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Exploring Pro-Environmental Behaviors and Health-Oriented Mindsets in Urban Slum Upgrading Projects: A Case Study of Surakarta City, Indonesia

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Abstract: Rapid urbanization has led to significant demographic shifts and environmental challenges worldwide, with a growing portion of the urban population living in slums. This study investigates the impact of an urban slum upgrading program on pro-environmental behaviors and health-oriented mindsets among residents in Surakarta City, Indonesia. Specifically, it aims to reveal how pro-environmental behaviors, house satisfaction, health-oriented behaviors, and sustainability beliefs manifest within this unique socio-cultural setting. A representative survey was conducted among 327 residents of newly renovated urban slum housing. Additionally, cluster analysis with the Silhouette method was performed to identify distinct demographic and social 'personalities' characterized by pro-environmental and health-oriented mindsets within the heterogeneous population across three observed districts. The findings show that while strong beliefs in sustainability are common, there is a gap in translating these beliefs into action, as evidenced by low engagement with recycling and waste-burning avoidance. Furthermore, four clusters with unique profiles emerged: (1) residents dissatisfied with housing but proactive in sustainability (23.3%); (2) health-focused residents satisfied with housing but less engaged in sustainability (5.8%); (3) residents content with housing but low on health awareness and moderate in sustainability beliefs (46.8%); and (4) residents with strong sustainability beliefs but minimal pro-environmental actions (24.1%). This study offers valuable insights for policymakers to guide urban slum upgrading programs with targeted interventions addressing the unique characteristics among the residents. These findings are vital for creating a sustainable urban environment and preventing upgraded areas from reverting to slum conditions.

Keywords: urbanization; slum upgrading; cluster analysis; sustainability; healthy housing

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1. Introduction

The rapid urbanization witnessed globally has led to significant demographic shifts and pressing urban management challenges [1]. By 2020, the global urban population reached approximately 4.2 billion, amplifying concerns about urban poverty [2]. Over one billion people, or 24.2% of the world's urban population, reside in slums, where overcrowding, inadequate housing, and limited access to essential services such as clean water

and sanitation, and other factors associated with congestion diseconomies are pervasive issues [3–7]. These conditions not only highlight severe urban inequality but also present environmental sustainability challenges, as slum areas often face higher exposure to environmental risks and resource scarcity [8,9]. Addressing these disparities requires targeted interventions, including sustainable development strategies that promote both healthier living conditions and environmentally responsible behaviors. Particularly, in urban slum areas where vulnerability to environmental hazards and resource scarcity is heightened [10]. Accordingly, sustainable development strategies must prioritize infrastructure improvements and foster community engagement in pro-environmental behaviors, such as energy conservation, waste management, and water-saving practices [11,12]. In this context, slum upgrading projects present a unique opportunity to cultivate health-oriented mindsets and encourage long-term sustainable behaviors among residents.

Indonesia exemplifies these global urbanization trends, facing similar challenges and opportunities, with its urban population having surpassed its rural population since 2018. Projections indicate that by 2050, nearly three-quarters of Indonesia's population will reside in urban regions [13]. Additionally, as of 2020, urban slum areas covered a total of 86,548 hectares across Indonesia's 34 provinces, presenting critical challenges [14]. In response to this issue, the Indonesian government initiated the Kampung Improvement Program (KIP) in the 1960s, one of Southeast Asia's most notable and long-standing urban slum upgrading programs [15–17]. KIP was designed to enhance living conditions in informal settlements by providing essential infrastructure such as roads, drainage, sanitation facilities, and clean water access [18–20]. This program empowered local communities to foster self-help improvements, leading to a significant reduction in slum areas. Over the years, KIP has evolved to incorporate more holistic and sustainable approaches, addressing not only infrastructure deficiencies but also enhancing the socio-economic resilience of poor urban communities [21]. However, despite these advancements, KIP still faces significant challenges such as insufficient funding, limited community participation in decision-making, and the need for stronger coordination between local governments and national initiatives [22]. Additionally, some residential units constructed through the program suffered from inadequate building designs and poor indoor air quality, largely due to limited funding, which poses significant health risks, especially for vulnerable groups such as children and the elderly [23,24]. Furthermore, urban residents are increasingly affected by the urban heat island effect, which intensifies heat-related health risks, particularly for low-income households that do not afford air-conditioning systems [24]. This situation underscores the urgent need not only to improve KIP housing quality but also to promote health-oriented and pro-environmental behaviors, particularly in low-income households in both slum communities and KIP districts.

Surakarta City, also known as Solo, is a culturally significant and densely populated urban center in Central Java, Indonesia. It represents a typical mid-sized Indonesian city with unique socio-economic dynamics and a strong heritage identity, making it an ideal case for examining the complexities of slum upgrading. The city has a diverse economy, with a growing informal sector and regional GDP that reflects moderate development compared to Indonesia's major metropolitan areas [25]. Surakarta City serves as a prominent example of both the challenges and successes associated with slum upgrading initiatives under the KIP. Between 2016 and 2021, the city achieved an impressive reduction in its slum area ratio, from 6.53% to 3.09% [26]. In the future, it has set a further target to decrease this to 0.67% by 2026. Sustaining this progress, however, poses considerable challenges, as financial constraints and fragmented governance often hinder these efforts [27]. Another key issue lies in ensuring that upgraded districts do not revert to slum-like conditions,

a frequent outcome of inadequate public space management and insufficient long-term community involvement.

These challenges, stemming from low incomes and limited access to formal education among former slum residents in Surakarta, highlight the broader need for effective community engagement and policy alignment to sustain improvements in slum areas [28,29]. Without active resident involvement, long-term improvements in well-being, housing quality, and environmental sustainability remain difficult to achieve. Therefore, identifying the factors that can (and cannot) promote health-oriented and environmentally responsible behaviors and mindset among former slum residents is crucial. Such understanding can help align national and local policies more effectively with the needs and behaviors of these vulnerable groups.

These challenges are not unique to Surakarta. The global literature highlights similar issues in slum upgrading programs, particularly regarding the correlation between such initiatives and the development of pro-environmental behaviors and health-oriented mindsets among the residents. This connection introduces an essential dimension to urban sustainability. For instance, a study in Nigeria revealed that resident involvement in decision-making leads to sustainable practices, such as proper waste disposal, maintenance of shared infrastructure, and resource conservation [30]. In Latin America, research on slum upgrading programs in Brazil highlights that adopting pro-environmental behaviors is linked to infrastructure improvements and social interventions that foster health-oriented mindsets among residents. Additionally, programs that include educational campaigns on environmental conservation and sustainable urban practices have boosted participation in recycling and community-led environmental preservation projects [31]. Furthermore, in India, upgrading initiatives in urban slums have emphasized the importance of designing environment-sensitive built environments. Such approaches play a crucial role in shaping energy policies, as they are influenced by the characteristics of house attributes, household practices, and energy choices of urban slum dwellers [32]. Particularly in Indonesia, Gumelar et al. (2018) explore how cultural styles influence pro-environmental behavior in Jakarta's slum areas. They found that in more individualistic communities, people tend to focus on personal gain, showing less interest in shared environmental efforts like waste management and energy saving. In contrast, collectivist communities are more likely to work together on environmental issues, motivated by social responsibility and shared benefits. This shows that cultural context plays a key role in how slum residents engage in sustainability efforts [33].

Nevertheless, despite the insights from global studies, there remains a significant research gap in understanding how the aforementioned factors manifest in Indonesia, where the socio-cultural context, economic conditions, and urbanization patterns are distinctly different. While international examples highlight the importance of pro-environmental behaviors and health-oriented mindsets in slum upgrading programs, limited research has explored these dimensions within Indonesia's context. For instance, although KIP has long been a model for slum upgrading in the country, most studies focus on infrastructure improvements and socio-economic outcomes. The critical integration of environmental sustainability, community participation, and behavioral change in such initiatives remains underexplored. Addressing these gaps could provide valuable insights into tailoring slum upgrading programs to Indonesia's unique conditions and advancing urban sustainability.

Therefore, this study aims to fill this gap by investigating the intersection of environmental sustainability and sociodemographic characteristics in the context of Indonesian urban slum upgrading projects, specifically in Surakarta City. Furthermore, this study seeks to uncover how pro-environmental behaviors, house satisfaction, health-oriented behaviors, and sustainability beliefs manifest within this unique socio-cultural setting. A

survey was conducted among residents of newly constructed KIP housing. By cluster analysis to the survey results, the study identifies distinct demographic and social 'personalities' that exist within the heterogeneous population of Surakarta City. These clusters reflect various typologies of slum dwellers, helping to reveal patterns that may not be immediately apparent through traditional analysis. The results will provide local policymakers with specific issues on preventing upgraded areas from reverting to slum conditions. Additionally, this study can support municipal strategies with the specific environmental and social needs of these subgroups, promoting both healthier living environments and greater community resilience.

2. Methodology

2.1. Questionnaire Survey Design

This study employed a cross-sectional design, utilizing a questionnaire survey as the primary data collection tool. This survey is part of a series of research efforts conducted in the same locations, building on a prior study [24]. All procedures performed in this study were in accordance with the ethical standards of Kyushu University and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards, being approved by the Ethical Committee of Kyushu University. The questionnaire consisted of 19 items addressing both the socio-demographic characteristics of residents and three key domains related to urban environmental sustainability and resilience—house satisfaction, health-oriented behaviors, pro-environmental behaviors, and beliefs—as detailed in Figure 1. These domains were chosen due to their integral role in shaping the living conditions and environmental impact of urban communities, as supported by previous studies [34–37]. Regarding socio-demographic characteristics, there were five questions covering gender, age distribution, household income level, education, and the length of time respondents had lived in Surakarta City. For the urban environmental sustainability and resilience section, respondents answered items using a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The house satisfaction items focused on aspects such as privacy, satisfaction with house construction, and indoor environmental comfort. Health-oriented items included questions on handwashing frequency, indoor smoking habits, and house cleaning routines. Pro-environmental behavior items addressed participation in neighborhood cleaning programs, the practice of the 3Rs (reduce, reuse, recycle), involvement in environmental sustainability programs, and waste management habits. Finally, the belief items assessed concerns about environmental sustainability and maintaining a healthy home environment.

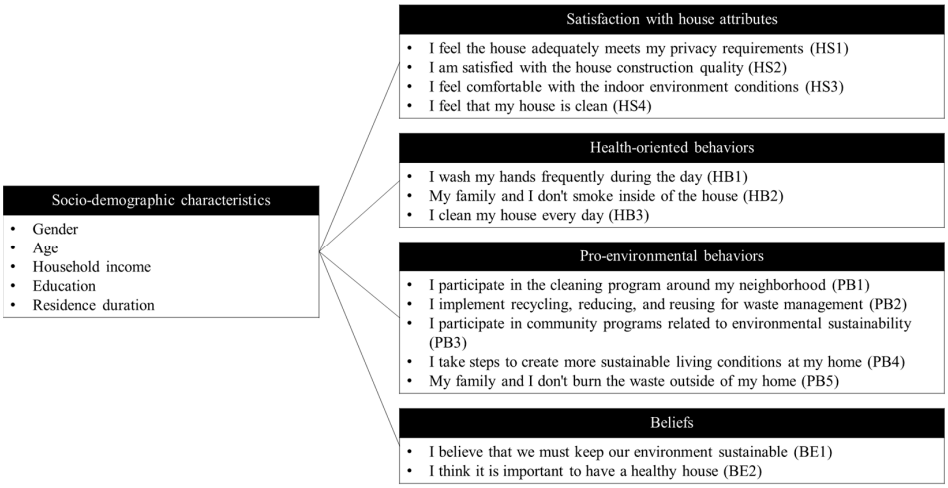


Figure 1. Information gathered from the questionnaire survey.

2.2. Selection of Target Area and Recruitment of Survey Participants

Having established the questionnaire framework, the next step involved selecting neighborhoods significantly impacted by slum upgrading projects for the survey. This study focuses on areas targeted by the KIP, implemented between 2016 and 2022. The KIP aimed to achieve three primary goals: 100% access to drinking water, elimination of slum areas, and 100% access to proper sanitation [38]. A key feature of the program is its participatory approach, which actively engaged community members in identifying local needs and prioritizing improvement efforts [39,40]. Through this approach, residents were directly involved in decisions on housing construction, road access, and development of semi-public space essential components for enhancing environmental and social resilience in these neighborhoods [41].

This cross-sectional study, conducted in Surakarta City, Central Java, Indonesia, focuses on three key districts that recently underwent development under the KIP initiative, as illustrated in Figure 2. We used purposive sampling to recruit participants from households in the selected districts with slum upgrades. In Kampung Metal Mojo (District M) established in November 2022, we surveyed 194 residents. Kampung HP 00001 (District H), built in December 2021, had 35 participants; Kampung Tipes (District T), constructed in January 2022, had 98 [28].

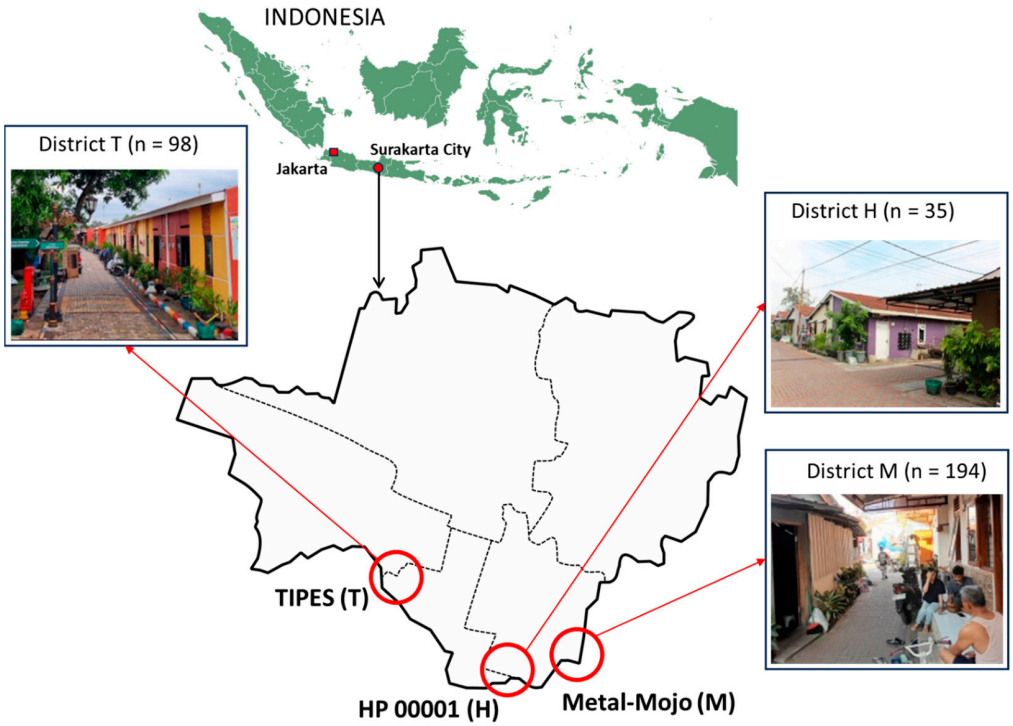


Figure 2. Target site the questionnaire survey conducted in Surakarta City.

3. Results

3.1. Questionnaire Survey Results

Table 1 depicts the demographic profiles of the respondents who participated in the questionnaire survey. The respondents were selected using purposive sampling, targeting residents from upgraded slum areas who had experienced direct impacts from recent urban renewal programs under KIP. The regional data column shows corresponding demographic information from Surakarta City in 2023 for comparison [42]. The survey found that 34.5% of the respondents were male, while 65.5% were female. Compared to the regional data, where the gender ratio is nearly equal, the proportion of female respondents is higher. With regard to age distribution, the percentage of respondents in the older age groups (45 and

above) is higher than the city's data. This is consistent with previous urban community-based surveys in Indonesia and other contexts, where women and older age groups are more likely to be present at home during survey visits and more responsive to household- and environment-related questions [43]. Furthermore, 53% of the respondents are low-income, earning below the regional wage level, approximately 10% higher than the regional average, while the proportion of earnings above the regional level is 3%, which is 10% lower than the regional data. In terms of education, the percentage of university graduates (3.4%) is lower than the city's average of 7.1%, showing lower educational attainment in the surveyed area. Additionally, the duration of respondents' residency in Surakarta City highlights that a substantial proportion of the respondents (40.4%) have lived in Surakarta for 15–35 years, while 32.1% have lived there for over 35 years, suggesting that most of the respondents are long-term residents in the surveyed area.

Table 1. Demographic profiles of the respondents being eligible for data analysis (total n = 327).

Respondent Profiles	Sample Number (%)	Regional Data (%)
Gender		
Male	113 (34.5%)	49.1%
Female	214 (65.5%)	50.9%
Age		
21–45 years old	127 (38.8%)	37.4%
45–60 years old	140 (42.8%)	20.0%
≥60 years old	60 (18.4%)	14.2%
Income		
<regional standard wage	173 (53.0%)	42.7%
=regional standard wage	144 (44.0%)	44.8%
>regional standard wage	10 (3.0%)	12.5%
Education		
No school	53 (16.2%)	15.1%
Elementary school	38 (11.6%)	20.2%
Middle school	71 (21.7%)	23.1%
High school	154 (47.1%)	34.5%
University	11 (3.4%)	7.1%
Years living in Surakarta City		
<5 years	31 (9.5%)	n/a
5–15 years	59 (18.0%)	n/a
15–35 years	132 (40.4%)	n/a
>35 years	105 (32.1%)	n/a

Figure 3 illustrates a detailed breakdown of respondents' perceptions and behaviors across four key domains (satisfaction with house attributes, health-oriented behaviors, pro-environmental behaviors, and beliefs). The data are based on responses from three different districts: District H (N = 35), District M (N = 194), and District T (N = 98). In the "Satisfaction with house attributes" domain, notable differences are observed across three districts for four categories: privacy (HS1), construction quality (HS2), indoor environment comfort (HS3), and cleanliness (HS4). For instance, 60% of respondents from District H reported that their houses meet their privacy needs (HS1), compared to 59.5% in District M and 84.5% in District T. In contrast, responses regarding indoor environment satisfaction (HS3) and cleanliness s (HS4) were predominantly neutral across all districts. District H recorded the highest dissatisfaction, with 25.7% of respondents expressing negative perceptions about their indoor environment (HS3). Cleanliness is also a concern, especially in District H (11.4%) and M (13.3%), where respondents expressed disagreement about the

cleanliness of their homes (HS4). These results highlight a persistent challenge in achieving comfortable and clean living in all three districts.

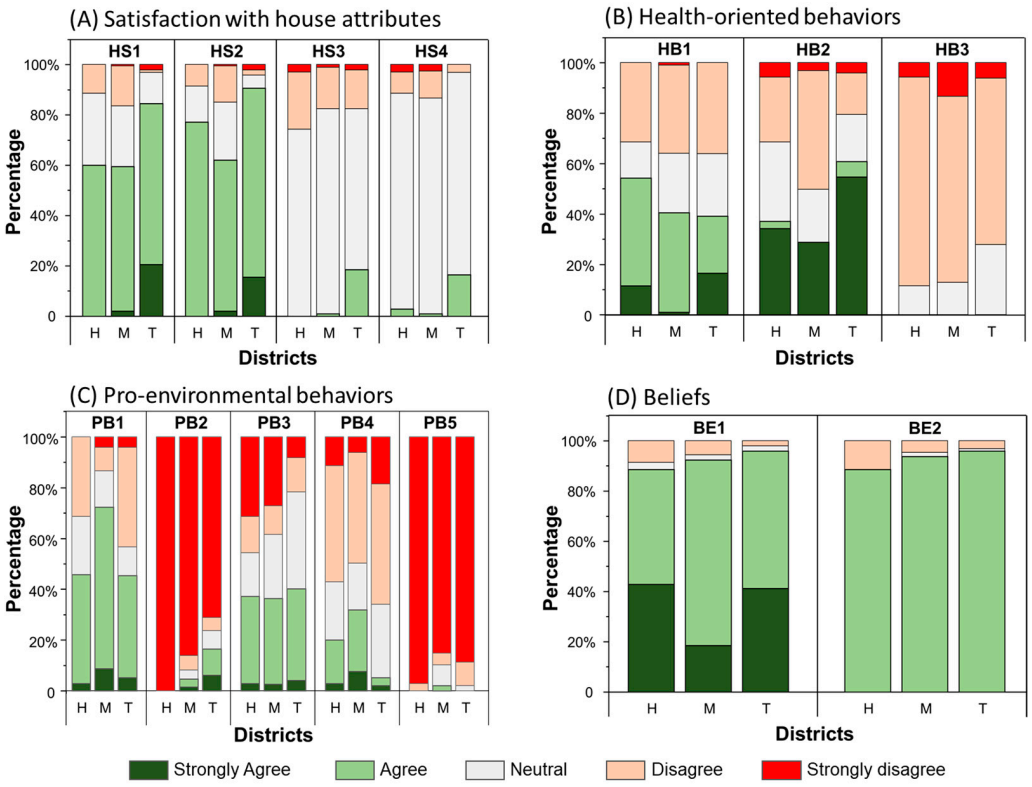


Figure 3. Percentages of responses across the four domains based on respondents' answers from District H (n = 35), District M (n = 194), and District T (n = 98).

In the "Health-oriented behaviors" domain, District T showed the strongest positive responses, with 60.8% of respondents agreeing that they avoid smoking indoors (HB2). In contrast District M recorded 50.2% disagreement on this behavior. Meanwhile, daily house cleaning (HB3) was the least practiced health-oriented behavior across all observed districts. In the "Pro-environmental behaviors" domain, District M showed the highest level of neighborhood cleaning participation (PB1), with 72.3% of respondents agreeing. In comparison, Districts H and T reported much lower participation rates, at 45.7% and 45.4%, respectively. The habit of reuse, reduce, and recycle (PB2) was particularly low across all districts, with District H reporting 100% disagreement, followed by District M (91.8%) and District T (76.3%). Similarly, waste burning avoidance (PB5) was minimal across all districts, with 85.1% to 97.1% of respondents strongly agreeing that they burn waste outside. In the "Beliefs" domain, all districts showed high levels of agreement on the importance of maintaining environmental sustainability (BE1) and a healthy home (BE2). District T had the strongest agreement, with 95.9% of residents highlighting the importance of these beliefs, while Districts H and M demonstrated slightly lower levels of agreement.

Additionally, Table 2 shows the questionnaire results on respondents' satisfaction with house attributes, health-oriented behaviors, pro-environmental behaviors, and beliefs, using a Likert scale from 1 (Strongly disagree) to 5 (Strongly agree). Respondents showed moderate satisfaction with house privacy (HS1: 3.62 ± 0.82) and construction quality (HS2: 3.67 ± 0.77), though comfort with indoor environmental conditions (HS3: 2.86 ± 0.52) was rated lower. Notably, strong beliefs in environmental sustainability (BE1: 4.16 ± 0.68) and the importance of a healthy home (BE2: 3.89 ± 0.44) were observed, suggesting most respondents value sustainability but may struggle with consistent behavioral applications.

Table 2. Mean and standard deviation (SD) for the questionnaire domains with corresponding Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree).

Domain	Code	Mean ± SD
Satisfaction with house attributes		
I feel the house adequately meets my privacy requirements	HS1	3.62 ± 0.82
I am satisfied with the house construction quality	HS2	3.67 ± 0.77
I feel comfortable with the indoor environment conditions	HS3	2.86 ± 0.52
I feel that my house is clean	HS4	3.94 ± 0.46
Health-oriented behaviors		
I wash my hands frequently during the day	HB1	3.12 ± 0.98
My family and I don't smoke inside of the house	HB2	3.33 ± 1.38
I clean my house every day	HB3	2.06 ± 0.52
Pro-environmental behaviors		
I participate in the cleaning program around my neighborhood	PB1	3.40 ± 1.01
I implement recycling, reducing, and reusing (3Rs) for waste management	PB2	1.39 ± 0.98
I participate in community programs related to environmental sustainability	PB3	2.85 ± 1.20
I take steps to create more sustainable living conditions at my home	PB4	2.64 ± 1.07
My family and I don't burn the waste outside of my home	PB5	1.21 ± 0.59
Beliefs		
I believe that we must keep our environment sustainable	BE1	4.16 ± 0.68
I think it is important to have a healthy house	BE2	3.89 ± 0.44

To better understand the satisfaction and belief scores, we analyzed demographic characteristics to identify patterns and statistical significance. Table 3 presents the ANOVA results for the four domains, focusing on key demographic characteristics that exhibit statistical significance. The result reveal that females reported slightly higher satisfaction with house attributes (3.53 ± 0.43) and pro-environmental behaviors (2.76 ± 0.49) compared to males. Respondents aged 45–60 showed the highest scores in health-oriented behaviors (2.87 ± 0.56), while those aged 21–45 reported lower scores in pro-environmental behavior (2.26 ± 0.43).

Table 3. Mean, standard deviation (SD), and significant difference using ANOVA among the four domains based on key salient demographic characteristics of the respondents.

Respondent's Profiles	Satisfaction with House Attributes	Health-Oriented Behaviors	Pro-Environmental Behavior	Beliefs	Significant Difference (*p*-Value)
Gender					
Male	3.50 ± 0.50	2.86 ± 0.58	2.33 ± 0.45	3.99 ± 0.58	<0.05
Female	3.53 ± 0.43	2.83 ± 0.59	2.76 ± 0.49	4.04 ± 0.48	<0.05
Age					
21–45 years old	3.52 ± 0.41	2.81 ± 0.59	2.26 ± 0.43	4.01 ± 0.54	<0.05
45–60 years old	3.52 ± 0.50	2.87 ± 0.56	2.32 ± 0.49	4.06 ± 0.47	<0.05
≥60 years old	3.54 ± 0.41	2.81 ± 0.63	2.28 ± 0.49	3.96 ± 0.57	<0.05
Income					
<regional standard wage	3.53 ± 0.50	2.87 ± 0.61	2.30 ± 0.49	4.01 ± 0.58	<0.05
=regional standard wage	3.52 ± 0.40	2.81 ± 0.56	2.28 ± 0.46	4.03 ± 0.44	<0.05
>regional standard wage	3.35 ± 0.37	2.63 ± 0.50	2.50 ± 0.37	4.10 ± 0.20	<0.05
Education					
No school	3.64 ± 0.21	2.80 ± 0.59	2.21 ± 0.43	3.86 ± 0.68	<0.05
Elementary school	3.61 ± 0.27	2.80 ± 0.57	2.24 ± 0.36	3.78 ± 0.69	<0.05
Middle school	3.59 ± 0.41	2.83 ± 0.58	2.27 ± 0.44	4.04 ± 0.47	<0.05
High school	3.41 ± 0.55	2.89 ± 0.59	2.34 ± 0.52	4.17 ± 0.35	<0.05
University	2.91 ± 0.51	2.76 ± 0.68	2.61 ± 0.72	4.21 ± 0.24	<0.05
Years living in Surakarta City					
<5 years	3.65 ± 0.55	2.61 ± 0.53	2.57 ± 0.54	4.06 ± 0.49	<0.05
5–15 years	3.63 ± 0.46	2.98 ± 0.69	2.24 ± 0.46	4.03 ± 0.58	<0.05
15–35 years	3.44 ± 0.46	2.84 ± 0.53	2.30 ± 0.47	4.04 ± 0.47	<0.05
>35 years	3.53 ± 0.40	2.83 ± 0.59	2.23 ± 0.44	3.99 ± 0.54	<0.05

Income levels also influenced satisfaction and belief scores. Respondents earning at or near the regional standard wage reported higher satisfaction (4.03 ± 0.44) and belief scores (3.53 ± 0.40). In contrast, those earning above the standard wage demonstrated the highest pro-environmental behavior (2.50 ± 0.37). Educational attainment also played a role: university graduates recorded the highest belief scores (4.21 ± 0.24) but reported lower satisfaction with house attributes (2.91 ± 0.51). Lastly, the length of residence in Surakarta City had a notable impact. Respondents who had lived in the city for 5–15 years exhibited the highest health-oriented behaviors (2.98 ± 0.69), whereas those residing in the city for over 35 years scored slightly lower in pro-environmental behaviors (2.23 ± 0.44).

3.2. Cluster Analysis Results

3.2.1. Number of Clusters

A cluster analysis was conducted using the silhouette method to identify distinct groups in terms of behaviors and health-oriented mindsets among the respondents. In this approach, individuals with similar characteristics are grouped together, ensuring that each cluster is unique while its members share common traits [44,45]. The total fourteen attributes from the domains of "Satisfaction with house", "Health-oriented behaviors", "Pro-environmental behaviors", and "Beliefs" were used to determine similarity between respondents in the cluster analysis. Furthermore, since the silhouette score ranges from −1 to 1, higher values indicate better-defined clusters. A score close to 1 suggests that objects within a cluster are well-matched to their own cluster and poorly matched to neighboring clusters. In contrast, a score close to −1 indicates potential misclassification. In this study, we determined that 4 clusters were optimal. According to Kaufman and Rousseeuw (1990), a silhouette score above 0.2 is generally considered acceptable, meaning that the clusters are well-defined [46]. Therefore, a score of 0.204 in this study, as shown in Figure 4A, suggests that the clusters are reasonably distinct from one another, indicating an acceptable quality of clustering. Furthermore, Figure 4B illustrates the distribution of data points across the four clusters, with each cluster represented by a distinct color and shape. The cluster sizes varied across the four groups: Cluster 1 included 76 people, Cluster 2 had 19, Cluster 3 comprised 153, and Cluster 4 contained 79. The boundaries around the clusters indicate that the groups are separated based on their dimensions (Dim1 = 22.1%, Dim2 = 14.7%), confirming the clustering approach and reinforcing the silhouette score's validity.

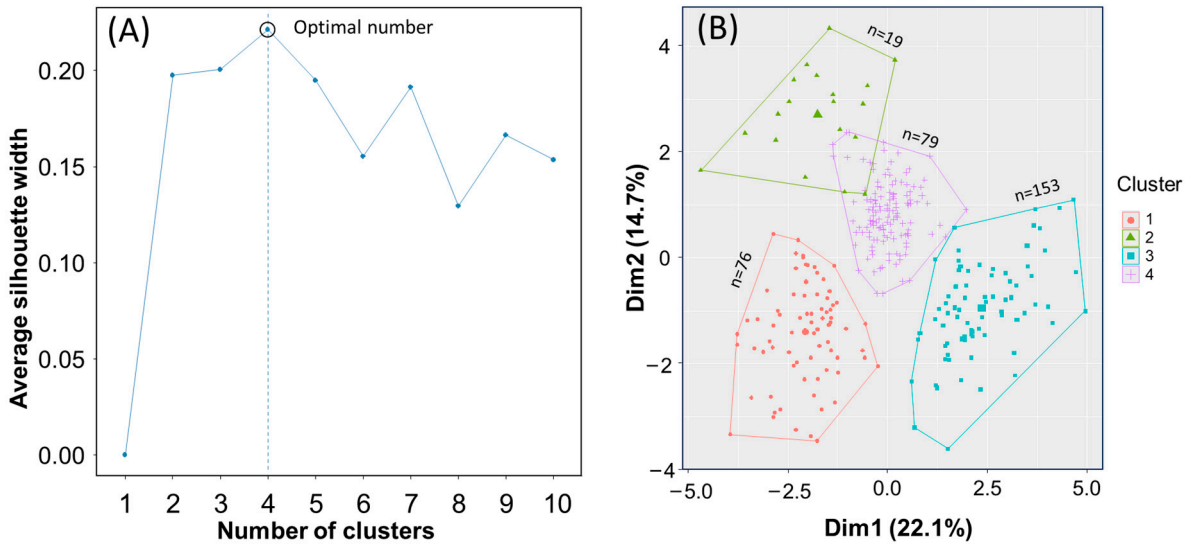


Figure 4. (**A**) Clustering diagram analysis and (**B**) the optimal number of clusters based on the Silhouette method.

3.2.2. Cluster Characteristics

To better understand the variations in behaviors and attitudes across the identified clusters, the normalized z-scores for the four key domains were analyzed. Figure 5 depicts the normalized z-scores of the observed domains from each cluster, visualizing how different clusters vary across four key domains: satisfaction with house attributes, health-oriented behaviors, pro-environmental behaviors, and beliefs. In terms of satisfaction with the house domain, including privacy (HS1), construction quality (HS2), indoor environmental conditions (HS3), and cleanliness (HS4). Cluster 4 shows the highest satisfaction in all attributes, especially for cleanliness (HS4), while Clusters 1 and 2 generally show lower satisfaction. For the health-oriented behaviors domain, Cluster 1 shows relatively higher engagement in handwashing and avoiding smoking indoors but lower scores in daily cleaning (HB3), while Clusters 3 and 4 show overall lower health-oriented behaviors. In the context of pro-environmental behaviors across the clusters, including neighborhood cleaning (PB1), waste management (PB2), community involvement (PB3), sustainable living styles (PB4), and waste-burning avoidance (PB5). Cluster 1 excels in pro-environmental behaviors, especially PB1 and PB3, while Cluster 4 has the lowest z-scores across most behaviors, indicating weaker pro-environmental engagement. Lastly, for the beliefs domain, Cluster 2 shows low scores in BE1 and a slight decline in BE2, while Cluster 4 demonstrates strong positive beliefs in both categories.

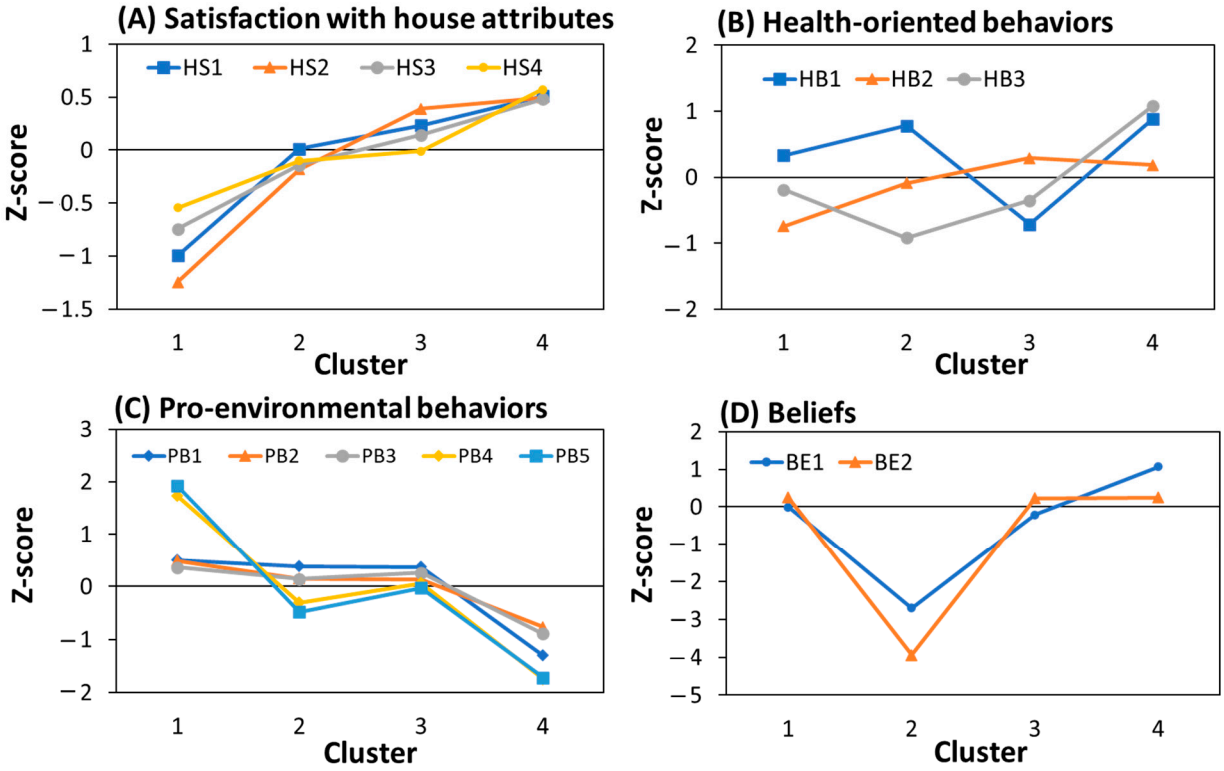


Figure 5. Normalized value using z-score of the observed domains from each cluster.

3.2.3. Cluster Demographic Typologies

Table 4 presents four distinct clusters of respondents based on key demographic characteristics such as gender, age, income, educational level, and years living in Surakarta. Cluster 1, labeled "House-discontented with environmentally proactive" (n = 76), includes a higher proportion of males (39.5%) compared to females (60.5%). This contrasts with the overall sample, where males make up 34.5% and females account for 65.5%. Most individuals in this cluster are dissatisfied with their living conditions but emphasize proactive environmental efforts and hold a strong belief in sustainability.

Table 4. Composition of the four clusters by key demographic characteristics of respondents.

Respondent's Profiles	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Gender				
Male	30 (39.5%)	8 (42.1%)	50 (32.7%)	25 (31.6%)
Female	46 (60.5%)	11 (57.9%)	103 (67.3%)	54 (68.4%)
Age				
21–45 years old	27 (35.5%)	4 (21.1%)	64 (41.8%)	32 (40.5%)
45–60 years old	34 (44.7%)	4 (21.1%)	67 (43.8%)	35 (44.3%)
≥60 years old	15 (19.7%)	11 (57.9%)	22 (14.4%)	12 (15.2%)
Income				
<regional standard wage	40 (52.6%)	13 (68.4%)	82 (53.6%)	38 (48.1%)
=regional standard wage	33 (43.4%)	5 (26.3%)	66 (43.1%)	40 (50.6%)
>regional standard wage	3 (3.9%)	1 (5.3%)	5 (3.3%)	1 (1.3%)
Education				
No school	10 (13.2%)	7 (36.8%)	23 (15.0%)	14 (17.7%)
Elementary school	10 (13.2%)	6 (31.6%)	13 (8.5%)	9 (11.4%)
Middle school	17 (22.4%)	1 (5.3%)	33 (21.6%)	20 (25.3%)
High school	36 (47.4%)	5 (26.3%)	79 (51.6%)	33 (41.8%)
University	3 (3.9%)	0 (0%)	5 (3.3%)	3 (3.8%)
Years living in Surakarta City				
<5 years	11 (14.5%)	0 (0%)	17 (11.1%)	3 (3.8%)
5–15 years	12 (15.8%)	2 (10.5%)	32 (20.9%)	13 (16.5%)
15–35 years	28 (36.8%)	7 (36.8%)	64 (41.8%)	33 (41.8%)
>35 years	25 (32.9%)	10 (52.6%)	40 (26.1%)	30 (38.0%)

Cluster 2, labeled "Health-focused and house-satisfied with low sustainability awareness" (n = 19), is predominantly composed of elderly people (>60 years), who represent 57.9% of the cluster compared to just 18.4% in the overall sample. Additionally, 52.6% of members in this cluster have lived in Surakarta for over 35 years, whereas this proportion is only 32.1% in the overall sample. A significant number of individuals in this group (36.8%) have no formal education, compared to 16.2% in the overall sample. This suggests that Cluster 2 predominantly comprises older, long-term residents with lower educational attainment. While this group is satisfied with their housing and demonstrates strong health-oriented behaviors, they are less focused on environmental sustainability and waste management efforts, despite being actively involved in the community.

Cluster 3, labeled "House-satisfied with low focus on health awareness and moderate sustainability beliefs" (n = 153), is the largest cluster and features a slightly higher proportion of females (67.3%) compared to the overall sample (65.5%). It also has a greater percentage of younger individuals aged 21–45 years (41.8%) compared to 38.8% in the total sample. Members of this cluster are highly satisfied with their homes and moderately engaged in sustainability efforts, but they place less emphasis on health-oriented behaviors.

Finally, Cluster 4, labeled "Sustainability belief-driven people with less environmental efforts" (n = 79), has a higher proportion of individuals earning the standard regional income (50.6%) compared to overall sample (44.8%). This cluster is characterized by high satisfaction with housing and a strong commitment to sustainability beliefs, yet members are less active in practicing personal pro-environmental actions.

3.2.4. Spearman Rank Correlation Across Clusters

Based on the Spearman rank test results shown in Figure 6, this study identified key correlations across clusters. In Cluster 1, a strong negative correlation was found between sustainable living practices (PB4) and satisfaction with house construction quality (HS2). Conversely, PB4 and neighborhood cleaning participation (PB1) showed a positive correlation, indicating that individuals practicing sustainability are more likely to engage in community cleaning efforts.

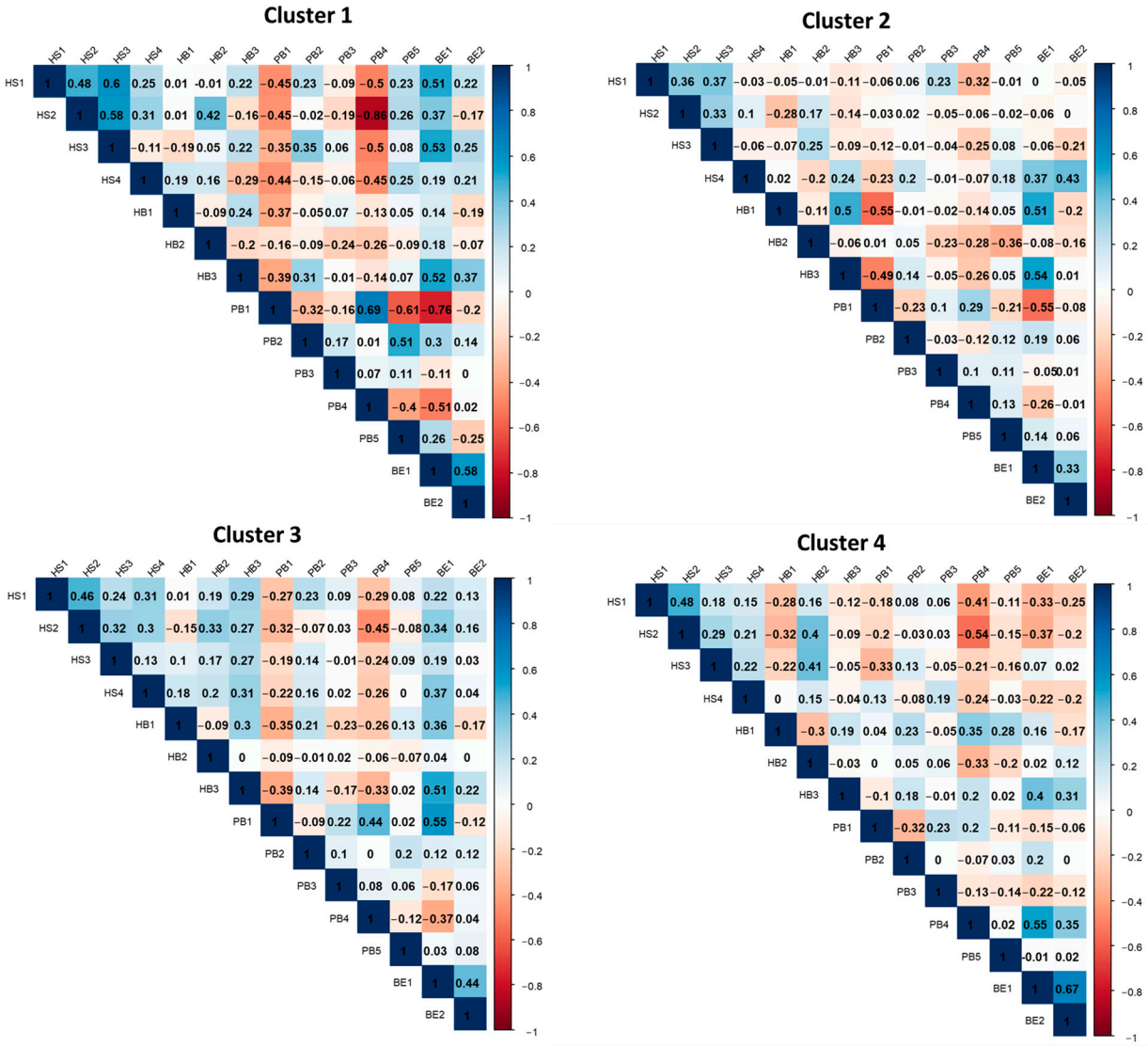


Figure 6. Spearman correlation analysis of the items from each domain across all clusters.

For Cluster 2, a strong negative correlation was observed between handwashing frequency (HB1) and neighborhood cleaning participation (PB1), suggesting that health-oriented behaviors are not always linked to environmental engagement. Additionally, daily house cleaning (HB3) and belief in environmental sustainability (BE1) demonstrated a strong positive correlation, indicating that healthier habits align with stronger sustainability beliefs.

In Cluster 3, neighborhood cleaning participation (PB1) had a strong positive correlation with belief in environmental sustainability (BE1), suggesting that active involvement in community cleaning reflects stronger environmental beliefs. For Cluster 4, belief in environmental sustainability (BE1) positively correlated with belief in the importance of a healthy home (BE2), emphasizing a link between sustainability and health-focused attitudes. However, a negative correlation was noted between satisfaction with house construction quality (HS2) and sustainable living practices (PB4), implying that greater engagement in sustainability practices corresponds to lower satisfaction with house construction quality.

4. Discussion and Recommendations

4.1. Reflection of Survey Outcomes

The survey results reveal a complex picture of environmental awareness and behavioral gaps among residents in Surakarta, highlighting a significant discrepancy between

general environmental understanding and specific actions, particularly in waste management practices. While respondents demonstrate strong awareness of environmental sustainability, there is a clear reluctance to abandon waste-burning practices and a lack of commitment to reduce, reuse, and recycle (3R). This issue is further contextualized by data from the Surakarta City government in 2022, which reported that household waste accounts for 58% of the city's total annual waste volume of 336,764 tons [42]. Despite this high volume, the city's waste management system remains underdeveloped, relying on limited recycling facilities and a single landfill in the Putri Cempo District [47–49]. The challenges faced by Surakarta align with findings from other urban slums worldwide, where high population density, limited resources, and logistical barriers hinder effective waste management practices. For instance, the challenges faced in Rio de Janeiro's Rocinha favela exemplify how narrow streets, dense populations, and resource constraints hinder waste management efforts, often requiring decentralized approaches for more efficient handling [50]. In addition, similar challenges are observed in Indian cities, where rapid urbanization, inadequate infrastructure, and financial limitations burden waste management, highlighting a common need for innovative and sustainable practices [51].

Moreover, the cultural and social context of Surakarta plays a significant role in perpetuating these waste-related behaviors. Studies by Suryo et al. (2017) and Rezagama et al. (2018) support this observation, noting that although residents acknowledge the importance of environmental conservation, deeply ingrained habits such as waste burning and minimal recycling persist [52,53]. This suggests that awareness alone is insufficient to drive behavioral change, especially in communities constrained by infrastructural limitations and entrenched cultural practices. A historical perspective further illustrates this challenge. Before the implementation of the Kampung Improvement Program (KIP), urban slums in Surakarta lacked a proper waste management system, which contributed to significant cleanliness and waste-related challenges. However, with KIP, infrastructure has improved considerably, providing better waste disposal systems and fostering cleaner environments. Accordingly, the findings of this study underscore the need for approaches that extend beyond mere infrastructure improvements to also address socio-cultural behaviors.

Interestingly, the findings indicate relatively high participation in neighborhood cleaning activities, suggesting that while residents may face challenges in adopting broader waste management practices, they are willing to engage in localized efforts to maintain cleanliness within their house surroundings. This willingness to participate in neighborhood cleaning may reflect a sense of community responsibility or a shared interest in preserving a livable environment, especially in visible communal spaces. In such cases, neighborhood cleaning could serve as a social activity that strengthens community bonds while addressing immediate cleanliness concerns. However, the survey further reveals low daily cleaning habits in homes, posing health risks from waste accumulation and unsanitary conditions that attract pests and pathogens. Irregular home cleaning worsens sanitation issues, heightening the risk of diseases in dense urban slums, where poor waste management fosters disease transmission [24,54]. This may reverse prior improvements, leaving neighborhoods vulnerable to deteriorating back into slum-like conditions [55,56]. Without consistent cleaning and sustainable waste management practices, the environment can deteriorate rapidly, potentially turning newly constructed districts into slum-like areas. This cycle of neglect and degradation threatens to undermine the positive impacts of Surakarta's urban improvement programs, creating a feedback loop in which improved areas quickly revert to poor conditions.

4.2. Potential Policy Recommendations for Each Cluster

Targeted policy recommendations are essential to address the unique needs and challenges of each group. By tailoring approaches to specific demographics, it becomes possible to foster sustainable practices in ways that resonate with each group's lifestyle and values. Accordingly, Figure 7 provides an overview of these targeted policy recommendations, offering a visual breakdown of strategies designed to support each group in contributing to a more sustainable and resilient community.

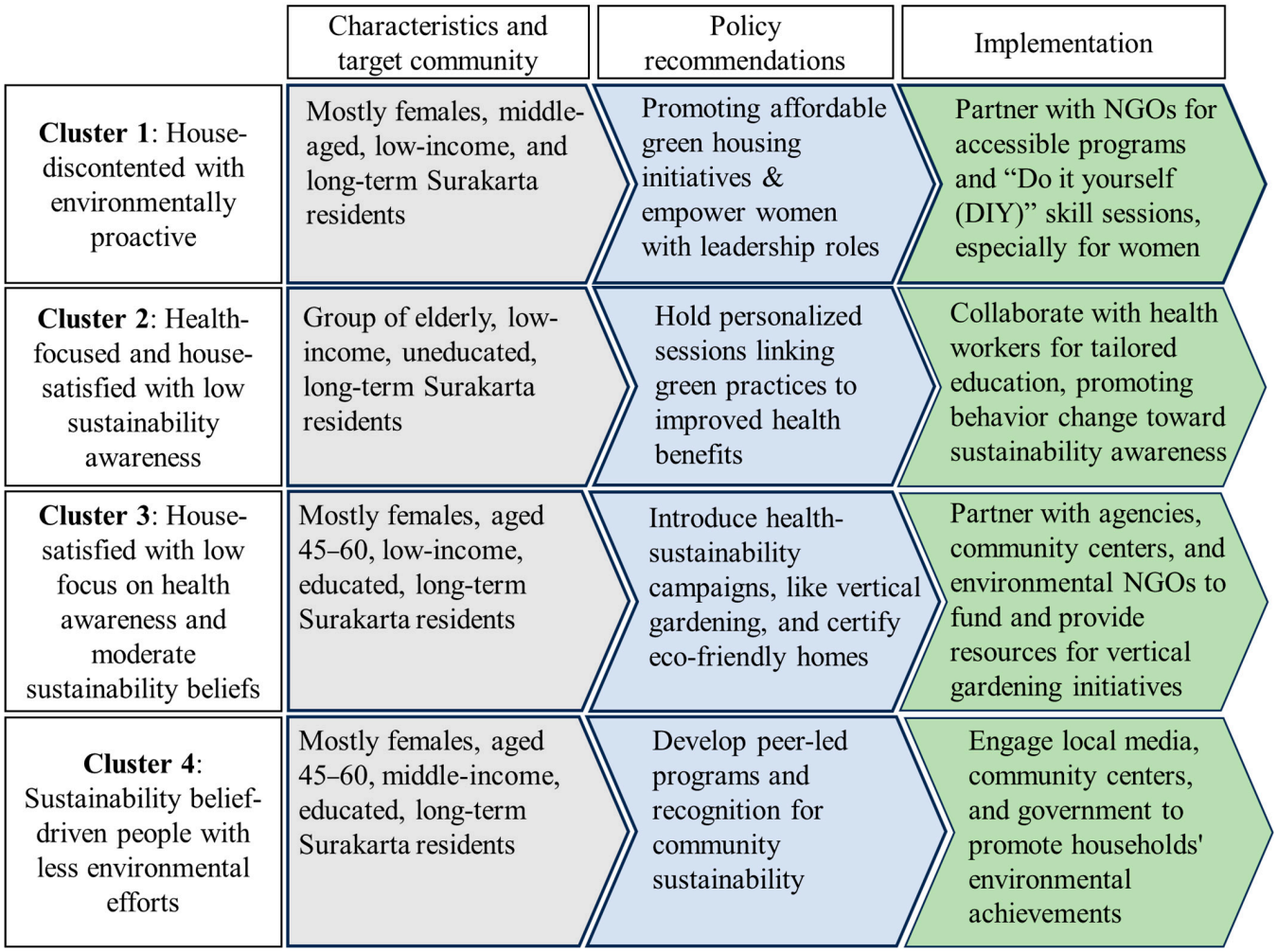


Figure 7. Policy recommendations and implementation for each of the four clusters.

Regarding Cluster 1, labeled "House-discontented with environmentally proactive", despite dissatisfaction with their housing conditions, this group of residents displays a proactive attitude toward environmental issues, suggesting a strong willingness to engage in sustainable practices if provided with the necessary resources and support. To leverage this environmental enthusiasm, policies could focus on affordable green housing programs that address both housing quality and environmental sustainability. Subsidized workshops, accessible green materials, and educational programs could empower these individuals to enhance their housing conditions while adopting eco-friendly practices. Additionally, creating leadership roles for women in local environmental organizations or community groups would allow them to actively promote environmental change within their community. These initiatives require partnerships with government, NGOs, and community groups to make green housing resources accessible and support community-led initiatives for sustainable development, positioning them as strategic green niches

with the potential to influence wider transformation in mainstream society [57,58]. To further empower residents, "Do it yourself" (DIY) skill sessions on affordable green home improvements could enable them to take immediate, practical steps [59]. Additionally, targeted training programs, especially for women, could deepen this cluster's engagement by building leadership skills and covering sustainable practices like waste management and energy-saving techniques. These programs are expected to equip participants with advocacy skills to support community-wide change, positioning the residents as a model for broader environmental initiatives.

Cluster 2, identified as "Health-focused and house-satisfied with low sustainability awareness", mainly includes older individuals satisfied with their housing but with limited awareness of sustainability practices. However, their focus on health behaviors presents an opportunity to link environmental benefits to personal health improvements. To engage this group, policies should emphasize personalized health and sustainability awareness sessions that connect the health benefits of green practices with sustainable behaviors [60]. For instance, programs could demonstrate how cleaner air from improved cookstoves can promote better respiratory health, while health-focused education on the environmental impact of waste reduction can increase awareness of how their actions affect broader environmental goals. According to Patrick et al. (2011), community health workers are essential in delivering these educational sessions, which could be held one-on-one or in small groups to address specific needs effectively [61]. Moreover, tailoring communication to emphasize the health benefits of green practices can help engage this group's primary concerns, promoting gradual behavior change [62]. This group may also benefit from demonstration sessions on sustainable practices, such as composting or waste reduction, which could be tied to tangible health improvements, reinforcing the link between personal well-being and environmental sustainability.

For Cluster 3, characterized as "House-satisfied with low focus on health awareness and moderate sustainability beliefs", expresses satisfaction with their housing but shows limited engagement in health-oriented behaviors and only moderate beliefs in sustainability. To address their needs, policies could integrate health promotion with sustainability efforts to make environmental practices more relevant to them. For instance, initiatives such as vertical gardening or green space development can simultaneously promote physical activity and sustainability [63]. Collaborating with community centers, agencies, and environmental NGOs can provide essential resources for vertical gardening, including seeds, training, and space for small community gardens. Implementing a sustainability certification program for households, with rewards for families adopting eco-friendly practices, could further motivate residents to engage in sustainable actions [64]. Partnering with local government or utility companies to certify households that meet specific sustainability criteria (e.g., energy-efficient lighting or water-saving appliances) would also reinforce sustainable practices. Certified households could receive recognition or small incentives, fostering a sense of accomplishment and encouraging further environmental action within the community.

Lastly, Cluster 4, described as "Sustainability belief-driven with low environmental efforts", includes individuals with strong sustainability beliefs but low engagement in pro-environmental actions. To bridge the gap between beliefs and actions, policies could establish peer-led environmental programs where community members, particularly women leaders, guide sustainable practices, as previous studies have shown that peer-led initiatives can foster strong community bonds and increase commitment to sustainable behaviors [65,66]. These programs could cover topics like composting, waste reduction, and eco-friendly practices to develop community action projects that encourage collective participation [67,68]. Additionally, creating small community groups or environmental

committees would enable this group to meet regularly, share progress, and receive support as they adopt sustainable lifestyle changes, fostering accountability and a network of like-minded individuals. Furthermore, a public recognition program could honor households or individuals who demonstrate measurable sustainability improvements [69], fostering active engagement in eco-friendly practices. For instance, partnerships with local media, community centers, and government offices would help publicize these achievements, providing positive reinforcement and highlighting the impact of their environmental contributions. By making these sustainable actions visible and celebrated, these initiatives have the potential to inspire broader community involvement in sustainability efforts [70].

5. Conclusions

This study highlights the significance of urban slum housing improvement programs, specifically the KIP initiative in Surakarta City, Indonesia, in promoting pro-environmental behaviors and health-oriented mindsets among residents. The research identifies variations in community responses to slum upgrading efforts, focusing on residents' house satisfaction, health-oriented behaviors, pro-environmental actions, and sustainability beliefs. By employing cluster analysis, the study outlines distinct demographic and behavioral typologies, which reveal how different subgroups within slum communities engage with environmental sustainability and health practices. This approach enables a nuanced understanding of how socio-economic and cultural factors influence attitudes and actions toward environmental sustainability within urban slums.

The findings underscore that while infrastructure improvements are essential, the success of slum housing improvement programs is significantly enhanced through active community involvement in decision-making and priority-setting. The KIP's participatory framework allowed residents to take ownership of local improvements, fostering a community-oriented approach to sustainability. However, the study also reveals gaps between residents' sustainability beliefs and their actual behaviors, particularly in waste management and recycling practices, which remain challenging due to limited resources and ingrained cultural habits. Addressing these behavioral gaps requires targeted interventions that go beyond infrastructure to include behavioral support and practical guidance.

Nevertheless, this study has several limitations that must be acknowledged. Firstly, the cross-sectional design limits the ability to observe changes in behaviors and mindsets over time, making it difficult to assess the long-term impact of the KIP in Surakarta City. Secondly, the reliance on self-reported data may introduce biases, as participants might overstate positive behaviors or underreport negative ones. Finally, the study's focus on specific districts within Surakarta City limits the generalizability of the findings to other urban slum contexts, where different socio-economic and cultural factors may influence outcomes.

Future studies could explore the integration of educational interventions targeting specific environmental behaviors, such as recycling and sustainable waste management, to address the behavioral gaps identified. Developing community-led workshops and peer-led initiatives can encourage residents to adopt and sustain pro-environmental behaviors that align with their existing beliefs. Additionally, longitudinal studies are recommended to assess the lasting impacts of slum upgrading programs on residents' behaviors and attitudes over time, offering valuable insights into the sustainability of these interventions. To enhance generalizability, future research could extend this approach to other urban slum areas across Indonesia and beyond, taking into account diverse cultural and socio-economic conditions. Comparative studies would provide policymakers with insights into context-specific strategies that may improve the effectiveness of slum upgrading programs. Finally, involving local government and non-governmental organizations in collaborative

research could lead to more practical and locally adaptable solutions, helping bridge the gap between residents' sustainability beliefs and their actual practices. By pursuing these recommendations, future studies can contribute to more resilient and sustainable urban slum communities.

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Institutional Review Board Statement: We confirm that all procedures involving human participants were conducted in accordance with national and international ethical standards. Prior to data collection, ethical approval for the study was obtained from the Ethical Committee of Kyushu University, Japan, ensuring compliance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Statement: All participants were fully informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without consequence.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon request.

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