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Ecological and Cultural Dimensions of Private Green Open Spaces (PGOS) in Balinese Residential Compounds: A Case Study of Peguyangan, North Denpasar

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Abstract Urban residential compounds in Bali represent culturally structured spaces where ecological functions and symbolic meaning are interwoven. Yet rapid urbanization and increasing land scarcity have disrupted this balance, raising concerns about the adequacy of private green open spaces (PGOS) in supporting environmental performance and cultural continuity. This study investigates the ecological and cultural dimensions of PGOS in Peguyangan, North Denpasar, using field measurements, spatial analysis, and qualitative observation across 52 residential compounds of varying lot sizes. The analysis reveals clear disparities: small (<200 m^2) and medium (200–500 m^2) compounds provide only 9% and 8.5% green coverage, falling below Denpasar's regulatory benchmark of 10–28%, whereas large compounds (>500 m^2) achieve 26.5% green coverage. These quantitative results demonstrate that ecological functions, such as stormwater infiltration, microclimate regulation, and biodiversity support, are significantly stronger in larger lots. Culturally, smaller plots show a contraction of natah courtyards and a shift toward symbolic vegetation concentrated around shrines, reflecting compromises caused by densification. Larger compounds, however, preserve the *Tri Mandala* spatial balance by maintaining green courtyards and ceremonial plantings. Collectively, these findings indicate a structural imbalance across the urban fabric, with small and medium lots contributing insufficiently to ecological performance, while larger compounds sustain both ecological and cultural roles. The study concludes that integrating ecological standards with culturally informed landscaping is essential for strengthening PGOS contributions to sustainable Balinese urban living.

Keywords Private Green Open Space (PGOS), Ecological Sustainability, Cultural Traditions, Balinese Residential Compounds, Urban Planning, Denpasar

1. Introduction

Green open spaces are widely recognized as a fundamental component of urban life, directly contributing to residents' quality of life by providing ecological, social, cultural, and health benefits. The presence of accessible and usable green areas in the residence has an important role in improving the quality of life and enhancing satisfaction with housing and overall well-being [1]. Research also indicates that green spaces support social contacts, mental health, and physical health, making them vital for fostering community cohesion and improving overall community well-being [2]. However, the distribution and provision of green spaces are underprovided or poorly distributed, leading to spatial inequalities between green space spatial layout provision levels and the location of residents [3]. Studies in rapidly urbanizing contexts further reveal that new residential developments tend to reduce both the quantity and quality of adjacent open spaces due to increasing building density. These deficiencies not only undermine the livability of urban settlements but also disproportionately affect vulnerable groups, especially children and the elderly, who rely heavily on nearby open spaces [4]. Consequently, green open spaces are increased significantly due to essential indicators of urban sustainability and resilience in the face of continuing urban growth [5].

Beyond their social functions, urban green spaces play a critical environmental role in reducing urban heat stress, reducing greenhouse gas emissions, and reducing stormwater runoff [6]. The integration of green space typologies into housing design has been shown to promote healthy living and well-being, underscoring their importance for residential planning [6]. Evaluations of neighborhood parks in dense housing areas, however, reveal that many fail to function effectively as public open spaces, highlighting gaps in both quality and usability [7]. To address these shortcomings, assessment tools such as the “Green Space Factor” have been introduced to more accurately evaluate the ecological performance of residential greenery [8]. At the same time, research highlights significant socio-economic disparities in the availability and accessibility of urban green spaces, with higher-income residents generally enjoying better access and proximity to these areas. This emphasizes the importance of promoting more socially just and inclusive urban green space planning [9].

Despite growing recognition of the multifunctional value of urban green spaces, much of the existing research continues to emphasize their social and recreational roles. Studies on urban parks, for instance, often analyze user behavior and utilization intensity, revealing that facilities such as walking paths or playgrounds attract more visitors, whereas other areas remain underutilized [10]. Conceptual frameworks for Green City Development also reinforce the economic, social, and ecological importance of open green spaces in urban areas [11]. Other approaches highlight the value of participatory planning, in which citizen engagement strengthens maintenance and long-term use [12]. A more comprehensive planning perspective has likewise been proposed, positioning green open spaces as an integral part of the urban landscape system and advocating for multidimensional management criteria that account for ecological, recreational, and even disaster-related functions [13].

What remains less explored, however, is the contribution of limited-access green spaces (LAGSs), such as gardens within schools, clubs, and religious institutions to overall urban green indices and environmental quality, even though empirical studies show their inclusion can significantly shift city-level measurements [14]. Although public open-green spaces are known to have positive effects on individuals’ physical, mental, and emotional health, the role of design criteria and users’ personal space perception in shaping their interactions with these areas has not yet been sufficiently reflected in sustainable landscape design approaches [15]. Likewise, despite the well-recognized role of private gardens in mitigating the urban heat island effect and enhancing microclimate regulation, particularly in densely built tropical cities, the majority of existing studies have focused on overall green cover rather than spatial configuration, which constrains comprehensive insights into the optimization of small-scale urban greenery [16]. In addition, the mapping and classification of public versus private greenery, including ownership and management aspects, are rarely incorporated into planning frameworks, despite findings that the majority of urban greenery is privately held and thus crucial for ecosystem services [17]. Finally, while private gardens clearly provide environmental and social benefits, there is still little clarity on whether they complement or substitute public green spaces across neighborhoods of different socio-economic conditions, leaving unresolved questions of equity and inclusivity in green space provision [18].

In the context of Bali, the role of private green open spaces is even more crucial because residential compounds—both traditional and modern—function not only as living spaces but also as cultural landscapes shaped by cosmological principles, spatial ethics, and everyday ecological practices. Rapid urban housing expansion has increasingly reduced permeable land within household compounds, creating tension between regulatory requirements for green space, local cultural values, and the realities of urban land pressure.

This situation reveals a research gap: private green open spaces remain underexplored, particularly when viewed through ecological and cultural perspectives that consider both formal regulations and local practices. Previous research has predominantly emphasized public open spaces, with limited attention to private greenery in domestic settings—especially those rooted in Balinese cultural frameworks such as the *Tri Mandala* layout, spatial zoning, and traditional garden stewardship. Addressing this gap, the present study aims to evaluate the condition of PGOS in Peguyangan using a dual ecological and cultural approach, with the expectation that the findings can generate recommendations to raise community awareness and better align urban planning practices with local realities. Accordingly, this study specifically aims to identify the ecological characteristics and cultural functions of private green open spaces in Balinese residential compounds, and to assess their contribution to environmental performance and cultural continuity within an urbanizing setting. Furthermore, the study seeks to contribute to broader discussions on sustainable urban development by highlighting the often-overlooked role of private green spaces in enhancing ecological resilience and cultural continuity within rapidly urbanizing environments.

2. Materials and Methods

2.1. Literature Review

In the Balinese context, residential green space cannot be separated from the island's cultural-spatial philosophy, which frames the house compound (*uma*) as an integrated ecological and spiritual entity. Traditional concepts such as *Tri Hita Karana*, which emphasize harmony between humans, nature, and the divine, underpin the organization of open spaces and plantings within the household compound [19]. This worldview is materialized in spatial doctrines such as *Tri Mandala* and *Sanga Mandala*, which structure the compound into hierarchical zones that guide the placement of gardens, trees, and open courtyards *(natah*) as essential cultural-ecological elements rather than optional landscape features [20]. Empirical studies on *telajakan*, the vegetated strip between compound walls and the roadside, further demonstrate how traditional Balinese settlements historically embedded ecological principles—stormwater regulation, species diversity, ritual provisioning, and semi-public interaction—into domestic greenery [21][22].

However, rapid urbanization has increasingly led to the reduction or disappearance of these culturally embedded green elements, as paving, densification, and "modernized" architectural preferences reduce permeable soil, eliminate ritual plants, and weaken the semi-public functions of *telajakan* [21][22]. Moreover, recent analyses of Balinese architectural values show that the axiological dimension of compound layout—religious, eco-theological, aesthetic, and cultural—remains essential for maintaining identity and environmental balance, yet is now under pressure from spatial limitations and shifting urban lifestyles [23]. Collectively, these studies suggest that private green open spaces in Bali are not merely ecological assets but also carriers of cultural continuity, cosmological order, and traditional ecological knowledge—highlighting the need for PGOS assessments that integrate both environmental and cultural dimensions.

2.2. Methodology

This research employed an integrated qualitative–quantitative descriptive approach to examining the ecological and cultural dimensions of private green open spaces (PGOS) within Balinese residential compounds. Data were collected through field observations, direct spatial measurements, vegetation assessments, and semi-structured interviews with household owners. To ensure representativeness, a stratified random sampling technique was applied by classifying residential compounds into three yard-size strata—small (<200 m^2), medium (200–500 m^2), and large (>500 m^2).

Spatial measurement formed the core of the ecological assessment. Each compound was measured onsite to quantify land area, built-up surfaces, open spaces, paved areas, and vegetated zones, both in square meters and proportional percentages. These results are presented in a comparative table to highlight ecological differences across the three strata, particularly regarding permeability and vegetation coverage. Vegetation surveys documented plant types, layering, and density, with special attention to culturally meaningful species such as Plumeria rubra (*jepun*). Observations of cultural spatial organization were conducted simultaneously to capture how PGOS relates to Balinese architectural concepts—including the arrangement of shrines, the presence or reduction of the *natah*, and plant placement for ritual use. Semi-structured interviews further enriched the analysis by revealing residents' perceptions, motivations, and the symbolic meanings attributed to greenery in daily practice. Together, these data provided a multi-layered understanding of how ecological functions and cultural values intersect within PGOS across varying compound sizes.

2.3. Study Area

Kelurahan Peguyangan in North Denpasar, Bali, served as the study area due to its dynamic urban landscape where traditional Balinese residential compounds coexist with rapidly expanding modern housing. Covering approximately 17.05 km^2, Peguyangan consists of eleven banjar—Kertasari, Pulugambang, Kepuh, Pemalukan, Dakdakan, Hita Bhuana, Tagtag Tengah, Tagtag Kelod, Prajasari, Tagtag Kaja, and Tektek—each exhibiting different levels of urban density and cultural retention. Its location near eco-tourism corridors and mixed water–land zones further contributes to varied environmental conditions that influence PGOS structure and performance. The area's ongoing urbanization, driven by increasing population and building intensity, has led to notable transformations in the configuration of residential compounds, making Peguyangan a relevant setting for examining how PGOS adapts to shifting socio-cultural and physical pressures. The spatial distribution of all sampled compounds is illustrated in Figure 1, using a color-coded map (green for small, yellow for medium, and red for large) to highlight their dispersion across the eleven *banjar*.

Figure 1. Distribution map of sampled households in Peguyangan, North Denpasar, categorized as small (green), medium (yellow), and large (red) residential compounds

A total of 52 samples were included, comprising 28 small compounds, 16 medium compounds, and 8 large compounds, spatially distributed across eleven *banjar* in Kelurahan Peguyangan. Field observations revealed substantial variation in PGOS characteristics across the three residential strata. Small compounds (<200 m^2) are typically dominated by buildings and paved surfaces, leaving only narrow strips or pocket gardens for vegetation. Medium-sized compounds (200–500 m^2) demonstrate more balanced proportions of built and open areas but increasingly show expanded hardscape areas for circulation or parking. In contrast, large compounds (>500 m^2) retain the most ecologically functional PGOS, characterized by broader permeable surfaces, richer vegetation layers, and spatial arrangements that more closely follow traditional principles such as *Tri Mandala*. To illustrate these contrasts in greater detail, Figure 2, Figure 3, and Figure 4 present representative samples from small, medium, and large compounds, respectively, through a combination of floor plans and onsite photographs showing the relationship between building footprints, PGOS distribution, and vegetation structure. These visual examples complement the quantitative ecological data and collectively deepen the understanding of how PGOS functions within Peguyangan's evolving residential landscape.

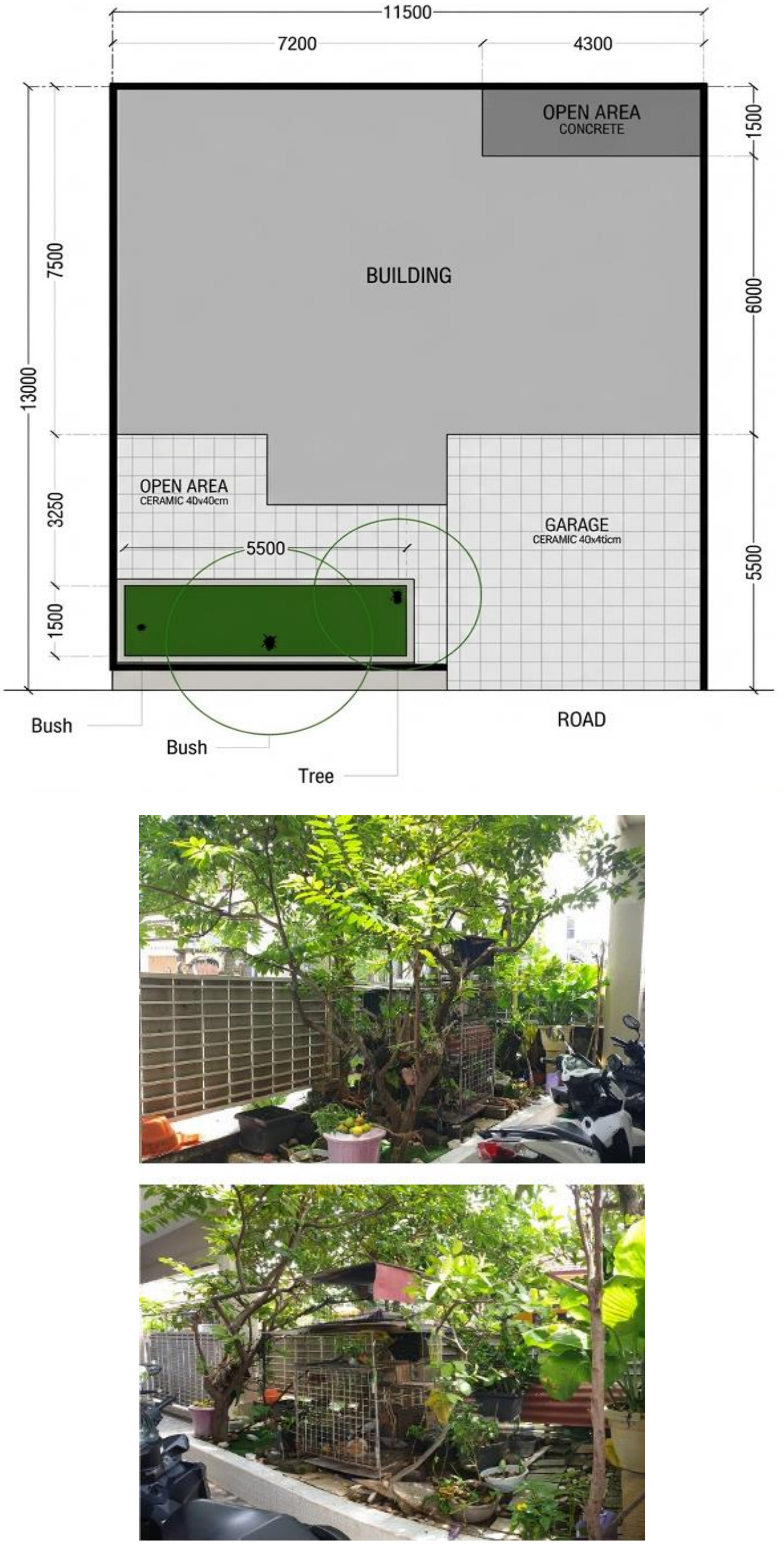

Figure 2. Representative small residential compound (<200 m^2) showing building footprint, open space configuration, and existing PGOS elements (floorplan and onsite photographs)

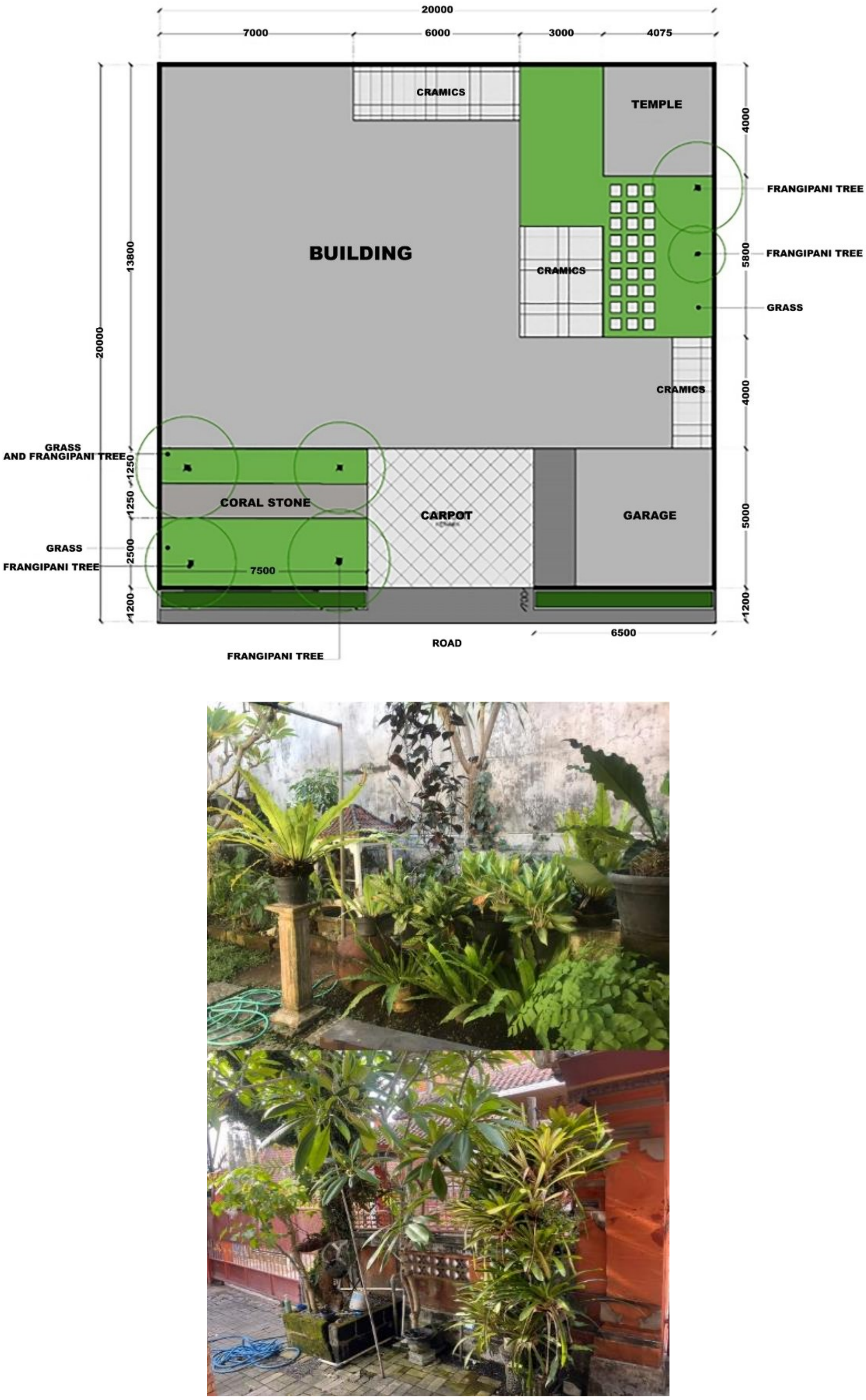

Figure 3. Representative medium residential compound (200–500 m^2) illustrating the distribution of built-up areas, permeable surfaces, and vegetation layers (floorplan and onsite photographs)

Figure 4. Representative large residential compound (>500 m²) depicting extensive PGOS, spatial organization, and vegetation composition (floorplan and onsite photographs)

3. Results and Discussion

3.1. Built-Up and Open Space Utilization in Residential Compounds

Field observations and direct measurements of the 52 sampled residential compounds in Peguyangan reveal clear and consistent differences in the balance between built-up areas and open spaces across the three compound-size categories. As shown in Figure 5, small compounds (<200 m^2) allocate an average of 65.7% of land to built-up structures, leaving 34.3% as open space. Medium compounds (200–500 m^2) display a nearly identical pattern, with 66.6% built-up area and 33.4% open space. These proportions indicate that both categories tend to exceed the recommended maximum building coverage ratio of 60% set by Denpasar's urban planning regulations. In contrast, large compounds (>500 m^2) demonstrate a more balanced land-use configuration, with 48.5% built-up area and 51.5% open space, enabling them to maintain compliance more consistently and preserve larger patches of greenery.

A closer examination of open space utilization further highlights significant contrasts among compound sizes. As illustrated in Figure 6, small and medium compounds show a strong dominance of hardscape elements, such as parking pads, circulation paths, and miscellaneous paved surfaces. Only 9.0% of the total lot area in small compounds and 8.5% in medium compounds is dedicated to vegetated private green open space (PGOS), while paved surfaces account for 25.3% and 24.9%, respectively. Large compounds, meanwhile, allocate an average of 26.5% of their land area to vegetation - slightly surpassing the proportion of paved surfaces at 25.0% - demonstrating a more ecologically favorable balance.

From an ecological standpoint, these findings highlight the limited contribution of small and medium compounds to the broader urban green infrastructure. With relatively low vegetation cover, these compounds provide insufficient support for key ecological functions such as microclimate regulation, stormwater infiltration, and urban biodiversity. Large compounds, however, exhibit greater ecological potential due to their more extensive permeable surfaces and diverse vegetation structures.

Culturally, the land-use patterns reflect shifting adaptations of traditional Balinese residential organization. In small compounds, high building density often compresses or reduces the *natah* (central courtyard), and the spatial hierarchy guided by the *Tri Mandala* principle becomes less pronounced. Greenery, when present, is typically concentrated around sacred or ritual areas, resulting in minimal integration with daily household spaces. Large compounds, by contrast, retain stronger alignment with traditional cultural frameworks, integrating vegetation into both functional and ceremonial zones—most notably through the widespread presence of *jepun* (Plumeria rubra), valued for its ritual utility and symbolic meaning.

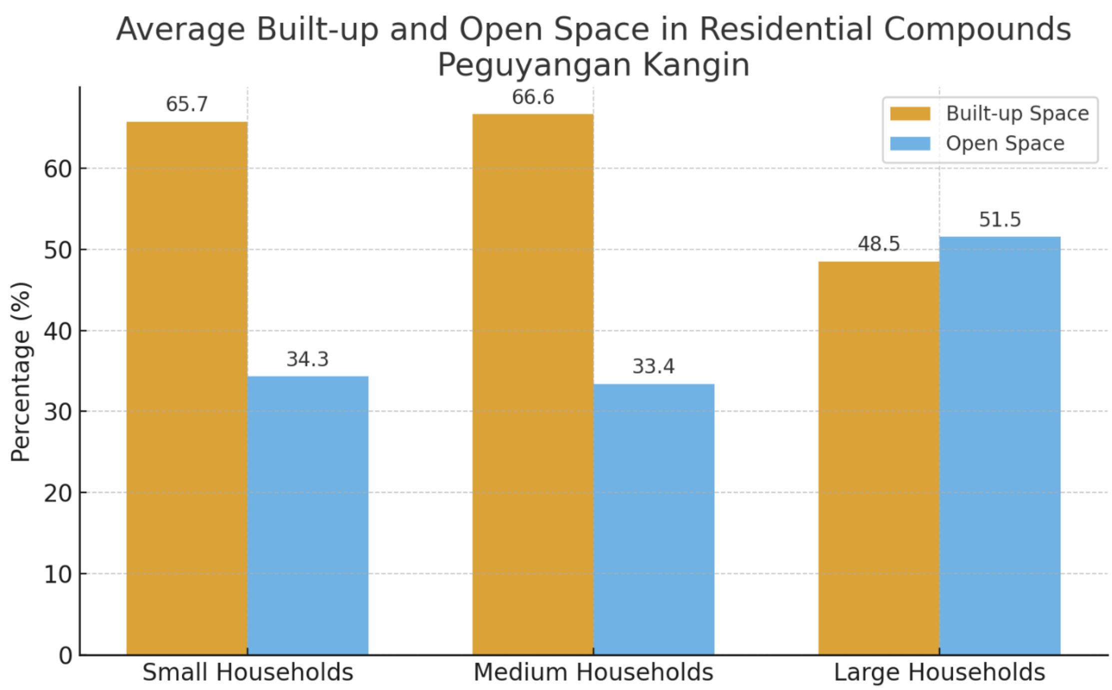

Figure 5. Average Built-up and Open Space in Residential Compounds Peguyangan Kangin

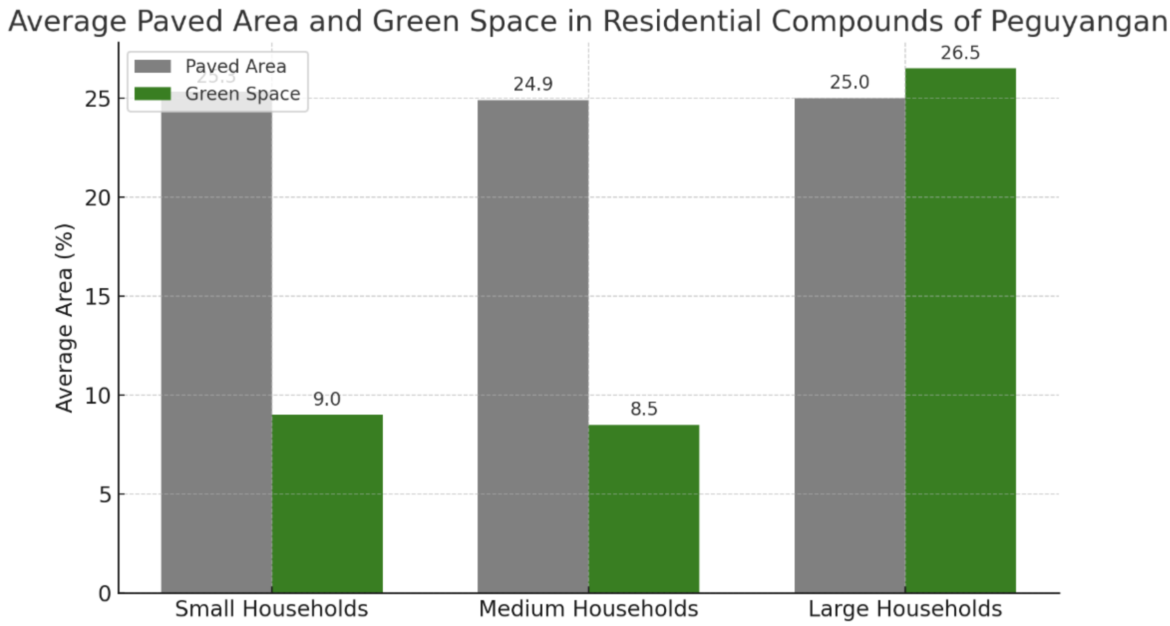

Figure 6. Average Paved Area and Green Space in Residential Compounds of Peguyangan

Overall, these results demonstrate an ongoing tension between formal planning regulations, ecological sustainability, and cultural practices. While regulations prescribe open space percentages, the ecological and cultural quality of these spaces is significantly diminished in smaller and medium residential lots due to urbanization pressures and the prioritization of built functions over greenery.

3.2. Accumulated Area of Private Green Open Spaces

The analysis of accumulated private green open spaces (PGOS) across residential compounds in Peguyangan shows a clear stratification based on lot size, with substantial gaps between small, medium, and large compounds. Current ecological planning principles recommend that at least 10% of residential land be maintained as vegetated softscape to support infiltration, cooling, and basic ecological functions. Local regulations in Denpasar specify an even broader standard—10–28% depending on lot size—making PGOS an essential component of sustainable residential development.

Table 1 summarizes the accumulated area of built-up spaces, paved open spaces, and vegetated areas across the three compound categories. In small lots (<200 m^2), built-up structures occupy an average of 64% of the land, leaving 36% as open space. Yet most of this open space is paved (72.2%), resulting in an average green area of only 9% of the total lot. This means that many small compounds either barely meet or fall below the minimum required threshold. In practice, greenery tends to appear only in modest, symbolic patches—often around shrines—indicating that cultural intentions persist, but ecological performance remains limited due to spatial constraints.

Medium-sized compounds (200–500 m^2) reflect a similar pattern. Even though they provide slightly more land, built-up areas still average 61.1%, with 38.9% remaining as open space. Within these yards, paved surfaces dominate (62.5%), leaving only 36.3% to vegetation—equivalent to 8.5% of the total lot, below the required 10–28% range. This suggests that despite having more room than small plots, medium compounds also prioritize circulation and functional yard use, resulting in reduced ecological contributions.

Large compounds (>500 m^2), however, show a contrasting profile. Built-up areas average 50.9% of the land, leaving almost half the plot as open space. Importantly, vegetated areas exceed paved surfaces, accounting for 26.5% of the total land—well within the regulatory threshold and far more ecologically functional. These compounds retain green courtyards, ceremonial vegetation, and spatial organization aligned with Balinese traditions, demonstrating that ecological and cultural values can coexist when land availability is sufficient.

Figure 7 visualizes this progression. The first bar chart highlights how small and medium compounds allocate almost two-thirds of their land to built-up areas, whereas large compounds maintain a near-even balance. The second chart shows how the composition of open space shifts dramatically across the three categories: small and medium plots remain dominated by paved surfaces, while large plots reverse this pattern, placing greenery at the center of their spatial organization.

Table 1. Accumulated Area of Private Green Open Spaces

Small Compounds (<200 m^2)										
No	**Sample**	**Land Area (m^2)**	**Built-up Space (m^2)**	**(%)**	**Open Space (m^2)**	**(%)**	**Paved Surfaces (m^2)**	**(%)**	**Vegetated Areas (m^2)**	**(%)**
1	Sample 1	72	45	62.5	27	37.5	26	96.3	1	3.7
2	Sample 2	72	52.5	72.9	19.5	27.1	18	91.3	17	87.2
3	Sample 3	72	54	75.0	18	25.0	16	86.1	25	138.9
4	Sample 4	72	60	83.3	12	16.7	12	100.0	0	0.0
5	Sample 5	84	60	71.4	24	28.6	22	92.1	19	79.2
6	Sample 6	117	68	58.1	49	41.9	14	27.6	35.5	72.4
7	Sample 7	104	48.3	46.4	55.7	53.6	50	90.3	54	96.9
8	Sample 8	150	120	80.3	29.5	19.7	26	86.4	4	13.6
9	Sample 9	180	79	43.9	101	56.1	50	49.5	51	50.5
10	Sample 10	171	109	63.9	61.5	36.1	48	78.0	13.5	22.0
11	Sample 11	180	114	63.3	66	36.7	75	113.6	58.5	88.6
12	Sample 12	126	55	43.7	71	56.3	36	50.7	35	49.3
13	Sample 13	140	90.25	64.3	50.2	35.7	34	67.5	16.4	32.7
14	Sample 14	100	43	43.0	57	57.0	43	75.4	14	24.6
15	Sample 15	100	60	60.0	40	40.0	10	25.0	30	75.0
16	Sample 16	164	96.4	58.7	67.8	41.3	49	72.9	18.4	27.1
17	Sample 17	96	73.55	76.6	22.5	23.4	23	100.0	0	0.0
18	Sample 18	100	68.5	68.5	31.5	31.5	21	66.7	10.5	33.3
19	Sample 19	135	98.2	72.7	36.8	27.3	30	82.3	65	176.6
20	Sample 20	103	74.7	72.5	28.4	27.5	23	80.6	55	193.7
21	Sample 21	155	102.75	66.2	52.5	33.8	53	100.0	0	0.0
22	Sample 22	157	84	53.4	73.2	46.6	48	65.6	25.2	34.4
23	Sample 23	99	65	65.7	34	34.3	12	35.3	22	64.7
24	Sample 24	150	110	73.3	40	26.7	32	80.0	8	20.0
25	Sample 25	165	104.8	63.5	60.2	36.5	14	23.7	45.95	76.3
26	Sample 26	150	90.5	60.5	59	39.5	36	61.0	23	39.0
27	Sample 27	160	101	63.1	59	36.9	24	40.7	35	59.3
28	Sample 28	148	97	65.5	51	34.5	42	82.4	9	17.6
	Average			**64.0**	**46.3**	**36.0**	**31.6**	**72.2**	**24.7**	**56.3**
Medium Compounds (200–500 m^2)										
No	**Sample**	**Land Area (m^2)**	**Built-up Space (m^2)**	**(%)**	**Open Space (m^2)**	**(%)**	**Paved Surfaces (m^2)**	**(%)**	**Vegetated Areas (m^2)**	**(%)**
1	Sample 29	271	184	67.9	87	32.1	68.6	78.9	12.4	14.3
2	Sample 30	332	203.8	61.4	127.9	38.6	85	66.5	42.9	33.5
3	Sample 31	287	163	56.8	123.8	43.2	81.1	65.5	42.7	34.5
4	Sample 32	210	111.44	53.1	98.55	46.9	28.65	29.1	69.9	70.9
5	Sample 33	312	171	54.8	140.98	45.2	84.75	60.1	56.23	39.9
6	Sample 34	300	160	53.3	140	46.7	56	40.0	84	60.0
7	Sample 35	240	179	74.6	61	25.4	41	67.2	20	32.8

Table 1 continued

8	Sample 36	210	162	77.1	48	22.9	37.5	78.1	10.5	21.9
9	Sample 37	297	212	71.4	85	28.6	67.5	79.4	17.5	20.6
10	Sample 38	430	174.5	40.6	255	59.4	12	4.7	13.5	5.3
11	Sample 39	225	143.25	63.7	81.75	36.3	72.75	89.0	9	11.0
12	Sample 40	263	153.5	58.5	109	41.5	89	81.7	20	18.3
13	Sample 41	330	189.5	57.4	140.5	42.6	56.4	40.1	84.1	59.9
14	Sample 42	253	179.9	71.1	73.1	28.9	37.8	51.7	35.3	48.3
15	Sample 43	479	249	52.0	230	48.0	173	75.2	57	24.8
16	Sample 44	210	133	63.5	76.5	36.5	71.5	93.5	5	6.5
	Average			**61.1**	**117.4**	**38.9**	**66.4**	**62.5**	**36.3**	**31.4**
Large Compounds (>500 m^2)										
No	**Sample**	**Land Area (m^2)**	**Built-up Space (m^2)**	**(%)**	**Open Space (m^2)**	**(%)**	**Paved Surfaces (m^2)**	**(%)**	**Vegetated Areas (m^2)**	**(%)**
1	Sample 45	576	453.7	78.7	122.6	21.3	66.31	54.1	56.29	45.9
2	Sample 46	542	259.1	47.8	282.4	52.2	91.1	32.3	191.3	67.7
3	Sample 47	634	371.3	58.5	263.1	41.5	154.9	58.9	108.2	41.1
4	Sample 48	546	335.6	61.4	210.6	38.6	118.4	56.2	92.2	43.8
5	Sample 49	503	240.6	47.8	262.4	52.2	154.4	58.8	108	41.2
6	Sample 50	815	53.7	6.6	761.3	93.4	369.5	48.5	391.8	51.5
7	Sample 51	677	367.1	54.3	309.5	45.7	218.5	70.6	91	29.4
8	Sample 52	675	352.0	52.1	323	47.9	98	30.3	225	69.7
	Average			**50.9**	**316.9**	**49.1**	**158.9**	**51.2**	**158.0**	**48.8**

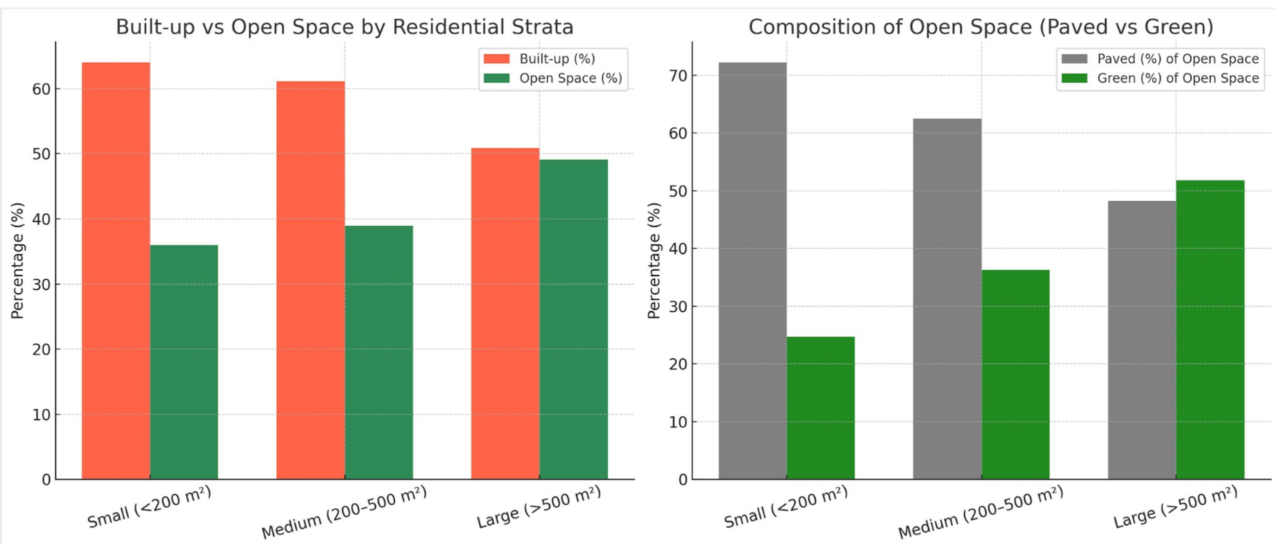

Figure 7. Built-up vs Open Space Bar Chart

A closer look at Sample 24 (Figure 8) further illustrates the typical condition of small-lot housing. With a lot area of 150 m^2 and a building footprint of 110 m^2, the compound reaches a Building Coverage Ratio (KDB) of 73.3%. Meanwhile, green area amounts to only 5.3% of the total lot—far below recommended minimums. Much of the remaining yard is paved, and the limited vegetation functions more as decoration than as an ecological asset. This reduces the compound's capacity for infiltration, runoff mitigation, and microclimate improvement.

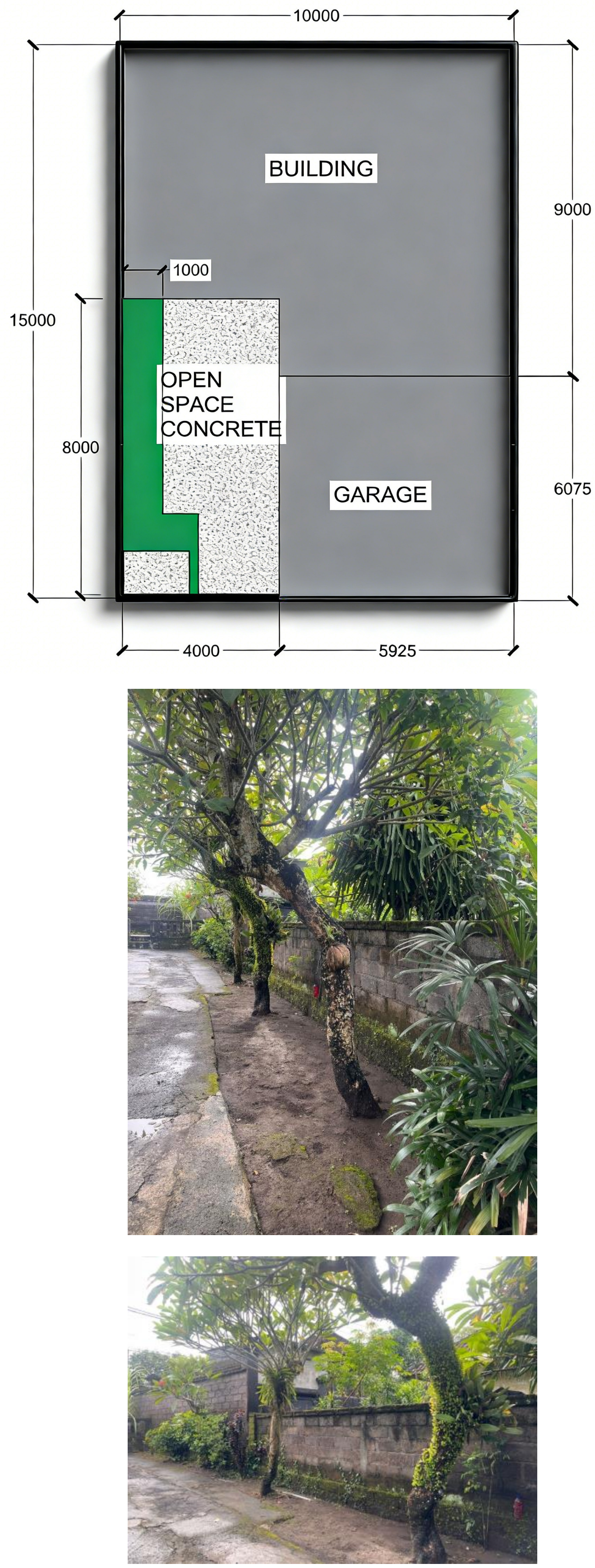

Figure 8. Example from Sample 24

When contextualized within the broader dataset, Sample 24 aligns closely with the average performance of small compounds, which maintain only about 9% greenery and are heavily paved (72%). Medium compounds do not fare much better, averaging only 8.5% green space. In contrast, large compounds reach an average of 26.5% greenery, exceeding minimum standards and contributing meaningfully to urban ecological infrastructure.

Overall, the findings confirm a consistent relationship between lot size and the ecological-cultural performance of private green open spaces. Larger compounds manage to sustain both regulatory compliance and cultural landscape traditions, while small and medium lots—common in dense urban areas like Peguyangan—struggle to provide adequate green space. This imbalance underscores a broader challenge: reconciling the pressures of urban densification with the need to maintain ecological functions and cultural identity within Balinese residential landscapes.

3.3. Discussion

The findings reveal that PGOS in Peguyangan exhibit marked variations across compound sizes, and these variations directly shape both their ecological performance and cultural integrity. From an ecological standpoint, the results reaffirm a consistent underperformance of small (<200 m^2) and medium (200–500 m^2) compounds, particularly in meeting functional green coverage requirements. The average green allocation in these two categories—9.0% and 8.5% respectively—falls below the 10–28% threshold mandated by local planning regulations [24], indicating that most households operate below the minimum ecological standard. This shortfall has tangible implications: reduced infiltration capacity, weaker microclimate regulation, and limited biodiversity support, which are core ecosystem services associated with residential greenery [25]. The case of Sample 24, with a Green Coverage Ratio of only 5.3%, illustrates how spatial limitations at the household level translate into compromised ecological function. Similar patterns have been identified in tropical urban environments, where green spaces below critical size thresholds fail to deliver adequate ecological benefits [26].

Conversely, large compounds (>500 m^2) demonstrate ecological performance that not only meets but often exceeds regulatory expectations, with an average green coverage of 26.5% of total plot area. This outcome suggests that ecological benefits derived from PGOS are unevenly distributed across the residential fabric, skewed toward properties with greater spatial resources [27]. Comparative studies indicate that larger residential lots tend to support higher biodiversity and more stable microclimates because they can accommodate canopy trees, layered vegetation, and permeable ground surfaces that small parcels cannot [28]. The ecological disparity observed in Peguyangan aligns with broader research on urban environmental inequality, highlighting how access to environmental benefits often correlates with property size and socio-economic advantage [29].

Culturally, the findings demonstrate that smaller and medium compounds struggle to maintain the spatial balance that characterizes traditional Balinese residential organization. The reduction of *natah* courtyards and the encroachment of paved multifunctional surfaces diminish the manifestation of the *Tri Mandala* zoning principle, which relies on proportional relationships between built and open spaces. The *Tri Mandala* system—comprising *nista*, *madya*, and *utama mandala*—requires dedicated open areas not only for circulation but also for spiritual grounding. In smaller compounds, greenery frequently remains only as symbolic plantings adjacent to shrines, reflecting an adaptation of cultural practices under spatial pressure. This erosion of open-space integrity mirrors broader challenges in maintaining traditional spatial logics within rapidly densifying urban areas [30].

In contrast, large compounds preserve greenery as both functional and ceremonial elements. The recurring presence of *jepun* and other culturally significant vegetation demonstrates how adequate land area enables the continuity of ritual-oriented landscape practices [31]. Thus, the ecological adequacy of larger compounds is paralleled by stronger cultural continuity. The relationship observed here supports the argument that compound size is a key determinant of environmental and cultural sustainability within Balinese residential settings [32].

Taken collectively, these patterns point to a structural imbalance in Peguyangan: while large compounds sustain both ecological functionality and cultural symbolism through PGOS, the dominance of small and medium-sized plots results in an overall urban landscape that underachieves in green provision. This tension reflects wider concerns related to urban densification, limited land availability, and the diminishing integrity of cultural landscapes in Bali. Research across rapidly urbanizing contexts shows that increased residential density frequently leads to reduced per-capita green space and weakened cultural spatial identity [33].

The implications extend beyond individual compound boundaries. Neighborhoods dominated by smaller lots face heightened urban heat island effects, lower stormwater infiltration, and reduced habitat connectivity, creating cumulative ecological stress. At the same time, the diminishing presence of traditional spatial configurations affects communal cultural identity and reduces opportunities for practices that rely on specific landscape arrangements. These ecological and cultural pressures reinforce the significance of PGOS as more than regulatory categories—they are everyday spaces that intertwine environmental function and cultural meaning.

This leads back to the core research gap: PGOS in urban Bali has rarely been evaluated in terms of how ecological performance and cultural traditions intersect under conditions of rapid urban transformation. The Peguyangan case shows that these two dimensions are mutually embedded, echoing long-standing Balinese principles in which environmental management is both practical and spiritual. This duality resonates with findings from other architectural contexts. For example, our previous research on bamboo construction demonstrated that integrating craftsmen's traditional knowledge reduced material waste from 17.89% to 5.99%, illustrating how indigenous practices improve ecological efficiency [34]. The parallel is clear: just as localized knowledge enhances sustainability in material use, traditional Balinese spatial principles elevate both ecological and cultural performance within PGOS.

In sum, the condition of PGOS in Peguyangan cannot be meaningfully assessed through quantitative compliance alone. Their significance lies in how ecological and cultural values overlap within spatial constraints. Small and medium compounds, which constitute the majority of the urban fabric, exhibit both ecological underperformance and cultural compromise, while larger compounds demonstrate the capacity to sustain both. This duality encapsulates a central challenge for urban Bali: balancing densification with the environmental and cultural functions historically embedded in residential landscapes. By situating PGOS at the intersection of ecological processes and cultural traditions, this study highlights their role as critical, everyday environments where regulations, environmental dynamics, and Balinese cultural values converge—providing the conceptual grounding for the conclusions presented in the next chapter.

4. Conclusions

This study set out to evaluate the ecological and cultural dimensions of private green open spaces (PGOS) in Balinese residential compounds, focusing on Peguyangan, North Denpasar. Through the analysis of 52 sampled households across small, medium, and large lot categories, the research reveals clear disparities in the allocation of built-up and open spaces, as well as in the integration of greenery into everyday living environments.

From an ecological perspective, the findings indicate that small (<200 m^2) and medium (200–500 m^2) lots contribute only marginally to urban green infrastructure. With green coverage averaging 9.0% and 8.5% of lot area respectively, these compounds fall short of both ecological minimums (10%) and planning regulations (10–28%). The predominance of hard paving over permeable surfaces reduces their ability to support infiltration, regulate microclimate, and sustain biodiversity, limiting their ecological contribution to the wider urban system. In contrast, large compounds (>500 m^2), with an average of 26.5% green coverage, not only comply with regulations but also provide more substantial ecosystem services, demonstrating that spatial capacity directly shapes environmental performance.

Culturally, the study also shows that plot size influences the ability of compounds to maintain Balinese spatial traditions. In small and medium lots, densification reduces the extent of *natah* courtyards and displaces functional greenery, confining vegetation largely to decorative or shrine-oriented plantings. This diminishes the cultural role of PGOS as spaces that express ritual practice, identity, and the spatial equilibrium embedded in the *Tri Mandala* principle. In contrast, large compounds retain the spatial flexibility to integrate sacred trees, ceremonial plants, and green courtyards, thereby sustaining cultural continuity alongside ecological adequacy.

Viewed together, these results highlight a structural imbalance in the performance of PGOS: while larger plots maintain both ecological and cultural functions, the dominance of small- and medium-sized household parcels in Peguyangan results in an overall urban landscape with insufficient green provision and weakened cultural spatial expression. This imbalance reflects broader tensions between rapid urbanization, land scarcity, and the preservation of ecological processes and cultural meanings within residential spaces.

The study addresses an important research gap by reframing PGOS not simply as regulatory compliance areas but as dual-functioning spatial elements situated at the intersection of ecology and culture. This perspective underscores the need for planning and community strategies that go beyond numerical green coverage thresholds and instead promote qualitative approaches—such as vertical greenery, clustered communal planting, or culturally grounded landscape guidelines tailored for smaller plots—to enhance both ecological resilience and cultural expression.

Future research may expand this work by examining how paving materials, soil permeability, and surface runoff dynamics in PGOS contribute to flood susceptibility during the rainy season, an increasingly urgent issue in Denpasar. Further studies focusing on heat retention, shading distribution, and airflow patterns across different PGOS configurations would also provide valuable insight into how culturally informed landscaping can mitigate thermal stress in dense urban areas. Comparative analyses between traditional compounds and modern housing clusters offer another promising direction, helping to reveal how lifestyle changes reshape ecological and cultural landscapes over time.

In conclusion, PGOS in Balinese residential compounds should not be seen as residual or decorative spaces; they are vital settings where ecological resilience and cultural continuity are simultaneously shaped. Strengthening their role requires policies and practices that honor both environmental sustainability and Balinese spatial traditions, ensuring that urban growth in Denpasar remains aligned with local identity and long-term ecological well-being.

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