli-dation	Total
	1	Residence	56.2%	46.6%	57.1%	51.2%
	2	Commercial	32.8%	15.2%	10.0%	22.8%
	3	Public facility	33.3%	0.0%	42.9%	33.3%
	4	Vacant land/house	0.0%	0.0%	33.3%	2.9%
		Total	44.6%	37.8%	31.8%	40.4%

Distribution of objects in street space

A total of 7,610 objects were observed in the survey. Of these, 3,617 (47.6%) were used for decoration (mainly plants), 1,132 (14.9%) were used for living, 766 (10.1%) were used for work, 728 (9.6%) were used for transport, and 643 (8.5%) were used by the public. These categories accounted for more than 90% of all observed objects. The share of objects used for events (367, 4.8%), which was composed mainly of religious objects, and commercial objects (306, 4.0%), was relatively low compared to the other categories (table 11).

The location of the observed objects was primarily in the Tagtagan (location 2), which contained 5,269 of the 7,604 objects (69.3%). Although the number of religious objects was

smaller than the number of other categories, the share of religious objects in Tagtagan at three locations showed the highest share (332/367 objects, 90.4%) among the other categories surveyed.

The second highest number of objects at five locations was observed in private spaces (location 4), which accounted for 1,771 objects (23.3%). Among all of the objects counted in private spaces, decorations accounted for the highest share (1,070 objects, 60.4%), which indicates that the private space between waterways and walls is mostly used for planting.

The original functions of Tagtagan have become more diverse, and now the Tagtagan are also used for living and commercial activities. On the other hand, roads and waterways (location 1 and 3) are rarely used for objects; only 35 (0.5%) objects in roads and 244 objects (3.2%) in waterways.

Distribution of objects over time scale and ownership

Traffic-related objects accounted for the highest share of objects in the temporary category, i.e., 677/727 objects (93.1%), as shown in table 11. Traffic-related objects were associated mainly with parking, followed by events (242/367, 65.9%), living activities (518/1,132, 45.8%), work activities (303/766, 39.6%), and commercial activities (60/306, 19.6%). The share of semi-permanent objects was high for events (97/367 objects, 26.4%), living activities (384, 33.9%), and work activities (373/766, 48.7%), indicating that the objects related to daily life activities tend to be used temporarily or semi-permanently.

On the other hand, a high percentage of permanent objects included decorations (3,253/3,621 objects, 89.8%) and public amenities (620/644 objects, 96.3%). The reason for the high percentages observed in the decoration and public amenity categories is that most of these objects are permanent, such as decorations (e.g., plants and statues), and decorated pavements. Although commercial activities have the highest share of permanent objects, such as advertising displays and extensions of restaurants/stores (161/306, 52.6%), the sum of the semi-permanent objects such as fixed stalls (85/306, 27.8%), and temporary objects such as movable stalls (60/306, 19.6%), which reaches 72.2% of all commercial objects, makes commercial objects more permanent than decorations and public amenities.

Regarding the ownership of objects, private objects accounted for the highest share (5,468/7,609, 71.9%). The share of objects in the community is generally relatively low, but some categories had relatively high percentages. For example, objects in the living (144/1,132, 12.7%), commercial (17/306, 5.6%) and event (7/367, 1.9%) categories had relatively high shares, whereas the share of community objects in other categories ranged from 0.0 to 0.5%. In particular, wooden elevated gazebos are commonly used in Balinese communities for resting and chatting.

Distribution of objects relative to road hierarchy

In terms of utilizing public spaces, different tendencies are observed depending on the road hierarchy. The intensity of traffic-related objects decreased in proportion to the level of the road category. The share of transport-related objects was 35.5% in the Marga Sanga, but this decreases to 8.6% in the Marga Dasa and to 5.3% in Marga (table 12 above). Commercial objects showed the same trend, accounting for 6.8%, 3.2% and 2.5% of the objects on these road types, respectively.

On the other hand, the share of objects related to daily life increases as one moves from the *Marga Sanga* to *Marga*. In terms of the road hierarchy, objects for living increased by 7.1%, 9.6% and 12.5%, objects for work increased by 0.0%, 4.7% and 9.5%, objects for decoration increased by 17.3%, 35.6% and 38.1%, and objects for events increased by 0.3%, 1.4% and 4.9%, respectively.

The findings clearly showed that there is a transition in terms of space utilization from transport/commercial activities in the *Marga Sanga* to spaces used for daily life in the *Marga*.

Table 11. Distribution of objects based on their attributes

	#	Category	Location						Timeline				Owner			
			1	2	3	4	5	Total	T	S	P	Total	Pr	Pb	C	Total
No. of	1	Living	7	800	52	230	43	1,132	518	384	230	1,132	969	19	144	1,132
	2	Commercial	7	237	4	38	20	306	60	85	161	306	263	26	17	306
	3	Work	0	523	56	176	11	766	303	373	90	766	745	18	3	766
	4	Decoration	5	2,360	87	1,070	95	3,617	25	343	3,253	3,621	2,327	1,281	13	3,621
	5	Event	0	332	2	32	1	367	242	97	28	367	358	2	7	367

	#	Category	Location						Timeline				Owner			
			1	2	3	4	5	Total	T	S	P	Total	Pr	Pb	C	Total
	6	Public	3	474	18	136	12	643	4	20	620	644	50	591	3	644
	7	Transport	12	516	23	74	103	728	677	11	39	727	714	14	0	728
	8	Unknown	1	27	2	15	0	45	5	3	37	45	42	3	0	45
		Total	35	5,269	244	1,771	285	7,604	1,834	1,316	4,458	7,608	5,468	1,954	187	7,609
Share	1	Living	0.60%	70.70%	4.60%	20.30%	3.80%	100%	45.80%	33.90%	20.30%	100%	85.60 %	1.70%	12.70 %	100%
	2	Commercial	2.30%	77.50%	1.30%	12.40%	6.50%	100%	19.60%	27.80%	52.60%	100%	85.90 %	8.50%	5.60%	100%
	3	Work	0.00%	68.30%	7.30%	23.00%	1.40%	100%	39.60%	48.70%	11.70%	100%	97.30 %	2.30%	0.40%	100%
	4	Decoration	0.10%	65.20%	2.40%	29.60%	2.60%	100%	0.70%	9.50%	89.80%	100%	64.30 %	35.40%	0.40%	100%
	5	Event	0.00%	90.50%	0.50%	8.70%	0.30%	100%	65.90%	26.40%	7.60%	100%	97.50 %	0.50%	1.90%	100%
	6	Public	0.50%	73.70%	2.80%	21.20%	1.90%	100%	0.60%	3.10%	96.30%	100%	7.80 %	91.80%	0.50%	100%
	7	Transport	1.60%	70.90%	3.20%	10.20%	14.10 %	100%	93.10%	1.50%	5.40%	100%	98.10 %	1.90%	0.00%	100%
	8	Unknown	2.20%	60.00%	4.40%	33.30%	0.00%	100%	11.10%	6.70%	82.20%	100%	93.30 %	6.70%	0.00%	100%
		Total	0.50%	69.30%	3.20%	23.30%	3.70%	100%	24.10%	17.30%	58.60%	100%	71.90 %	25.70%	2.50%	100%

Notes: Location numbers correspond to the definitions given in Fig. 6.
T = Temporary, S = Semi-Permanent, P = Permanent, Pr = Private, Pb = Public, C = Community

Table 12. Density of objects of different types in different street types

	Street	Living	Commercial	Work	Decoration	Event	Public	Transport	Total
No. of Street Objects	Marga Sanga	23	22	0	56	1	29	115	324
	Marga Dasa	281	92	138	1,039	40	186	252	2,919
	Marga	823	162	626	2,514	326	396	349	6,600
	Total	1,451	397	1,029	4,667	416	850	1,033	9,843
Share	Marga Sanga	7.10%	6.80%	0.00%	17.30%	0.30%	9.00%	35.50%	100%
	Marga Dasa	9.60%	3.20%	4.70%	35.60%	1.40%	6.40%	8.60%	100%
	Marga	12.50%	2.50%	9.50%	38.10%	4.90%	6.00%	5.30%	100%
	Total	14.70%	4.00%	10.50%	47.40%	4.20%	8.60%	10.50%	100%

Conclusion

The major findings of this study can be summarized as follows: (i) The original land use in Cakranegara was occupied mainly by residential areas. These have been transformed such that around 60% of these areas are residential areas and around 30% are occupied by commercial facilities, which tend to be distributed along the northern and southern ends of the Kriang. The distribution of temples tends to have remained unchanged since their construction; (ii) Almost half of the lots have retained their original size and they efficiently meet a variety of modern uses. Around 30% of lots were subdivided and around 20% of them were consolidated. Those transformations usually follow the original lot borders; (iii) The lots located at the northern and southern ends of the Kriang, where the commercial facilities are typically located, indicated a relatively high percentage of consolidation (29.8%) whereas those in the center of the Kriang, where the houses are typically located, tend to be subdivided (30.3%); (iv) Approximately half of the houses that were surveyed have Sanggah, even when the lots are subdivided. This indicates the strong relationship between the residents and their religious beliefs. Sanggah are also distributed in approximately 30% of public and commercial facilities; (v) The utilization of public space can be analyzed and evaluated using seven object categories, three-time scales, three types of ownership, and five categories of space; (vi) Street objects were mainly for decoration (47.6%), followed by objects related to living (14.9%), work (9.6%) and transport (8.5%). Around 70% of objects at Tagtagan were mainly used for private use. Tagtagan are currently used for a variety of living and commercial activities; (vii) The utilization of public space corresponds to the road hierarchy. As the street level transitions from higher to lower categories, the types of objects change from those used for commercial activities and transportation

to objects used for daily living. Thus, transformation in Cakranegara is characterized by having a dualistic spatial structure; northern and southern sides of the Karang are typically commercial spaces, and the areas inside the Karang are residential spaces.

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Author(s) contribution

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Norio Maki contribute to methodology, supervision, and validation.

Yui Matsumoto contribute to methodology, supervision, and validation.