Outlining Smart Kampung Indicators: Preference Study in Kampung Terban Yogyakarta

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Abstract. Kampung, as a form of Indonesia’s informal urbanism, requires special attention in terms of urban development. Efforts to manage the quality of kampung space have become very important, including planning and development through smart system applications. However, the culture of the community living in kampung in accepting a new system has not been well-mapped. This research aimed to be the beginning of the development of smart kampung system that focuses on identifying the community’s preferences for the concept of this novel system. The research was conducted by a case study in Terban Subdistrict, Gondokusuman, Yogyakarta using Analytical Hierarchy Process methods. Initial findings indicate that Terban community’s preference for the concept of kampung is based on the concept of providing alternative energy and water quality. The research also shows that of smart city projects in the future should include community participation to ensure its applicability, acceptance, and sustainability.

1. Introduction
Informal settlements such as Indonesian kampung generally are residual zones that result from rapid urbanization which causes complex problems. Pejorative notions such as dysfunctional urban form or disjointed urbanization create kampungs and their residents as issues to be corrected by the middle, elite and ruling class, and are essentially sidelined in the decision-making process. Formalizing the informal without exploring people-driven capability to change will perpetuate non-contextual practices [1]. Studies show that development in fast-growing cities in the world today, which grow toward the less formal, fails to incorporate advanced knowledge or seize opportunities for leap-frogging solutions. Bettencourt argued that from the formal processes of spatial design planning and development may be enriched by new data and methods of analysis that can fulfill aspirations to create open-ended complex systems with inherently good design which has emerged gradually in the history through bottom-up, even informal, processes [2]. The smart city discourse is indeed pervasive across many areas of urban policy, but local contextualization is critical key [3].

However, discussion on whether smart city projects are marketing gimmicks or have real impact is not a new renaissance [4], or top-down perspective that is seeking democratizing ground through commons-oriented approach [5], and continuously seen as a theory and practice engaging with a complex adaptive urban system which continuously operates on its potential [6]. Smart city policies have also been facing the more problematic who are the actually existing 'smart citizen' or actual denizens who remain largely excluded from such decision and policy-making processes of the city [7]. The praxis of smart city itself, tends to be categorized as three variegated logics: (a) the city portrayed as technological simulacrum, (b) the focus on specific sectoral activities, and (c) a chameleonic tendency
to envelop previous eco-urban agendas into smart urbanism. Those three logics open a new critical space for alternative future pathways of smart city trajectories [8].

From the above narrative, we have seen the discussion on the site-specific smart city, such as in an informal urban setting is far from any final conclusion. We need more evidence to see smart city in the making from the grassroot level to foster more democratic policies as well as sustainable and inclusive smart city vision, policy, and architecture [9]. Smart city from below is needed to cut through the cluttering definitions by investigating perceptions and local urban actors [10]. The question of whether smart city from below in informal urbanism in the Indonesia context is indeed relevant not only locally but also perhaps globally in similar situations. Answering the question of how the preference of the aspects of smart city is based on the perception of kampung residents, or what aspects of smart city that are considered important for the kampung residents, will be the core research question of this article.

Through this 'mapping' of the local kampung actors’ perspectives on smart city applications, we aim to address the more general question of how the locals may suggest relevant indicators for themselves that may shift the existing approaches of governance. The potential tension between pragmatic orientation and ambitions to standardize smart and sustainable urban development [11] will hopefully be contested for the future trajectory, and definition, of 'smart' kampung. We hope that this study will also contribute the shared vision and 'adaptive use' of informal social governance [12] in this complex smart community in the future. These vision and strategy are needed as smart city, or locally specific smart kampung, may invite diverse stakeholders with conflicting values and political agendas challenging for effective smart city implementation.

2. Smart City Indicators in Kampung Context

The concept of smart kampung is inseparable with the concept of smart city where information technology becomes the backbone of smart city development. Batty et al. have comprehensively described this in their study titled Smart Cities of the Future [13] which defines it as a synthesis of physical infrastructure, knowledge, and social infrastructure. They agreed that social infrastructure and the quality of communication are very important to become the competitiveness aspect in this concept of smart city. They identified the typology of smart city roles into six types (Table 1).

| Smart Economy (Competitiveness) | Smart People (Social and Human Capital) | Smart Governance (Participation) |
|--------------------------------|----------------------------------------|---------------------------------|
| Innovative spirit             | Level of qualification                 | Participation in decision-making|
| Entrepreneurship              | Affinity to life-long learning         | Public and social services      |
| Economic image & trademarks   | Social and ethnic plurality            | Transparent governance          |
| Productivity                  | Flexibility                            | Political strategies & perspectives|
| Flexibility of labor market   | Creativity                             |                                |
| International embeddedness    | Cosmopolitanism/Open-mindedness        |                                |
| Ability to transform          | Participation in public life           |                                |

| Smart Mobility (Transport and ICT) | Smart Environment (Natural Resources) | Smart Living (Quality of Life) |
|-----------------------------------|--------------------------------------|-------------------------------|
| Local accessibility               | Attractivity of natural conditions   | Cultural facilities           |
| (Inter-)national accessibility    | Pollutions                            | Health conditions             |
| Availability of ICT-infrastructure| Environmental protection             | Individual safety             |
| Sustainable, innovative and safe transport systems | Sustainable resource management | Housing quality |
|                                   |                                      | Education facilities          |
|                                   |                                      | Touristic attractivity        |
|                                   |                                      | Social cohesion               |

Recent studies have developed these typologies into elaborate indicators necessary for evaluations. One study conducted by Huovila, Bosch, and Airaksinen compared and analyzed 413 indicators...
categorized in seven smart city standards [14]. The standards were ISO 37120 [15], ISO 37122 [16], ETSI [17], ITU 4901 [18], ITU 4902 [19], ITU 4903 [20], and the UN Sustainable Development Goals (SDG) [21]. The indicators are distributed in ten city sectors: natural environment, built environment, water and waste, transport, energy, economy, education, culture, innovation & science health, well-being and safety, governance and citizen engagement, and the information and computer technology (ICT). The indicators were also mapped in the urban concept (sustainability, people, planet, prosperity, smartness, hard and soft smartness) and type (input, process, output, outcome, and impact). The study concludes the choice of indicators are important to provide guidance for city managers and policy makers in the selection of the most suitable indicator standard. The selection may also depend on many factors such as phase in city development (planning, operation), spatial scale (district, city, region, country), time scale of evaluation (real-time to annual) and purpose of assessment (target setting, monitoring, official reporting, self or cross-city benchmarking, marketing [14]. Aside from the above global standards, some use Batty's concept to frame the vision in a more localized context. The Ministry of Environment, Sustainable Development, and Disaster and Beach Management of Mauritius additionally shaped this conceptual roadmap as the cycle of those six elements [22].

However, not many smart city indicators have been developed for the non-urban context. In rural areas, a joint research program between the Consultative Group on International Agricultural Research (CGIAR) and the Climate Change, Agriculture and Food Security (CCAFS) produced a formulation of Climate-Smart Village elements. The indicators are clustered into four aspects that are described as follows: (a) Climate and environment: these elements require village management ability to address the micro and/or macro climate and environmental conditions, (b) Human and natural resource: these elements are the ability of the kampung community in managing the natural resources and human resources in general, (c) Knowledge and information: these elements are village management ability to provide knowledge and information for the community, and (d) policy participation that shows the ability of the village community to involve the community in policy making process by utilizing information technology. Here this Climate-Smart Village is an effort to increase productivity and income, build resilience to climate change, reduce gas emissions, and improve national food security. The researchers saw that the concept of smart kampung can be formulated based on typology, criteria or cycles that have been developed above by looking at the residents’ interests [23].

In this preliminary study, the researchers did not examine the community’s preferences for all indicators. From the above four main clusters of indicators, we studied only clusters of indicators that were highly related to the context namely: the climate and environment elements, of which the priority was in the environmental aspects. For the purposes of clarity, it is referred to as the Kampung's Smart Indicators. To bring details of these indicators, the researchers referred to the typology of smart city described by Batty et al. [13] which also includes the smart environment. In this element, the indicators to be elaborated are: (1) natural conditions, (2) pollution management, (3) environmental protection, and (4) management of sustainable natural resources.

3. Materials and Methods

3.1. Kampung Terban Yogyakarta as the case

Kampung Terban is a subdistrict located in Gondokusuman, Yogyakarta (7°46'37.9"S 110°22'16.2"E). Geographically, Terban is in the embankment of river Code River that flows across Yogyakarta city. This kampung, as many in Indonesia, is an informal settlement where, using the terms of urban design traditions [24], an organic pattern of urban design that have been growing in the natural features and becoming more permanent. Seen from its urban morphology, from 2006 to 2020, the settlements did not show any significant change. However, in the areas close to road access, some development of new buildings is changing the scope as is shown in the time lapse taken from Google maps in the figure 1. The Special Region of Yogyakarta government has implemented policies to improve the quality of this informal environment such as the construction of low-cost rented apartments on the banks of Code River as they were applied in the area of Jogoyudan, Cokrodirjan and Juminahan, and also in Yogyakarta. However, a study conducted by Ayodiya in 2014 showed that the majority (81%) of residents on the
Code riverbank preferred to remain living there rather than to move or be relocated. Hence, the solution was considered to be unable to effectively resolve the settlement issues on the banks of Code River [25].

![Figure 1. Time series spatial composition of Kampung Terban](image)

The application of information technology in Terban is not a new change and has been at least a small part of the new ‘smart city’ features. Internetization and information technology-based kampung gentrification were also introduced as one of the solutions. As reported by Bohlen and Maharika [26, 27], a water purification facility named Waterbank AirKami that supported by Internet of Things (IoT) was installed over the existing water spring. The smart infrastructure using cloud computing has been built at that water bank that can be accessed at AirKami website (www.airkami.org). The cloud computing on AirKami produces periodical statistical data on the water quality that can be obtained by the community. This smart feature may become the basis of initial ideas of kampung Terban character that distinguishes it from other kampungs in Code riverbanks and may become a reference for similar kampungs. As this study attempted to assess the preferences of the Terban community in understanding the concept of smart city in general and the context of smart kampung in particular, hence the presence of this technology opened local knowledge concerning the smart city concept suitable as the case study.

3.2. Defining Preference by Analytical Hierarchy Process Method

Methodologically, to define the preference of local community we utilized the Analytic Hierarchy Process (hereinafter abbreviated as AHP) introduced by Thomas Saaty [28, 29]. AHP is an effective tool in dealing with complex decision making. It considers a set of evaluation criteria as well as a set of alternative options among decisions to be made. AHP has a priority composed of various options that might be in the forms of criteria that have been previously decomposed. Therefore, priority is set based on a process that is structured, hierarchical and logical. AHP helps solve complex problems by compiling a hierarchy of criteria that is then assessed by any parties that become the object of this method. Basically, AHP consists of three processes: decomposition, comparative judgment, and synthesis of priorities. First, a decision maker shall break a problem into several elements and compile them into a hierarchical structure showing the relationship among targets, objectives, sub-goals, and decision alternatives. In this study, based on the indicator mapping in the literature review we decomposed them and then we asked respondents to complete the questionnaire we provided. Since not all respondents were able to respond directly to this, some in-depth interviews were also conducted to support the respondents. We defined the respondents as local persons who are considered key figures representing the young, mid, and older generations. In the process of filling out the form, the concept of a kampung’s smart environment was first explained referring to their experiences and knowledge, then the respondents were asked or helped to complete the form according to their own preference.
The data obtained using this method were then synthesized to result in a ranking of the community’s preference. In this case, the researchers used Expert Choice software (https://www.expertchoice.com/ahp-software) version 11 to make calculations more accurate.

4. Results and Discussions
The objective of this study was to understand the community’s preference to the concept of kampung’s smart environment which has been developed by the researchers. As preliminary study, the scope is still very limited, that is to provide an initial picture regarding smart-environment applications at the kampung level. In its application in Terban, the criteria of the smart kampung indicator is described by decomposing it into five basic criteria: (a) In the aspect of natural conditions: microclimate information, macro-climate information, green space availability, and utilization of natural energy, (b) In the aspect of pollution management: air quality, water quality, waste management, soil quality, (c) In the aspect of environmental protection: efforts to protect nature, information on potential disasters, information on disaster management, participatory information on disaster management, (d) In the aspect of management of natural resources: electricity efficiency, water efficiency, waste management, rainwater management, and energy conservation, and (e) In the aspect of water management: information on water availability, drinking water supply, drinking water quality, well water quality, and information on distribution of drinking water. Figure 2 shows the diagram of the above decomposition. These decomposed criteria were then selected by sampling respondents showing their preferences.

![Figure 2. The AHP diagram of the smart kampung indicators.](image)

4.1. Description of the subjects of interview
Of the seven subjects who were interviewed and asked to fill out the forms, the characteristics of subjects are shown in the following Table 2.

| No. | Initial | Gender | Age | Position in the Terban community                                                                 |
|-----|---------|--------|-----|---------------------------------------------------------------------------------------------------|
| 1   | SB      | M      | 15  | Terban resident, high school education, representing the younger generation and sufficient knowledge of modern day digital equipment |
| 2   | YT      | F      | 36  | Terban resident, representing adult female generation and sufficient knowledge of modern equipment as well as conventional one |
4.2. Description of the sampling subjects of interviews

We reported the first hierarchy and the result of AHP analysis as shown in Figure 3. It can be seen that the respondents consider the natural conditions and resources management as their priority. However, they still lacked complete understanding about pollution and environmental protection.

![Figure 3. The AHP of first hierarchy of Kampung Smart-Environment on Terban.](image)

In the second level of indicators, respondents show variety of preferences. Figure 4 shows all of preferences and figure 5 depicts the tendencies in the cluster. From these data, we saw that the community has a higher preference for the utilization of natural energy. This option was perhaps a rational choice for them as the electricity bill is a necessary and constant expense which by reducing it will give more positive impact to their livelihood. The next choice of water related preferences are also rational choices as they live in river embankment where piped water from government has not yet reached the area and there are concerns about pollution that may negatively affect their quality of living. They are also aware about the importance of preserving water well quality as one of their priorities. The notion from AirKami Waterbank which gave report of water well quality perhaps induced this knowledge and preference.

From the finding, we could presume that spatial intervention such as architecture in particular or urban design in general may reverberate the awareness. Böhlen and Maharika study showed that the smart kampung concept needs to integrate architectural program, spatial planning, and social engineering in the form of community participation with information technology as a key to sustainable urban quality improvement for a more effective planning [27]. Information that is spatialized may improve the locally existing knowledge into more precise direction important to foster people to learn. Perhaps this 'learning city' where people increase their digital literacy is a quality needed before a city may be called smart [30].

In clusters of natural conditions, the community showed the least preference on the green space although spatially they lacked this feature. This finding needs further investigation as green space is important factor in this dense area. In the use of natural resource, concern to water efficiency is high. In terms of pollution management, the community considers both air and water quality but not really to the notion of the quality of waste management and soil quality. For environmental protection cluster, the community’s first preference is the protection effort specially to deal with annual threat of flood. To this preference for environmental protection, besides the contextual notion of the locality, this notion somehow adds more general criteria of smart kampung developed by Rahmawati et al. through the study.
conducted in Surabaya. Their criteria comprises twelve aspects namely: implementation of wastewater and waste management activities, environment quality improvement program, adequate infrastructure, comfort, the communities’ literacy in technology usage for daily activities, basic service provision and efficiency, community empowerment activities, the communities’ ability to adopt new things wisely, household-based economic activities or small and medium enterprises, security, access to public facilities, and quality of life of society increases in everyday life [31].

![Figure 4](image_url). The AHP results of all indicators.

![Figure 5](image_url). The AHP result on four clusters.

Since Terban’s physical characteristics are closely related to water and to the city center, we added an additional preference assessment of water management (figure 6a) and their preference of how information and policy can be accessed (figure 6b). The results confirmed that water well quality (which comes from the spring) has a high value of preference and onsite and direct participation are still the majority of community preference in dealing with information and policy. The online with website and smartphone is among the least preference to them; the finding that should be considered amidst the smart city interventions.

![Figure 6](image_url). The AHP result water efficiency (a, left) and information and policy (b, right).
From the above findings we could draw more clear analysis. In more specific contexts, such as in developing countries, the systematic literature survey conducted by Tan and Taehagh confirmed the need of digital technologies as possible solutions for the population pressures. The report also showed that technology-enabled smart cities in this localized context can only be realized when concurrent socioeconomic, human, legal, and regulatory reforms are instituted. Governments need to step up their efforts to fulfill the basic infrastructure needs of citizens, raise more revenue, construct clear regulatory frameworks to mitigate the technological risks involved, develop human capital, ensure digital inclusivity, and promote environmental sustainability. A supportive ecosystem that encourages citizen participation, nurtures start-ups, and promotes public-private partnerships needs to be created to realize their smart city vision [32]. Offenhuber’s report also shows that the Indonesian Smart City initiatives must consider specific processes of bricolage or the improvisation process within that may also need the processes of improvisation in the design of urban data platforms. This improvisation and bricolage allow the social dynamics around smart city platforms and their impact on the system to be differentiated [33].

From kampung community preference we have presented, we also may learn that their concept of smart city is simply to support their basic livelihood and locally rooted with natural feature and thread. The new technologies which involved indeed generates new thinking for future kampung, but it is perhaps not the entire story. We may also infer from their preferences that possible future for kampung may be varied. It is also possible to direct kampung to the not-really smart, but which re-actualize their local ecological knowledge through spatial design as suggested in some recent critics to smart city projects [34] or its radical ‘opposition’ of traditional ecological knowledge [35]. This new direction may also open to real contribution to the more global effort in sustainability [21,36].

5. Conclusions and Further Research
It is undeniable that, in the future, Indonesian cities sooner or later will implement smart-city system either part or in full capacity, including their kampungs. However, strongly localized cultures in the kampung cannot simply accept just any new system. From this preliminary study, it can be concluded that the community in Terban has a high preference for the utilization of natural energy while waste management is the least preferred one. The range of preferences gives insight that there are local knowledge that is rooted from the spatial characteristics that may differ or turn the normative standards, criteria, or indicators into more specific attachment to them. Adjustments and adaptations are always needed. We also saw that architecture and urban design may provide instrumental tools to spatialize [26] the smartness to foster the learning community towards more compatible learning to become smart city [29].

This preliminary study is still very limited to a small number of community representatives and there is a need to triangulate with different methods, locations, and scales. The future study is also expected to use more kampung with different characteristics so that the becoming smart-kampung system will be more impactful and localized according to the characteristics of the kampungs that are commonly found in Indonesia. Future smart kampung singularity [37], the smartness from and for the below is not only needed but also must be architecturally designed, not only about architecture of the technology, but also the actual design space and form.

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