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# An evaluation of the capacity-building effects of participatory GIS (PGIS) for public participation in land use planning

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# An evaluation of the capacity-building effects of participatory GIS (PGIS) for public participation in land use planning


## Abstract

Spatial participatory methods called "participatory GIS" (PGIS) are intended to improve public participation for land use planning. An internet PGIS was implemented in Perlis, Malaysia, to examine the public capacity-building effects of PGIS. Two delivery modes (*facilitated* and *self-administered*) were evaluated. We found that PGIS significantly enhanced perceived public knowledge about place and land use planning while increasing spatial technology skills, regardless of implementation mode. The results indicate that PGIS can increase public capacity for participating in land use planning, an important finding for developing countries with historically low levels of public participation and low public awareness and knowledge of planning.



Keywords: participatory GIS, PGIS, land use planning, public participation, cognitive ability, capacity-building

## 1. Introduction

Citizen participation is viewed as "a cornerstone of democracy" (Roberts, 2004, p. 315) and a "virtuous" strategy to increase the legitimacy and democracy of the public policy-making process (van der Heijden and Heuvelhof, 2012). Effective public participation not only incorporates public values into decisions, but improves the substantive quality of decisions, helps to resolve conflict, builds trust, and educates and informs the public (Beierle and Cayford, 2002). An effective public participation process also builds public capacity through enhancement of participant knowledge and opportunities for social learning that help people develop the confidence and skills necessary for them to achieve their purpose (Wilcox, 1994). Capacity building is a precursor to participation in that ordinary people are unlikely to take action or responsibility without sufficient capacity for participation (Warburton, 1998). Public participation in land use planning is more likely to be effective if people are equipped with the necessary skills and knowledge to play their part.

Beirele (1999) has argued that the knowledge requirements for active public participation in environmental decisions are too ambitious except in a few cases (p. 82). In contrast, Brown (2016) offered a more optimistic view that public participation processes, if structured properly, can tap into "crowd wisdom" to inform complex land use planning activities that are traditionally considered the domain of experts. In view of these contrasting perspectives, participatory geographic information systems (PGIS) have emerged that call upon citizens to participate in planning activities that require spatial knowledge and understanding of place. An important research question is the extent to which these newer spatial participatory methods can be effectively implemented with a non-expert, lay public while concurrently building capacity for public participation in future planning activities. We address this research question in the context of a developing country, Malaysia, which has historically lacked high levels of public participation and engagement with land use planning activities.

The relatively rapid development of participatory GIS (PGIS) methods and applications has out-paced research to fully evaluate their effectiveness. Early studies investigated how PGIS could help citizens participate in the delivery and management of everyday services in their neighbourhood (Kingston et al., 2001) while describing the challenges associated with implementing new technologies for on-line decision support systems such as training, internet access, and copyright issues (Carver et al., 2001). Multiple PGIS studies examined the potential of geospatial technologies to empower broader publics in land use decisions and governance (Corbett and Keller, 2005a and 2005b; McCall and Minang, 2005; Tsai et al., 2013) while more recent studies have focused on PGIS usability (Bugs et. al, 2010; Gottwald et al., 2016), data quality (Brown, 2012a; Brown et al. 2014), and sampling effects and bias (Brown, 2016). In a recent review of spatial public participation methods, Brown and Kyttä (2014) noted the continuing need to evaluate the effectiveness of participatory mapping applications in providing decision support given their relatively low adoption rate by government and non-government agencies (Brown, 2012b). To date, relatively little research has formally assessed the effects of spatially-explicit participation methods on participant knowledge and capacity-building, the focus of this study.

### *1.1 Participant Knowledge, Place Familiarity, and PGIS Useability*

People living in the vicinity of the planning area or that may be otherwise affected by planning decisions possess cognitive ability acquired through the experience of living in the area (McCall, 2003). This cognitive ability is often referred to as indigenous spatial knowledge. Cognitive ability refers to an "individual's capacity to think, reason and problem solve" (Cheung et al., 2015) and includes working experience, memory, attention, and spatial abilities (Czaja and Lee, 2007). The aim of PGIS is to facilitate the inclusion of knowledge and experiences relevant to land use and development, especially from local and marginalized community groups such as ethnic minorities and indigenous communities in the decision-making processes. The use of participatory mapping in a planning process often includes stakeholders, broadly defined as those who may be affected by the plan or project outcomes. Although the purpose of PGIS is not to collect information better provided by experts, previous studies indicate that lay people can provide spatial information that is generally consistent with expert-derived spatial data (Brown, 2012a; Cox et al., 2014 & 2015; Brown et al., 2014; Brown, 2015).

According to Brown (2012b), the cognitive challenge of spatially mapping place-specific attributes is related to the level of expertise or scientific knowledge required of participants. Among the many spatial attributes that have been mapped in PGIS applications, environmental variables such as ecosystem services require the highest levels of expertise. In contrast, participant identification of place-based values, activities, experiences, and development preferences are grounded in life experience and do not require a high level of technical expertise. These latter attributes provide important information for land use planning decision support as they help identify the compatibility of potential land uses with social acceptability criteria.

PGIS studies indicate that individuals with greater familiarity and experience with the planning area will tend to provide greater spatial information (Brown, 2005; Brown and Weber, 2013; Brown and Reed, 2009). This may be viewed as a positive bias because knowledge of the area results in better information about place qualities (Brown (2012b). However, the lack of population representativeness, especially from PGIS participatory processes that are exclusively volunteer, can lead to mistrust of the information for planning decision support.

PGIS usability is a part of the human computer interaction (HCI) discipline, which refers to evaluating whether an application works and has met its design goals according to the user's needs (Nielsen, 1993). Meng and Malczewski (2010) assert that there is a strong relationship between a system's usability and public engagement. Usability in PGIS has tended to focus on the general public rather than a specific user group (Haklay and Tobón, 2003; Poplin, 2015) with multiple studies assessing the usability of PGIS applications (see Sidlar and Rinner, 2007; Aditya, 2010; Bugs et al., 2010; Gottwald et al., 2016). For example, Sidlar and Rinner (2007) found that participants were generally satisfied with the usability of the mapping tool but suggested map navigation, display of discussion contributions, and online status of participants as added features to improve functionality. However, increasing mapping application functionality can also increase the interface complexity, hindering elderly and less technically skilled people from using it (Steinmann et al., 2005; Gottwald et al., 2016). Bugs et al. (2010) found that easy-to-use features will help eliminate substantial problems in using the mapping tools, but participant capacity is still a concern in settings where the general population lacks experience with the intended purpose of PGIS (in this case, land use planning) and internet mapping technology.

*1.2 Study Context and Research Questions*

In Malaysia, the Town and Country Planning Act 1976 (Act 172) states that the Director General of Town and Country Planning Department has a statutory obligation "to provide information and education to the public regarding town and country planning" (Malaysia, 2006, p.16). However, the evidence from studies on public participation in Malaysia reveal that the public lacks planning-related information and awareness (Omar and

Leh, 2006; Maidin, 2011; Marzuki et al., 2012) due to low levels of public involvement, suggesting limited public capacity for participating in land use planning activities. Further, there have been no PGIS processes implemented in Malaysia to assess the potential of participatory mapping methods for land use planning. The historical lack of public participation in land use planning in Malaysia, combined with a lack of familiarity with participatory mapping methods, provides an opportunity to examine the potential of PGIS to increase participant capacity for land use planning activities and to evaluate the effectiveness of different modes of PGIS implementation with a public that has no experience with participatory mapping.

In this study, spatial data in the form of place values and land use preferences were solicited from a lay public in Perlis, Malaysia using two modes of PGIS implementation, *facilitated* and *self-administered*. The *facilitated* mode assumes limited participant knowledge and experience with land use planning in general, and internet-based mapping in particular. A facilitator assists the participant in starting and completing the mapping process. The *self-administered* mode, the most common type of PGIS implementation in developed countries, directs prospective participants to a web-based mapping application where the participant provides spatial information without any direct human assistance.

This research assesses the potential effects of the PGIS process on participant perceived knowledge gain as an indicator of increased capacity for public participation in land use planning, and whether this effect differs by PGIS mode of implementation. The specific research questions we sought to answer were as follows: 1) does PGIS enhance perceived knowledge of place, land use, and mapping technology as a result of participation, and 2) does the PGIS mode of implementation (*facilitated* vs. *self-administered*) influence participant capacity to provide information in support of land use planning.

## 2. **Methods**

### *2.1 Study area*

The study was conducted in the northern state of Perlis, Malaysia, comprising an area of 821 $km^2$, and a population of about 240,000. The state is bordered by the country of Thailand to the north, the state of Kedah to the south, and the Straits of Malacca to the west. The state is zoned for a wide range of land uses, including high density urban areas for business and services, residential, industrial and community facilities, and non-built areas such as forest, agriculture, and water bodies. The current land use in the study area is dominated by agricultural land use (54,560 hectares) and forestry land (12,179 hectares)

(Town and Country Planning Department, 2009). The state of Perlis falls under the jurisdiction of only one local authority, the Kangar Municipal Council (MPK) whose development objective is to internationalize the state of Perlis through a strong regional economic foundation that offers high quality of life within a sustainable environment (Kangar Municipal Council, 2011).

**[Insert Figure 1 here]**

*2.2 PGIS mapping and survey questionnaire*

We developed a website using a Google Maps Application Interface (API) for PGIS mapping and for recording responses to non-spatial survey questions related to the study. The website had the following features: (1) a welcome page where an access code is entered and validated, (2) an informed consent screen, (3) a set of text-based pre-mapping survey questions to identify the residence of participants, how they learned about the study, and their self-assessed familiarity of land uses in Perlis, (4) a Google Maps screen with three panels of digital markers that participants drag and drop onto the study area map (see Figure 2), and (5) a webpage with additional text-based survey questions (post-mapping).

**[Insert Figure 2 here]**

On the mapping page, the standard Google Maps navigational tools were available for respondents to zoom and pan the map to different locations to place the markers. No limit was placed on the number of markers that participants could place on the map. In the instructions section of the web page, the participants were encouraged to place at least 20 markers. Each marker type and location placed by the participants was recorded in a webserver database for later download and analyses. The mapping application contained 24 icons/markers representing spatial attributes for land use planning. Seven place values (aesthetic/scenic, nature, history/heritage, recreation, economic, spiritual, special place) were adapted from the regional participatory mapping studies implemented by Brown (2005; 2006) and a new 'built environment' value was added to identify areas valued for human space and activities. In addition, there were 16 development preferences where participants could identify locations they considered *acceptable* or *not acceptable* for a given type of development. The *acceptable* development preferences (residential, community facilities, industrial, agriculture, environment protection, public parks and open space, tourism, other development) were selected based on their relevance to general land use planning and their consistency with specific zoning classes contained in the Perlis land use plan. The parallel set of development preferences (*acceptable* and *not acceptable*) for each type of development provided participants with the opportunity to express multiple preferences for a given location. For example, a participant could identify an area as *acceptable* for residential development, but also identify the same area as *not acceptable* for commercial/industrial development.

There were two pages of text-based survey questions on the website. The first survey page was designed to collect information about the respondents and their perceived knowledge prior to participating in the mapping activity. The final web page consisted of a series of text-based survey questions to assess participant perceived knowledge after the mapping activity. A series of survey questions with Likert-scale responses was formulated to assess participant perceptions toward the use of the PGIS and the cognitive challenges they encountered in the process.

### *2.3 Data Collection Procedure*

The study used non-probability, purposive sampling for participant recruitment. The study was conducted between August and November 2014 with participants limited to Perlis residents over the age of eighteen. Two different PGIS modes were implemented for data collection, referred to as *facilitated* and *self-administered*. In the facilitated mode, participants were recruited by the researcher and completed the internet-based PGIS survey in the presence of the researcher. The facilitated approach was an appropriate method given that a web-based PGIS survey is considered a novelty in the study area and administering the survey face-to-face allowed the researcher to explain, monitor, and provide technical assistance, especially during the mapping component of the survey. The PGIS participants from the self-administered group were individuals who accessed the PGIS website without the presence of a researcher.

#### *2.3.1 Facilitated PGIS*

To ensure consistency during the facilitated PGIS recruitment process, a standard recruitment procedure (script) was developed and followed. The researcher established nine workstation locations in the study region (Kangar, Kuala Perlis, Arau, Padang Besar, Beseri, Pauh, Simpang Empat and Mata Ayer). Prospective participants were approached in public spaces to ascertain eligibility for participation. Upon obtaining consent from a potential participant, the researcher explained the potential benefits of internet-based spatial mapping to collect information for land use planning. Each participant was given a unique access code to login to the website. Once logged in, the participant viewed an informed consent page to accept agreement to participate. Upon consent, participants proceeded to the next web page to answer text-based questions about their familiarity with the Perlis study region. Once the pre-mapping survey questions were completed, participants were guided to the main mapping page. The researcher (facilitator) explained the instructions in detail and conducted a short demonstration on how to do mapping by dragging and dropping different value and preference markers onto the study area map. Respondents were given 10 to 15 minutes to complete the mapping activity. The researcher continued to observe the respondent and only offered technical assistance if requested. Once a participant was satisfied with the mapping activity, he/she completed a set of text-based survey questions asking about the participant and his or her mapping experience. The session ended by thanking the participants and offering each a small, non-cash token of appreciation for their time and effort.

*2.3.2 Self-administered PGIS*

The second method used social media for participant recruitment. A Facebook® page was created containing information about the study with a link to the PGIS study website. In total, 48 Facebook users accessed the study website with 24 individuals fully or partially completing the study. A partial completion included answering the pre-mapping questions and placing one or more markers on the map. A full completion included mapping and answering the post-mapping survey questions that followed the mapping activity.

*2.4 Data Analyses*

*2.4.1 Examining knowledge change pre- and post-PGIS*

To examine the change in participant perceived knowledge about place and land use, and to assess their technical skills using Google Maps, we asked the same survey questions pre- and post-mapping and analyzed the results using the Wilcoxon signed-rank test given that responses were not normally distributed. Three hypotheses were proposed and a critical value of $p \leq 0.05$ was selected to compare pre- and post-mapping survey responses as follows:

$H1_0$: there is no difference in perceived knowledge about place before and after using PGIS (Question: *How would you rate your knowledge of places in the state of Perlis?* 1=Poor/little 2=Below average 3=Average 4=Good 5=Excellent)

$H2_0$: there is no difference in perceived knowledge about land use planning before and after using PGIS (Question: *How would you rate your knowledge of land use planning?* 1=Poor/little 2=Below average 3=Average 4=Good 5=Excellent)

$H3_0$: there is no difference in perceived knowledge/skills using Google Maps before and after using PGIS (Question: *How would you rate your knowledge of using Google Maps?* 1=Poor/little 2=Below average 3=Average 4=Good 5=Excellent)

*2.4.2 Cognitive challenge, familiarity, and PGIS usability by PGIS implementation mode*

Multiple survey questions were developed to assess elements of cognitive challenge (n=3), the effect of place familiarity on mapping (n=2), and PGIS usability (n=5). The survey questions appear in Table 2. The results of each question were analyzed by implementation mode (*facilitated* vs. *self-administered*) using the Mann-Whitney U statistic to test the following hypotheses:

$H4_0$: there is no difference in cognitive challenge between the *facilitated* and *self-administered* groups (3 survey questions)

$H5_0$: there is no difference in the influence of place familiarity in the mapping of values and preference between the *facilitated* and *self-administered* groups (2 survey questions)

$H6_0$: there is no difference in PGIS usability between the *facilitated* and *self-administered* groups (5 survey questions)

*2.4.3 Assessing the quality of data by PGIS implementation mode*

Two criteria were used to examine the quality of PGIS data, mapping effort and logical consistency of mapped markers with land use type. Brown et al., (2012) proposed that mapping effort (i.e., number of markers placed) is a reasonable proxy for spatial data quality for subjective PGIS attributes (e.g., values such as scenic beauty and development preferences) where traditional GIS spatial accuracy criteria cannot be applied. Mapping effort was evaluated between the *facilitated* and *self-administered* participants by examining the number of participants in each group that mapped the expected number of markers (20 or less) or greater than the expected number (21+) of markers. A contingency table and chi-square test was used to determine whether implementation mode was related to mapping effort:

$H7_0$: there is no relationship between participant mapping effort and PGIS mode of implementation

To determine whether the mode of implementation was related to logical consistency in participant mapping, we examined the counts of agricultural and residential values that were mapped in areas currently zoned for agriculture and residential land use in the Perlis land use plan. Markers with values related to the zones were classified as consistent (i.e., agricultural values mapped in agricultural zones, residential values mapped in areas zoned for residential use); otherwise, markers were classified as inconsistent. The following hypothesis was tested using the chi-square statistic:

$H8_0$: There is no relationship between participant logical consistency in mapped locations and PGIS mode of implementation.

## 3. Results

*3.1 Characteristics of respondents*

A total of 316 individuals participated in the study, with n=292 *facilitated* respondents and n=24 *self-administered* respondents. The age of respondents ranged from 18 to 67 years with 165 male (52%) and 151 female (48%) respondents.

*3.2 Perceived knowledge change pre- and post-mapping*

There were significant changes in participant perceived knowledge of places, land use, and use of Google maps as a result of the PGIS mapping activity. Prior to PGIS mapping, 26% of participants rated their knowledge of places in Perlis to be "good" or "excellent". Following mapping, this percentage increased to 82%. For knowledge of land use planning, the perceived knowledge rated as "good" or "excellent" increased from 11% (pre-mapping) to 74% (post-mapping). And self-rated knowledge of using Google Maps increased from 16% to 69% from pre- to post-mapping. The Wilcoxon signed-rank test was used to determine if these changes were statistically significant. For all three survey questions, the differences in ratings pre- and post-mapping were highly significant ($p < 0.000$). *Conclusion: there is strong evidence for changes in participant perceived knowledge for places (H1), land use planning (H2), and use of Google maps resulting from PGIS participation (H3).*

**[Insert Table 1 here]**

*3.3 Cognitive challenge, familiarity, and PGIS usability by PGIS implementation*

We assessed cognitive challenge, effect of place familiarity, and PGIS usability by mode of implementation (*facilitated* vs. *self-administered*) using the non-parametric Mann-Whitney U test. A large majority of participants (range 67% to 81%) agreed or strongly agreed that they found identifying values, places, and areas suitable for development a difficult task (Table 2). There were no statistically significant differences in any of the three survey questions by implementation mode, thus the hypothesis (H4) that the cognitive challenge of PGIS mapping differs by mode of implementation is not supported. The presence of a facilitator did not influence the perceived difficulty of the PGIS mapping activity reported by participants. *Conclusion: facilitation does not influence the perceived difficulty of the mapping activity.*

There were small, but statistically significant differences ($p \leq 0.05$) in responses by implementation group on two survey questions that asked about whether participants would have placed more values and development preference markers if they were more familiar with the area (Table 2). There was strong or very strong agreement by the majority of participants (range 95% to 100%) that they would have mapped more values and preferences in PGIS had they been more familiar, but the *self-administered* group had somewhat less agreement with the two statements. Thus, the hypothesis (H5) of no difference in the potential influence of familiarity on the number of markers that would be mapped is rejected. *Conclusion: participants are aware that the amount of PGIS mapping is related to familiarity with the planning area, with facilitated participants somewhat more aware of the importance of familiarity.*

The majority of *facilitated* and *self-administered* participants agreed or strongly agreed (range 81% to 99%) that the PGIS website was relatively easy to use, but there were statistically significant differences in all survey questions related to the useability of the PGIS website (Table 2). The facilitated PGIS participants found the website instructions, marker symbols and definitions, map navigation, and general website easier to use than those who participated on their own (Mann-Whitney U, $p \leq 0.05$ for all survey items). Thus, the hypothesis (H6) that there is no significant difference in PGIS usability between the *facilitated* and *self-administered* mode is rejected. The face-to-face support provided in the facilitated PGIS process resulted in stronger participant perceptions that the website was easier to use than those who undertook the PGIS mapping on their own. *Conclusion: the facilitated mode had positive effects on the perceived useability of the mapping application.*

**[Insert Table 2 here]**

*3.4 Relationship between mapping effort and PGIS implementation (facilitated vs. self-administered)*

To evaluate whether the PGIS mode of implementation was related to mapping effort and thus data quality, we cross-tabulated the number of participants that mapped the expected number of markers as per instructions (20 or less) with the number of participants that mapped 21+ markers and performed a chi-square test of independence. The results are shown in Table 3. A larger percentage of *facilitated* participants (46%) mapped 21+ markers compared to *self-administered* participants (29%), suggesting that mapping effort is related to PGIS implementation mode. However, the chi-square statistic was not significant at $\alpha = 0.05$ ($X^2 = 2.61$, $df = 1$, $p = .079$). This relationship would likely be significant at $\alpha = 0.05$ with a larger sample size of self-administered participants for analysis. *Conclusion: the PGIS implementation mode appears related to mapping effort, but the evidence is weak given the small number of self-administered participants.*

*3.5 Relationship between logical consistency in mapping and PGIS implementation (facilitated vs. self-administered)*

To evaluate whether there is a relationship between logically consistent mapping and PGIS implementation mode, we tabulated the number of agricultural and residential value markers that were mapped in areas currently zoned for agriculture and residential land use in the Perlis land use plan. Each marker was classified as “consistent” or “not consistent” based on its mapped location. The percentage of consistent markers were similar between facilitated (46.8%) and self-administered (45.8%) participants, but the chi-square test for independence was significant at $\alpha = 0.05$, ($X^2 = 20.618$, $df = 1$, $p = 0.000$). *Conclusion: facilitated participants were more consistent in placing markers that were logically associated with the underlying land use zoning, but the difference was small.*

**[Insert Table 3 here]**

## 4. **Discussion**

This study evaluated the potential influence of PGIS on the capacity of a lay public to participate in land use planning activities in a developing country (Malaysia) characterized by historically low and ineffective public participation. A presupposition of the study was that a *facilitated* type of PGIS, rather than the more common type of *self-administered* PGIS, would be more effective in building capacity for public participation in land use planning processes. Operationally, we examined whether the PGIS process enhanced perceived knowledge associated with place, land use, and mapping technology that are supportive of public participation in land use planning activities, and the potential influence of PGIS implementation on mapping outcomes.

We found that PGIS participants perceived their knowledge of places, land use planning, and the use of Google maps to be greater following PGIS mapping indicating positive learning outcomes. In the process of mapping, it is probable that some participants discovered new insights about the place/region where they live and current land uses while becoming more proficient using Google maps. Even if PGIS data were not actually used for planning decision support, the results indicate PGIS helps inform citizens, thus building greater social capacity for public participation. We are, however, guarded about overstating the modest capacity-building outcome described in this study that only included about 300 participants, although the potential exists for much larger capacity-building. For example, the use of participatory mapping in the Helsinki master planning process attracted 3,745 participants (Kahila-Tani et al., 2015).

The cognitive challenge associated with PGIS mapping was not influenced by the presence of a facilitator. The explicit spatial identification of place values and preferences as person-place relationships involves complex cognitive reasoning. Participants must reflect on the values and preferences that are personally important, either explicit or tacit, while thinking about places that support or constrain these values and preferences. Relating personal importance to place importance is a task that most individuals can do, but people are seldom asked to explicitly describe these relationships on a map. Cognitive challenge may be one of the reasons why participatory GIS tends to have participation bias toward older, more highly educated individuals (Brown and Kyttä, 2014). The greatest potential benefit of *facilitated* PGIS is not reducing the complexity of the mapping activity, but rather recruiting and getting participants to complete the PGIS activity. The face-to-face contact in PGIS recruitment appears especially important in a society that lacks a historical tradition of public participation and engagement with local government processes. In this study, the acceptance rate for participation when approached by a facilitator was about 70 percent, a reasonable acceptance rate that would not likely be achieved through random household or volunteer sampling.

Given the cognitive complexity of PGIS mapping, is the resulting spatial data of sufficient quality to provide planning decision support in a development country context? We believe so. The criteria for assessing the validity of expert GIS data quality do not apply to many subjective PGIS spatial attributes such as place values and preferences, i.e., there are no benchmarks for positional accuracy, attribute accuracy, or data completeness, or what is termed the *validity-as-accuracy* perspective (Spielman, 2014). Rather, the validity of participatory mapping data is more conducive to a *validity-as-credibility* perspective where spatial data quality is linked to the credibility of the mapper. From this perspective, mapping effort, or the earnestness that participants bring to the PGIS mapping process, is an important proxy measure for assessing the quality of PGIS data. In this study, almost half of the facilitated participants (46%) mapped more than the suggested number of markers (20) suggesting reasonably good data quality. We found some evidence that mapping effort was greater in the *facilitated* versus *self-administered* mode of participation, suggesting somewhat lower quality in the self-administered group, but the evidence was weak given the small sample size of self-administered participants. For comparison, in a larger meta-study of mapping effort, Brown (2016) found greater mapping effort in participatory mapping studies that used purposive sampling (most similar to *facilitated* mode in this study) over volunteer sampling (similar to *self-administered* mode in this study), but there was a high degree of inter-study variability with some studies showing greater mapping effort among volunteers. Participant motivation likely plays a significant role in mapping effort. We speculate that greater feedback in the mapping process through pop-up boxes and/or real-time marker gauges could potentially increase participant mapping effort, but encouraging participants to identify more place attributes based on limited experience could reduce overall data quality.

In the second measure of data quality, logical consistency of mapped spatial attributes with zoning classifications, we found a somewhat higher level of marker consistency in *facilitated* implementation. However, the results were more suggestive than definitive. The presence of a facilitator may encourage participants to be more deliberate in the placement of their markers, but the effect of facilitation on logical consistency was small, and arguably, inconsequential to the overall mapped results. The larger question is why both PGIS participants, regardless of implementation mode, placed markers that appear less than 50 consistent with the existing land use zoning classifications for agricultural and residential land use. There are two plausible explanations. The first is that participants were not directed to map place values that reflect current land use zoning, but rather to map place values that were important to the participant. Thus, markers could represent future, desirable land uses rather than current land uses. For example, land may be currently zoned for agriculture but may be valued by the participant more for residential development. The second explanation is that participants were not provided with a current land use zoning map in the PGIS application as an overlay. Participants mapped locations without the knowledge of current zoning boundaries in the study region.

## Conclusion

The impetus for this study was the prevailing view that the current practice of eliciting public participation for land use planning in Malaysia was ineffective owing to a number of barriers, including inadequate channels for participation and transparency in decision-making processes (Dola and Mijan, 2006). PGIS should not be viewed as a panacea for participation deficiencies in Malaysia because PGIS will not resolve the fundamental issue of trust in authority that is required for effective participation outcomes. However, PGIS can address one important barrier to effective public participation in Malaysia which is the lack of public awareness and knowledge of land use planning. Our results suggest that PGIS has the potential to act as a capacity-building process to enhance public participation in a developing country context by increasing knowledge about place and land use while enhancing spatial technology skills for information collection.

In Malaysia, the Town and Country Planning Act (1976) states that the planning department is obligated to find ways to educate and inform the public about land use planning. Passive modes of public engagement with land use planning in Malaysia have not been effective in the past. PGIS represents an active mode of public engagement that can overcome barriers to participation, but it will require planning authorities leave the comfort zone of passive engagement and embrace a more active role in capacity building for public participation. The *facilitated* mode of PGIS appears well-suited to Malaysia because it can achieve high participation rates while increasing knowledge about land use planning. Implementation of *facilitated* PGIS will require more time and resources than *self-administered* PGIS, but the costs appear modest relative to the benefits. A further benefit of *facilitated* PGIS is the greater probability of gaining participation from minority and marginalized groups which is a core PGIS principle (Brown, 2012a). While usefulness of the PGIS spatial data for planning decision support in Malaysia is significant and described elsewhere (Zolkafli et al., 2017), the educational and information benefits of PGIS alone merit further trials. Post-mapping interviews with Malaysian planning authorities support this view. Future research should expand PGIS trials in Malaysia and other developing countries to determine whether the capacity-building benefits found in study can be replicated to increase the external validity of the findings. Further, additional research should be undertaken to determine the levels of trust in participants and planning authorities in the PGIS process as this variable appears most critical for the adoption of PGIS methods.

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**Table 1**. Pre- and post-mapping results for perceived change in knowledge about place, land use planning, and use of Google Maps.

| | Pre-mapping | | | | Post-mapping | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Survey question | % Excellent or Good | % Below average or Poor | Mean[a] | SD | % Excellent or Good | % Below average or Poor | Mean[a] | SD | Z score | *p value* |
| ***Knowledge of Places (H1)*** How would you rate your knowledge of places in the state of Perlis? | 26.0 | 9.7 | 3.2 | .63 | 82.1 | 1.6 | 3.8 | .54 | -12.2 | 0.000 |
| ***Knowledge of Planning (H2)*** How would you rate your knowledge of land use planning? | 11.0 | 20.1 | 2.9 | .59 | 74.4 | 3.6 | 3.7 | .62 | -12.7 | 0.000 |
| ***Knowledge of using Google Maps (H3)*** How would you rate your knowledge of using Google Maps? | 15.9 | 37.3 | 2.8 | .82 | 68.5 | 1.6 | 3.7 | .61 | -12.6 | 0.000 |

[a] Means were calculated from a five-point Likert scale with responses as follows: '1'— Poor; '2'— Below average; '3'— Average; '4'— Good; '5'— Excellent.

**Table 2.** Perceived cognitive challenge, the effect of place familiarity, and useability by PGIS implementation mode (*facilitated* vs. *self-administered).*

| Survey Item | Facilitated (*N*=292) | | | Self-administered (*N*=24) | | | Mann-Whitney U statistic | *p value* |
|---|---|---|---|---|---|---|---|---|
| | % Agree or Strongly agree | Mean[a] | SD | % Agree or Strongly agree | Mean[a] | SD | | |
| ***Cognitive Challenge (H4)*** | | | | | | | | |
| a. Identifying the values for places in Perlis was a difficult task. | 73.1 | 3.52 | 1.02 | 66.7 | 3.55 | .80 | -0.53 | 0.595 |
| b. Identifying development preferences in Perlis was a difficult task. | 77.7 | 3.62 | .95 | 76.2 | 3.64 | .95 | -0.016 | 0.988 |
| c. Identifying areas not suitable for development was a difficult task. | 73.4 | 3.57 | .96 | 81.0 | 3.68 | .84 | -0.461 | 0.645 |
| ***Effect of Place Familiarity (H5)*** | | | | | | | | |
| a. I would have identified more values if I were more familiar with the area. | 97.2 | 4.63 | .58 | 94.7 | 4.28 | .87 | -2.257 | 0.024 |
| b. I would have identified more development preferences if I were more familiar with the area. | 98.3 | 4.67 | .52 | 100.0 | 4.36 | .58 | -2.699 | 0.007 |
| ***Usability (H6)*** | | | | | | | | |
| a. The instructions provided were clear and easy to follow | 96.9 | 4.56 | .57 | 95.0 | 4.07 | .85 | -3.279 | 0.001** |
| b. The ideas or objects represented by the icons were clear to me | 97.9 | 4.55 | .54 | 95.0 | 4.16 | .89 | -2.284 | 0.022* |
| c. The icon definitions were easy to understand. | 98.2 | 4.57 | .55 | 85.7 | 3.96 | 1.13 | -3.090 | 0.002* |
| d. The Google map was easy to use and navigate | 94.8 | 4.50 | .64 | 81.0 | 3.86 | 1.17 | -3.029 | 0.002 |
| e. Overall, the website was easy to use. | 99.3 | 4.60 | .50 | 95.0 | 4.21 | .74 | -2.766 | 0.006 |

[a] Means are based on a five-point Likert scale with responses as follows: '1'— strongly disagree; '2'— disagree; '3'— neither disagree nor agree; '4'— agree; '5'— strongly agree.

**Table 3.** Mapping effort and consistency by PGIS implementation mode (*facilitated* vs. *self-administered*).

| | | PGIS implementation | | | | $X^2$ | *p* value |
|---|---|---|---|---|---|---|---|
| | | ***Facilitated*** | | ***Self-administered*** | | | |
| | | Count | Percent | Count | Percent | | |
| **Mapping effort (H7)** | 21 and above | 135 | 46.2 | 7 | 29.2 | | |
| | 20 and below | 157 | 53.8 | 17 | 70.8 | 2.61 | 0.079 |
| | Total individuals | 292 | 100.0 | 24 | 100.0 | | |
| **Mapping consistency (H8)** | Consistent | 1559 | 46.8 | 56 | 45.8 | | |
| | Not consistent | 1776 | 53.3 | 132 | 54.2 | 20.62 | 0.000 |
| | Total markers | 3335 | 100.00 | 188 | 100.00 | | |

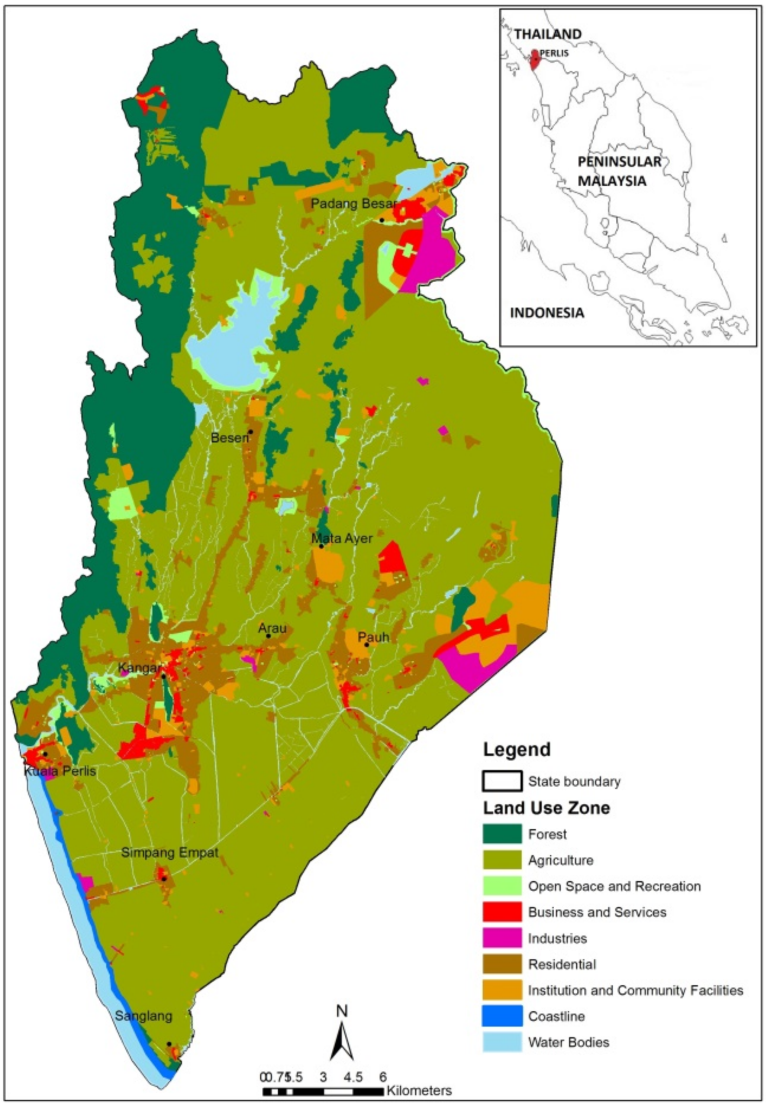


**Figure 1.** State of Perlis and land use zones identified in the Kangar Municipal Council local plan.

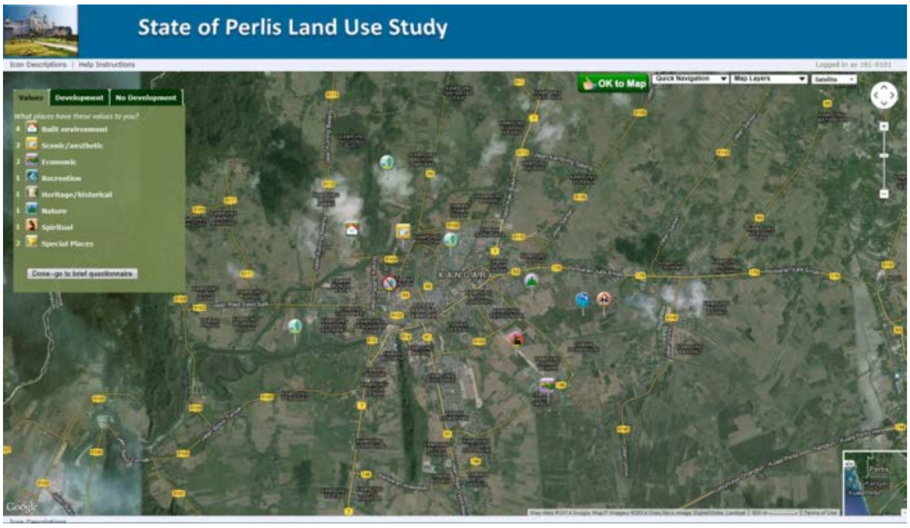


**Figure 2** Screenshot of the PGIS mapping page. Source: http://www.landscapemap2.org/perlis/map_bm.php