AN EVALUATION OF PARTICIPATORY GIS (PGIS) FOR LAND USE PLANNING IN MALAYSIA

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ABSTRACT
Public participation for land use planning in developing countries is challenged by multiple barriers including low public awareness and engagement with the process. This paper evaluates the capacity of the general public to effectively contribute to land use planning outcomes in Malaysia using Participatory GIS (PGIS). Spatial attributes that identify place values and land use preferences were collected from the public through a web-based PGIS using *facilitated* and *self-administered* methods and compared with land use zones developed by planning experts. We assessed the quality of the PGIS mapped data by analysing participants' mapping effort and the consistency of the mapped data with existing land use zones. The results indicate logical consistency between the mapped attributes—place values and preferences—and land use zones contained in the expert-driven land use plans. The results further indicate that the *facilitated* PGIS process produced higher quality spatial data compared with the *self-administered* PGIS survey. Our results suggest that PGIS can provide planning authorities with a viable platform to enhance public participation for land use planning in Malaysia, but that a *facilitated* PGIS process will be required to increase public participation and the quality of spatial data generated.

KEYWORDS: Participatory GIS (PGIS); land use planning; public participation; Malaysia

1. INTRODUCTION

Public participation is an important process where public concerns, needs, and values are included in government decision-making (Creighton, 2005). The importance of public participation has been described as an "imperative of contemporary society" (Roberts, 2004, p. 315) wherein democracy "without citizen deliberation and participation is ultimately an empty and meaningless concept" (Pimbert and Wakeford, 2001, p. 23). While public participation in planning is considered a "virtue" (Heijden and Heuvelhof, 2012) where democratic government should "operate so as to include rather than exclude citizens from participating in the process" (Davidoff, 1965, p. 332), some planning scholars have argued that modern planning practice lacks effective integration of different social groups (Healy, 1997) and that the mechanisms of public participation may be technically and substantively flawed (Heijden and Heuvelhof, 2012). Further, the benefits of increasing community participation in government decision making may be contextual and uncertain (Irvin and Stansbury, 2004).

The dominant view toward public participation is that it provides multiple benefits such as enhanced citizenship (King, Feltey, and Susel, 1998), better decisions (Beierle, 1999; Thomas, 1995), and a learning system for social stability (Smith, 1973) as well as change (Nelson and Wright, 1995). Despite the putative social and planning-specific benefits of public participation, there has been relatively little formal evaluation of participatory processes (Laurian and Shaw, 2008; Brown and Chin, 2013). The effectiveness of public participation varies by culture and planning context (Abram and Cowell, 2004; Lane, 2003) with differing levels of process transparency and influence on the decision-making structure (Alfasi, 2003). The promise of expanded public participation and citizen engagement through crowd-sourcing (Brabham, 2009; Brown, 2015) and new information technologies such social media and mobile technologies presently amount to "wishful thinking" with little empirically validated evidence (Kleinhans et al., 2015).

The Malaysian government recognizes that public participation is an integral part of sustainable development and good governance (Mohamed et al., 2013). Further, public participation is not just an alternative for better planning, but is a requirement in the planning law (Omar and Leh, 2009). People in Malaysia have the right to participate in decision-making processes that affect their communities where they live and work, but the current level of public participation in Malaysia for land use planning appears limited (Maidin, 2011). An important question is whether current public participation approaches in Malaysia are effective in including the public in land use planning decisions that affect community quality of life, and if not, how the participation process could be improved. In this study, we evaluate the potential of a spatially-explicit method called Participatory GIS (PGIS) for increasing the effectiveness of public participation for land use planning in Malaysia.

1.1. Public Participation in Malaysia

The Town and Country Planning Act 1976 (Act 172) provides the statutory mechanism for the public to be involved in the preparation of development plans (Maidin, 2011). However, studies indicate that the public participation for land use planning in Malaysia has not been effective due to the lack of detailed information, lack of public awareness, and limited government initiatives to promote effective participation (Omar and Leh, 2009). Further, vague legislation and loose enforcement of public participation (Maidin, 2011; Marzuki, Hay and James, 2012) contribute to structural and operational shortcomings of the public participation process (Dola and Mijan, 2006; Marzuki et al., 2012; Kawasmila and Songorwa, 2009).

Evidence from previous studies indicates low levels of public involvement in land use planning in Malaysia. A study of participation between 2001 and 2009 showed that only 1 to 12% of the residents visited the Local Plan exhibition and 1 to 8% of the residents visited the Structure Plan exhibition (Town and Country Planning Department, 2009). A "structure plan" is a written statement describing the policy and strategic recommendations for state level land use and development whereas a "local plan" is a physical planning document that puts the structure plan policies into more detailed and practical form (Department of Town and Country Planning, 2015). A study by Muhammad et al. (2015) found that over 61% of respondents were not involved in any development plans or improvements in service delivery by local authorities. In addition, local

residents were not aware of their right to contribute ideas to planning and development programs. The same study also found that less than 35% were involved in public hearings for local plans (Muhammad et al., 2015). Thus, although the current participatory approach in Malaysia satisfies requirements under the legal system, public participation for land use planning has not achieved high rates of public engagement. Further, there has been little research to assess the type and quality of information provided by non-experts (i.e., the general public) in the planning process.

1.2. PPGIS, PGIS, and VGI Concepts

Over the past decade, academics and planning practitioners have developed new methods and geo-information technologies to increase and enhance public participation. Public Participation GIS (PPGIS) has emerged as a method to generate and integrate public knowledge and opinions for decision making. The term PPGIS was established in a series of workshops conducted by the National Center for Geographic Information and Analysis (NCGIA) in 1996 to describe how GIS technology could support public participation for a variety of applications (Sieber, 2006; Mukherjee, 2015). The term participatory GIS (PGIS) and its practice was the outcome of a spontaneous merger of Participatory Learning and Action (PLA) methods with geographic information technologies (Rambaldi et al., 2006). The harnessing of tools, especially the internet, to create, assemble, and disseminate geographic data provided voluntarily by individuals has been termed volunteered geographic information (VGI) (Goodchild, 2007; Sui, 2008). The most well-known VGI application is OpenStreetMap.

The terms PPGIS, PGIS, and VGI have not been consistently used by academics or practitioners over time given their differing origins and the variety of methods for generating and disseminating spatially-explicit information. Brown and Kyttä (2014) reviewed how the terms PPGIS, PGIS and VGI were used in practice to help clarify and distinguish the concepts. In principle, both PPGIS and PGIS can support the inclusion and empowerment of individuals and communities that have not been traditionally involved in urban or rural planning. The difference between PPGIS and PGIS is largely due to the global context where the methods have been developed and applied. PPGIS has its origin in developed countries where it focuses on enhancing the participation process with spatially-explicit information to improve the quality of planning and management decisions whereas PGIS has been used more in developing countries as a form of community empowerment and the development of social capital (Brown and Kyttä, 2014). With PPGIS, the dominant form of spatial data collection involves probability sampling of individuals, often through household surveys or interviews, to ensure population representativeness and involvement of the "silent majority". In contrast, PGIS often uses purposive sampling to ensure that key stakeholders such as community leaders are included in the mapping process (Brown and Kyttä, 2014). PGIS often uses simpler, non-digital mapping technology that is more suited for rural or remote settings in developing countries, whereas in developed countries, PPGIS and VGI are increasingly dominated by digital, internet-based mapping techniques. However, the distinction among PPGIS, PGIS and VGI is less obvious today with advances in internet and mobile mapping technologies. The availability of high quality digital maps and imagery, coupled with application programming interfaces (API), offer high-technology participatory mapping options even in remote environments.

The study described herein, situated in Malaysia, has characteristics of both PPGIS and PGIS in that the study generated spatial information for both urban and rural areas using digital, internet

technologies, but Malaysia is still regarded as a developing country (International Statistics Institute, 2015). For convenience, we use the term PGIS to refer to the participatory mapping methods used in this study given the geographical context and the use of purposive sampling as the primary means for data collection.

1.3. Evaluation of PPGIS/PGIS

The rapid development of PPGIS/PGIS has raised many questions regarding the strengths and limitations of the methods that require systematic evaluation (Sieber, 2006; Craig et al., 1998). In the early stages of development, scholars focused more effort on evaluating PPGIS/PGIS tools and technology than participatory outcomes or the quality of the spatial data. For example, multiple studies have assessed the usability of PPGIS/PGIS (Aditya, 2010; Bugs, 2010; Jankowski and Nyerges, 2003; Sidlar and Rinner, 2007; Steinmann et al., 2004), but relatively few studies have examined the effects on empowerment (Corbett and Keller, 2005; Kyem, 2004; Tsai et al., 2013) or engagement (Rinner and Bird, 2009). There is also a small, but expanding body of evaluation research that has examined the quality of the spatial data and how sampling methods and participant characteristics can influence the participatory mapped results (Brown, 2017).

The overarching goal of PGIS is to facilitate the inclusion of relevant knowledge and opinions, especially from local and marginalized groups, in decision-making processes. The use of participatory mapping in a planning process includes gathering data from stakeholders, broadly defined as those who may be affected by the plan or project outcomes. The collected data is used to help formulate one or more possible alternatives. People living in the geographical vicinity of the planning area or that may be otherwise affected by planning decisions often do not possess expert knowledge in planning. What they do possess is knowledge they have acquired through the experience of living in the area which is called indigenous spatial knowledge (McCall, 2003). A recurring question for PGIS is the quality of the spatial data generated from this indigenous spatial knowledge relative to expert knowledge.

Some might argue that participatory mapped data should be evaluated with the same standards of spatial accuracy as found in expert GIS data, but the quality of the PGIS spatial data generated is dependent on the specific attributes mapped and their intended use. For some spatial attributes, the relationship of the participatory mapped data to expected, physical landscape features has been used to benchmark the quality of PGIS spatial data using spatial accuracy. For example, studies have evaluated the ability of non-experts to accurately identify the location of native vegetation in New Zealand (Brown, 2012), suitable habitat for threatened species (Cox et al., 2014a), watershed services such as fish nurseries and flood protection (Cox et al., 2014b), ecosystem services (Brown et al., 2014), and areas of high conservation importance (Brown et al., 2015). Collectively these studies suggest that non-experts can provide spatial information that is generally consistent with expert-derived spatial data. For subjective mapped attributes such as place values and preferences, the level of accuracy may be indeterminate and analyst judgment must be rendered to accept or reject the data as valid. Brown et al. (2012) suggested that mapping effort and usability of the mapped data are reasonable indicators of data quality for subjective mapped values such as place values and preferences.

There has been some research to determine the effects of participant characteristics on the resulting spatial data. For example, Brown (2013) found that some individuals translate their non-spatial ideologies into mapped values and land use preferences and that volunteer sampling methods in particular, can result in the mobilization of some social groups with land use preferences that significantly differ from the general public (Brown et al., 2014). Further, stakeholder groups representing multiple interests can map land use preferences that conflict in the same spatial location (Brown et al., 2015), raising the important question of whose interests should count more in the decision-making process such as zoning for land use and development.

A distinguishing characteristic of the previous evaluation studies of participatory mapped data is that the setting was in developed countries (e.g., U.S., Australia, and New Zealand) with established systems for engaging the public in land use planning. In this study, we evaluate the type and quality of PGIS spatial information that can be generated in support of land use planning in a developing country context (Malaysia) using the benchmark of the current, expert-driven development plan. PGIS spatial data in the form of place values and land use preferences were collected from a non-expert public using two modes (*facilitated* and *self-administered*) in Perlis, Malaysia, and spatially intersected with the Perlis development plan. The quality of PGIS data was assessed using two criteria: (1) logical consistency of mapped attributes with the physical characteristics of the planning area and current land use zoning classifications, and (2) participants' mapping effort. The specific objectives of the study were to: (1) determine whether PGIS mapped place values and land use preferences appear logically consistent with landscape features and current land use zones in the state development plan, (2) compare participants' mapping effort between the two PGIS survey modes (*facilitated* versus *self-administered*) and assess how different PGIS data collection methods influence the quality of the spatial data.

2. METHODS
2.1. Study Area

The state of Perlis, Malaysia comprises 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 wide range of land uses (see Figure 1) with overall dominance by agriculture (54,560 hectares) and forestry (12,179 hectares) (Town and Country Planning Department, 2009). The state of Perlis falls under the jurisdiction of one authority, the Kangar Municipal Council (MPK), whose development focus is to internationalize Perlis through a strong economy that offers a high quality of life within a sustainable environment (Kangar Municipal Council, 2011).
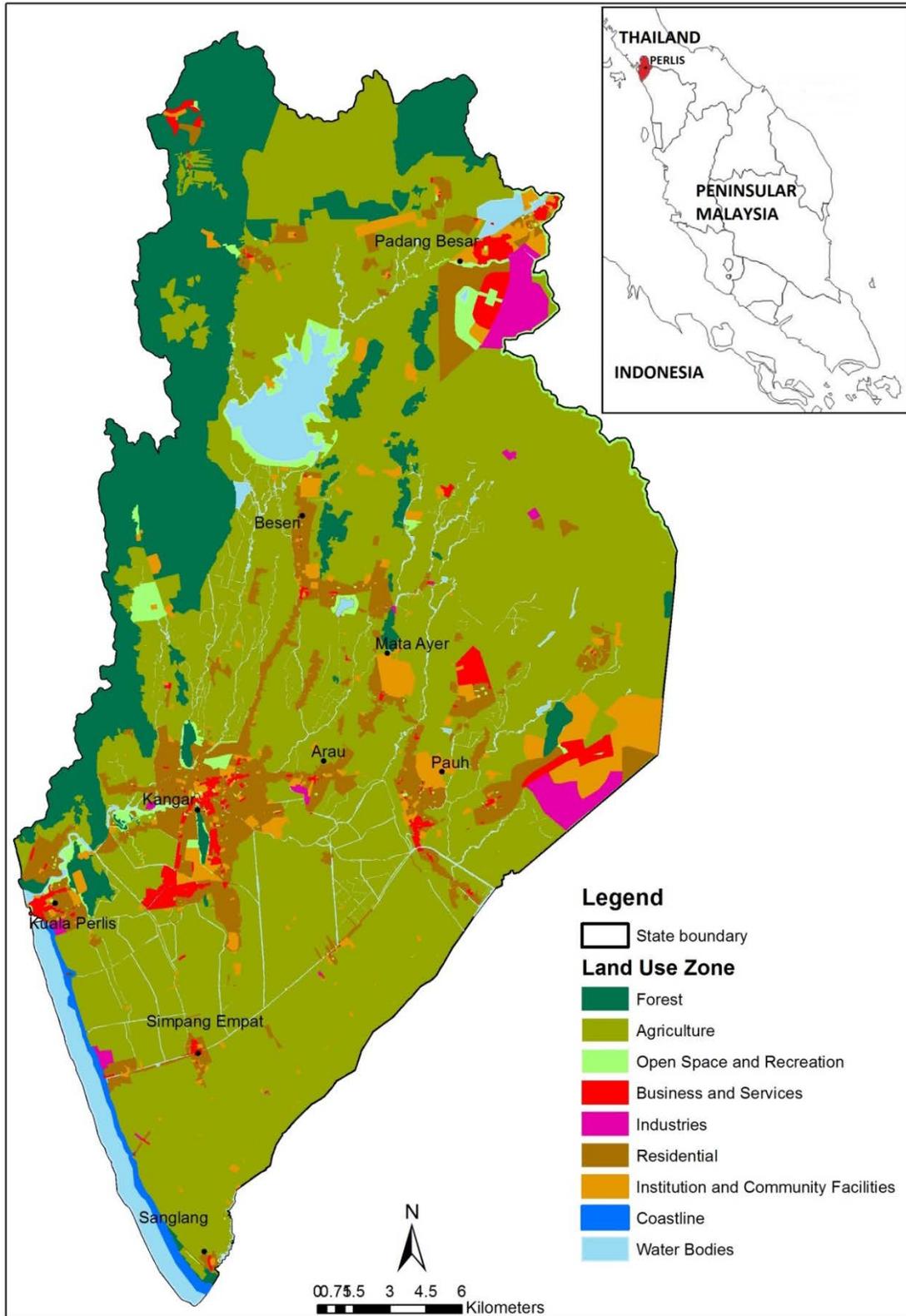
Figure 1: State of Perlis and Land use Zones Defined in the Local Plan. (Adapted from Kangar Municipal Council, 2011)

2.2. Internet-based PGIS Mapping

A PGIS website was developed and implemented using a Google Maps® API. 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 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 the study participants could drag and drop onto the map (see Figure 2), and (5) a page with additional text-based survey questions to identify respondent characteristics.

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 markers. No limit was placed on the number of markers that participants could place on the map and participants were encouraged to place at least 20 markers. To ensure a minimum level of mapping precision, the application only allowed marker placement when the zoom level scale was approximately 1:100,000 or larger. The marker type and location were recorded in a web-server database for later download and analyses.
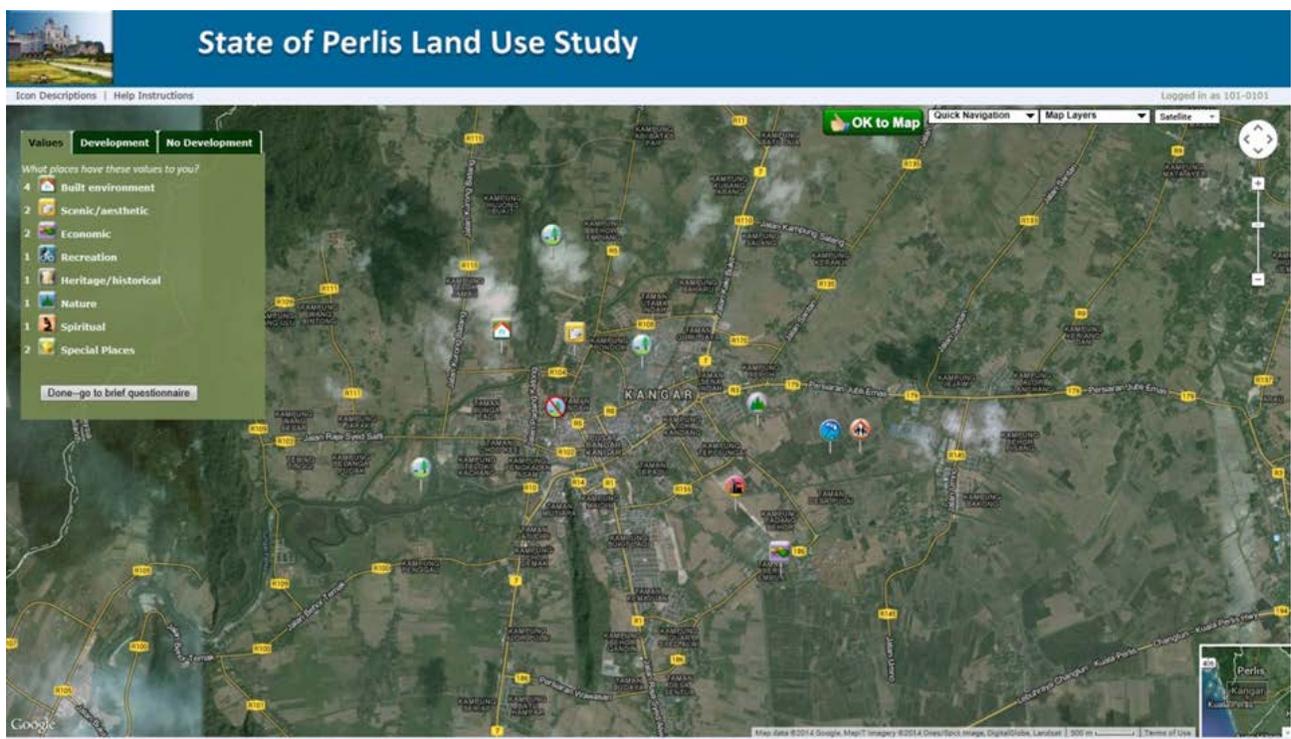
Figure 2: Screen Image of the Google® Map Page from the PGIS Website.

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 regional participatory mapping studies implemented by Brown (2005; 2006) with an additional "built environment" value to provide for the identification of areas valued for human development and activities. In addition to these eight values, there were 16 development preferences allowing for participant identification of locations

that were *acceptable* or *not acceptable* for a given type of development. The development preferences (residential, community facilities, commercial/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. A 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 a residential development, but also identify the same area as *not acceptable* for commercial/industrial development. Table 1 shows the place values and development preferences used in the study, including their operational definitions.

Table 1: Place Value and Land Use Typology, Icons, and Operational Definitions used in the Study.

Spatial Attributes	Icons	Operational definitions
Built environment		I value these places because they provide good setting for human-made space and activities
Spiritual		I value these places because there are spiritually special
Recreation		I value these areas because they provide outdoor opportunities
Economic		I value these area for economic benefits such as commercial, Industry, agriculture and tourism
Aesthetic/scenic		I value these places for the attractive scenery, sights, smells or sounds
Heritage/History		I value this place because they have natural and human history
Nature		I value this place because they help produce clean air and varieties of flora and fauna
Special Places		I value these places because there are special to me.
Housing development		this area is acceptable for new housing area
Community facility		this area is acceptable for new community facilities
Public parks and open space		this area is acceptable for public parks
Industrial/Commercial Area		this area is acceptable of new commercial area like shops, clothing store, restaurant, cinema, factories etc.
Agricultural area		this area is acceptable for agricultural activities like paddy, oil palm
Tourism area		this area is acceptable for tourism activities and services
Environment protection		this area is acceptable for forest or water preservation and conservation
Other development		Other development- this area is suitable for future development
NO housing development		this area is NOT acceptable for residential development
NO Community facility		this area in NOT acceptable for new community facilities

No Public parks and open space		this area is NOT acceptable for public parks
NO Industrial/Commercial		this area is NOT acceptable of new commercial area like shops, clothing store, restaurant, cinema, factories etc.
NO Agricultural		this area is NOT acceptable for agricultural activities like paddy, oil palm
NO tourism		this area is NOT Acceptable for tourism activities and services
NO Environment protection		This area in NOT acceptable for forest or water preservation and conservation
NO development		this area is not acceptable for any kind of development

2.3. Sampling

Study participants were recruited through non-probability, purposive sampling methods. Data was collected from two different sampling groups, which we call *facilitated* and *self-administered* PGIS groups. Facilitated PGIS study participants were recruited by the researcher and completed the internet-based PGIS survey in the presence of the researcher. Self-administered PGIS study participants completed an internet-based survey online without any direct interaction with the researcher. Facilitated PGIS was considered an appropriate method given that an internet-based spatial 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. Facilitated PGIS participants were recruited at nine locations in Perlis, six urban and three rural. The urban locations were Kangar, Kuala Perlis, Arau, Padang Besar, Beseri and Pauh while the rural locations were Simpang Empat, Sanglang, and Mata Ayer (see Figure 1). A total of 280 potential participants were contacted in the urban areas and 120 participants in the rural areas. Participation in the study was limited to individuals over the age of eighteen and the survey was conducted between August and November 2014.

A standard recruitment procedure (script) was developed and followed to ensure consistency during the facilitated PGIS process. The researcher established workstation locations in cafés, restaurants, and at community events in each of the nine locations. Prospective participants were approached in public spaces to determine eligibility for study participation (age 18 or over and a resident of Perlis). If confirmed, the researcher explained the purpose of the study, and to stimulate further interest in the study topic, asked potential participants their general sentiments regarding current development and land use in the area. The researcher further explained the potential benefits of internet-based spatial mapping to collect spatial information for land use planning. After receiving verbal consent to participate in the study, each participant was given a unique access code to login to the website. Once logged in, the participant viewed a consent page and acknowledged 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 these pre-mapping survey questions were completed, the respondents were guided through the main mapping page. The researcher (facilitator) explained the instructions in detail and conducted a short demonstration to show how to drag and drop the different place value and land use preference

markers onto the map. Respondents were given 10 to 15 minutes to complete the mapping activity. The researcher observed the respondent and only offered technical assistance if needed. Once the participant was satisfied with the mapping activity, each participant completed a final task which was answering text-based survey questions about themselves and their mapping experience. The session ended by thanking each participant and providing a small, non-cash token of appreciation for their time and effort.

The second sampling method (*self-administered*) was trialled for collecting participatory mapping information using social media for recruitment. A Facebook® page was created in September 2014 containing information about the study with a URL link to the study website. In total, 48 Facebook users accessed the study website and 24 individuals fully or partially completed the study. A partial completion included answering the pre-mapping questions and placing one or more markers on the map. A full completion included answering the survey questions that followed the mapping activity.

A total of 292 people (out of 400 recruitment contacts) participated in the *facilitated* study. In the recruitment process, efforts were made to obtain balanced gender participation and some ethnic diversity. The number of study participants by gender and ethnicity is shown in Table 2. A total of 153 males and 139 females participated in the study. Recruitment of the dominant Malay ethnic group in Perlis (90% of the population) was generally effective, but recruitment of non-Malay participants (n=40 attempts) was not effective.

Table 2: Gender and Ethnicity of Study Participants with Participation Rates.

Respondents' Characteristics	2013 Population census	Survey conducted in percent	Number of Survey conducted	Consent to participate	Refuse to participate	Participation rates
Gender						
Male	50%	50%	200	153	47	76.5%
Female	50%	50% about	200	139	61	69.5%
Total	100%	100%	400	292	108	73.0%
Ethnicity						
Malay	85%	90%	360	292	68	81%
Non-Malay (Chinese, Indian, and other races)	15%	10%	40	0	40	0%
Total	100%	100%	400	292	108	

3.   DATA ANALYSES

To describe the basic distribution of place values and development preferences mapped within the different land use zones, we calculated *social landscape metrics* as described by Brown and Reed (2012). The value count (P0) metric counts the number of mapped point locations by marker type within each land use zone while the value percent (P1) metric calculates the percent of mapped points by marker type in the zone relative to the total number of mapped points across all land use zones. The dominant value (D) metric is simply the marker type with the largest count of points

within the zoning class. The value dominance index (D1) quantifies the dominance relationship between the most frequently mapped marker type within a land use zone and the next most frequent marker type on a scale that ranges from 0 (i.e., there is no difference in dominance among marker types) to 1 (i.e., there is only one marker type in the land use zone). The value density (D2) metric calculates the density of markers per area while the value diversity index (D3) metric calculates the standard Simpson diversity index commonly used in ecological studies within a zoning classification. According to Brown and Raymond (2014), there are several approaches for generating the conflict potential index (C) metric. This study used the method where the conflict potential index is calculated based on the ratio of opposite land use preferences (*development* versus *no development*) mapped within each zoning class, multiplied by the intensity (number) of place values located in the same land use zones. Details on the computation of the *conflict metric* can be found in Brown and Raymond (2014).

To visualize the distribution and pattern of mapped place values and preferences, we generated kernel density rasters in ArcGIS using a grid cell size of 1000 meters and a search radius of 3000 meters. Kernel density mapping is based on a quadratic kernel function (Silverman, 1986) that fits a smoothly curved surface over each point, producing a circular area (kernel) of a certain bandwidth (or search radius). Kernel density maps identify "hotspots" or higher density clusters of points within the study area.

To evaluate the quality of the mapped PGIS data using the zoning consistency criterion, the mapped locations of the 24 attributes were spatially intersected with nine land use zone classifications (water bodies, residential, coastline, forest, public park and open space, business and services, industry, institution and community facility, and agriculture). Four land use zones (infrastructure and utilities, transportation, drainage and irrigation, aquaculture and husbandry) were omitted from the analysis because these zones occupy relatively small and fragmented areas within Perlis. Cross-tabulations (contingency tables) by marker types and zones were generated for place values and development preferences indicating the number and percentage of markers falling within each zoning classification.

We calculated chi-squared statistics and standardized residuals to determine whether the observed number of mapped points by category differs significantly from the number that would be expected in each zoning classification. Residual analysis provides a way to assess the strength of association between two categorical variables and is often done following a statistically significant chi-square result to determine which pair-wise categorical relationships most contribute to the overall significant association. A standardized residual is calculated by dividing the residual value by the standard error of the residual. Standardized residuals are a normalized score similar to a z score without unit and if greater than +1.96 (rounded to +2.0), indicate significantly more values or development preferences than would be expected, while standardized residuals less than -1.96 (rounded to -2.0) indicate significantly fewer values or development preferences than would be expected.

To ensure sufficient numbers of observations for chi-square analysis without violating assumptions of the test, it was necessary to combine several marker categories. Two place values were combined (heritage/history and special places), two development preferences were combined (public parks/open space and environment protection), and all of the individual *no development*

categories were combined into a single *no development* category (no commercial/industrial, no development, no residential development, no agricultural area, no tourism area, no public parks and open space, no community facility and no environment protection).

Mapping effort was the second criterion used to further evaluate the quality of the PGIS data. Mapping effort was measured using three indicators: the total number of markers placed in the mapping process, the total elapsed clock time placing the markers, and the mean elapsed time in placing a marker. These measurements were compared between the two types of recruitment/sampling groups in the study, *facilitated* and *self-administered*.

4. RESULTS

A total of 6211 points were mapped in the study region. Five markers mapped outside of the study boundary were excluded from the analysis. The frequency distribution of the mapped attributes is presented in Table 3. The most frequently mapped place value was built environment (n=1051), more than twice the next most frequently mapped value (economic, n=495). The next most frequently mapped values were recreation (n=328), aesthetic/scenic (n=297), nature (n=256), spiritual (n=86), heritage/history (n=50) and special places (n=17).

Table 3: Frequency Distribution of all PGIS Mapped Points.

Mapped attributes	Number of points	Percentage (%)
Place Values		
Built environment	1051	40.74%
Economic	495	19.19%
Recreation	328	12.71%
Aesthetic/scenic	297	11.51%
Nature	256	9.92%
Spiritual	86	3.33%
Heritage/History	50	1.94%
Special Places	17	0.66%
Total	2580	100%
Development Preferences		
Agriculture	1213	33.45%
Residential development	962	26.53%
Commercial/ Industrial	377	10.40%
Tourism development	295	8.14%
Community facility	261	7.20%
Environmental protection	176	4.85%
Public parks and open space	89	2.45%
No Commercial/ Industrial	67	1.85%
Other development	58	1.60%
No development	45	1.24%
No Residential development	38	1.05%
No Agricultural area	15	0.41%
No tourism Area	13	0.36%
No Public parks and open space	8	0.22%
No Community facilities	5	0.14%
No Environment protection	4	0.11%
Total	3626	100%

There were 16 development preferences available for participants to map. The most frequently mapped preferences were for agriculture (n=1213), residential development (n=962), commercial/industrial (n=377), tourism (n=295), community facilities (n=261), and environmental protection (n=176). The least frequently mapped preferences were for no public parks and open space (n=8), no community facilities (n=5) and no environment protection (n=4). The point distribution maps with kernel densities for the study region are illustrated in Figure 3. Kangar had the highest densities of mapped points. Lower point densities were located in the north and north-east regions, areas dominated by agricultural land use.
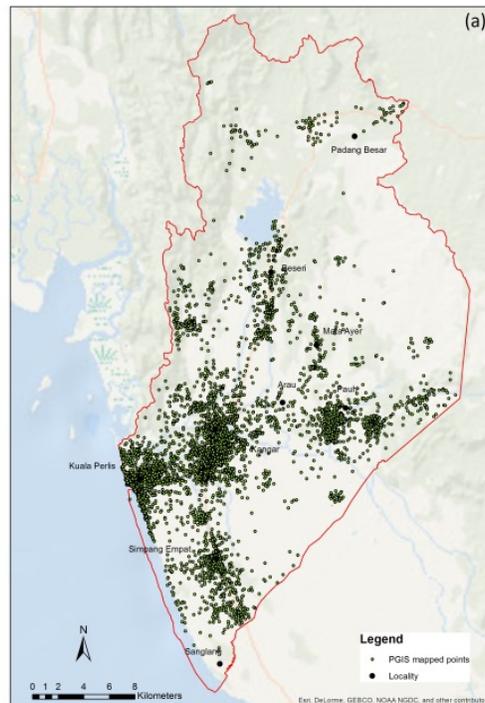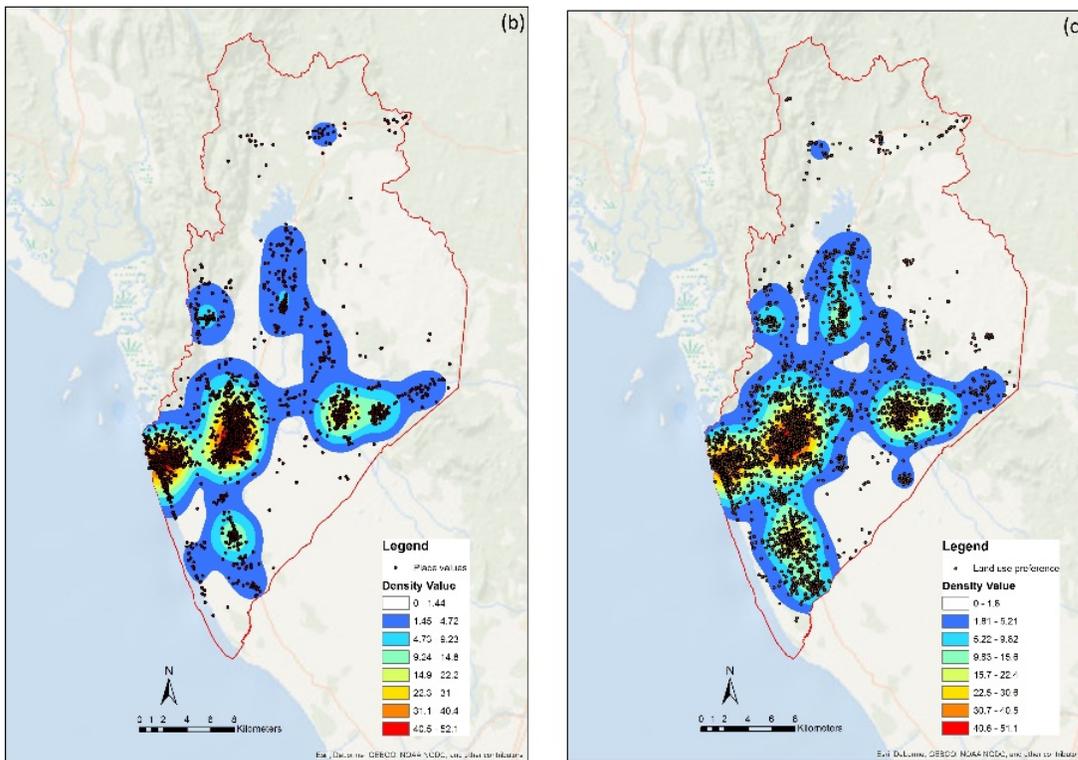
Figure 3: (a) Overall mapped point distribution with (b) place value point distribution and density and (c) land use preference point distribution and density.

4.1. Social Landscape Metrics for Place Values and Development Preferences

Social landscape metrics quantify the distribution of value and preference points that fall within the boundaries of zoning polygons. Social landscape metrics were calculated separately for value preferences for all land use zones (see Table 4). The mapped values were consistent with prescribed land uses in the current zones in the plan. The "built environment" place values were dominant (D) in the residential and institutional zones while economic values were dominant in business, industry, and agricultural zones. Recreation value was dominant in the open space zone, natural value was dominant in the forest and public park zone, and scenic value was dominant in the water and coastline zones. The spatial locations of mapped development preferences were also logically consistent with current land use zones: environmental protection preferences were dominant in the water and forest zones, agricultural preferences were dominant in the agricultural zone, commercial development preferences were dominant in the business and industry zones, and residential development was dominant in the residential zone. The dominance index (D1) confirmed that many of these values and preferences were highly dominant within the zone. For example, built environment values (0.80) and residential preferences (0.80) were highly dominant in the residential zone while agricultural development preference (0.84) was highly dominant in the agricultural zone. The highest density of values (D2) was located in the coastline zone (0.35) while the highest density of development preferences was located in the business zone (0.25). The greatest diversity (D3) of mapped values was in the residential (0.54) and coastline (0.44) zones

respectively, while the greatest diversity of mapped development preferences was in the agricultural zone (0.56).

The conflict index metric indicated that the highest potential for land use conflict was located in the Institution and Community Facilities zone, the result of contrasting preferences on whether the area should be assigned for infrastructure development for community services or whether the area was more suitable for residential, business or industrial uses. The conflict index was also higher in the Residential and Agricultural zones, which derived from the interrelated and the most common land dispute whether the land use preference is for residential development or to maintain it as agriculture land.

Table 4: Social Landscape Metrics for Place Values and Development Preferences by Land Use Zones.

Land use zone	Area in Ha (Rank)	Dominant Value (D)		Sum (P0)		Percentage (P1)		Dominance Index (D1)		Density Index (D2)		Frequency Index (F)		Diversity Index (D3)		Conflict index (C)
		Place values	Development preference	Place values	Dev. Pref.	Place values	Dev. Pref.	Place values	Dev. Pref.	Place values	Dev. Pref.	Place values	Dev. Pref.	Place values	Dev. Pref.	
Water Bodies	4540.35 (4)	Aesthetic/ scenic	Environment protection	103	71	0.04	0.02	0.07	0.52	0.02	0.02	0.36	0.18	0.22	0.25	29.61
Residential	6818.03 (3)	Built environment	Residential	804	1006	0.31	0.28	0.80	0.80	0.15	0.12	2.80	2.50	0.54	0.39	302.88
Institution & Community Facilities	3387.52 (5)	Built environment	Community Facilities	440	395	0.17	0.11	0.71	0.40	0.13	0.12	1.53	0.98	0.30	0.19	363.32
Business	1349.37 (7)	Economic	Commercial/ industry	289	341	0.11	0.09	0.26	0.33	0.21	0.25	1.01	0.85	0.35	0.25	60.46
Industry	1330.35 (8)	Economic	Commercial/ industry	18	55	0.01	0.02	0.13	0.82	0.01	0.04	0.06	0.14	0.36	0.53	0.64
Coastline	293.65 (9)	Aesthetic/ scenic	Tourism	104	62	0.04	0.02	0.42	0.70	0.35	0.21	0.36	0.15	0.44	0.53	0.10
Agriculture	51523.72 (1)	Economic	Agriculture	340	1373	0.13	0.38	0.16	0.84	0.01	0.03	1.19	3.41	0.26	0.56	302.22
Forest	12676.78 (2)	Nature	Environment protection	315	189	0.12	0.05	0.65	0.58	0.02	0.01	1.10	0.47	0.35	0.37	6.12
Open Space	1547.94 (6)	Recreation	Tourism	167	134	0.06	0.04	0.59	0.48	0.11	0.09	0.58	0.33	0.28	0.21	33.64

4.2. Association of Place Values with Zones

A chi-square test for independence was performed to examine the relationship between place values and land use zones (see Table 5). The relationship between these variables was statistically significant (χ^2=2202.833, *df* =120, p<.001), indicating significant association (lack of independence). Standardized residuals indicate whether the number of observations in a given table cell is significantly larger (more than +2.0) or smaller (less than -2.0) than would be expected if there was no association. The largest, over-represented pair-wise associations were between the forest zone and nature values (residual=24.3), the residential zone and built environment values (13.7), and between the coastline zone and scenic/aesthetic values (13.6). Larger and under-represented associations were between the forest zone and built environment values (-10.8), residential zones with scenic/aesthetic values (-7.4), and residential zones with nature (-7.0). Nature values were under-represented in all land use zones except forest, industry, and water body zones.

Table 5: The association of place values with land use zones. The overall association is statistically significant (χ^2 = 2172.331, *df* = 48, p<0.001) with standardized residual more than 2.0 (in green) and less than -2.0 (in red) highlighted.

Category		Agriculture	Business and Services	Coastline	Forest	Industries	Institution and Community Facilities	Open Space and Recreation	Residential	Water Bodies	Total
Built environment	Count	108	100	0	6	7	218	28	575	9	1051
	Expected Count	138.5	117.7	42.4	128.3	7.3	179.2	68.0	327.5	42.0	1051.0
	Std. Residual	-2.6	-1.6	-6.5	-10.8	-0.1	2.9	-4.9	13.7	-5.1	
Economic	Count	128	136	10	8	8	53	26	116	10	495
	Expected Count	65.2	55.4	20.0	60.4	3.5	84.4	32.0	154.3	19.8	495.0
	Std. Residual	7.8	10.8	-2.2	-6.7	2.4	-3.4	-1.1	-3.1	-2.2	
History and special	Count	3	5	0	22	0	23	2	12	0	67
	Expected Count	8.8	7.5	2.7	8.2	0.5	11.4	4.3	20.9	2.7	67.0
	Std. Residual	-2.0	-0.9	-1.6	4.8	-0.7	3.4	-1.1	-1.9	-1.6	
Nature	Count	16	6	1	167	0	20	7	17	22	256
	Expected Count	33.7	28.7	10.3	31.3	1.8	43.7	16.6	79.8	10.2	256.0
	Std. Residual	-3.1	-4.2	-2.9	24.3	-1.3	-3.6	-2.4	-7.0	3.7	
Recreation	Count	30	15	34	58	2	37	73	51	28	328
	Expected Count	43.2	36.7	13.2	40.0	2.3	55.9	21.2	102.2	13.1	328.0
	Std. Residual	-2.0	-3.6	5.7	2.8	-0.2	-2.5	11.2	-5.1	4.1	
Aesthetic/ Scenic	Count	51	26	59	54	1	25	30	21	30	297
	Expected Count	39.1	33.3	12.0	36.3	2.1	50.7	19.2	92.6	11.9	297.0
	Std. Residual	1.9	-1.3	13.6	2.9	-0.7	-3.6	2.5	-7.4	5.3	
Spiritual	Count	4	1	0	0	0	64	1	12	4	86
	Expected Count	11.3	9.6	3.5	10.5	.6	14.7	5.6	26.8	3.4	86.0
	Std. Residual	-2.2	-2.8	-1.9	-3.2	-0.8	12.9	-1.9	-2.9	0.3	
Total	Count	340	289	104	315	18	440	167	804	103	2580
	Expected Count	340.0	289.0	104.0	315.0	18.0	440.0	167.0	804.0	103.0	2580.0

4.3. Association of Development Preferences with Zones

There was a statistically significant association between development preferences and land use zones (X^2=4389.813, *df* =56, p<.001) (see Table 6). Larger and over-represented pair-wise associations were found between agriculture preferences and the agriculture zone (residual= 25.8), between public park and environment protection preferences and the forest zone (25.6), and between community facilities preferences and the institution/community facilities zone (20.0). Larger and under-represented pair-wise associations were found between agriculture preferences and all land use zones except for the agriculture zone. There was a similar trend in association between non-agricultural development preferences and the agriculture zone, suggesting preferences for retaining agricultural uses within the zone.

Table 6: The association of development preferences with land use zones. The overall association is statistically significant (X^2=4389.813, *df* =56, p<.001) with standardized residuals greater than +2.0 (in green) and less than -2.0 (in red) highlighted.

Category		Zoning Agriculture	Business and Services	Coastline	Forest	Industries	Institution and Community Facilities	Open Space and Recreation	Residential	Water Bodies	Total
Agriculture	Count	1012	19	0	1	5	44	8	118	6	1213
	Expected Count	459.3	114.1	20.7	63.2	18.4	132.1	44.8	336.5	23.8	1213.0
	Std. Residual	25.8	-8.9	-4.6	-7.8	-3.1	-7.7	-5.5	-11.9	-3.6	
Commercial	Count	43	131	13	2	39	40	6	97	6	377
	Expected Count	142.8	35.5	6.4	19.7	5.7	41.1	13.9	104.6	7.4	377.0
	Std. Residual	-8.3	16.0	2.6	-4.0	13.9	-0.2	-2.1	-0.7	-0.5	
Community	Count	33	14	0	1	0	135	5	69	4	261
	Expected Count	98.8	24.5	4.5	13.6	4.0	28.4	9.6	72.4	5.1	261.0
	Std. Residual	-6.6	-2.1	-2.1	-3.4	-2.0	20.0	-1.5	-0.4	-0.5	
No development	Count	68	9	3	27	1	21	7	54	5	195
	Expected Count	73.8	18.3	3.3	10.2	3.0	21.2	7.2	54.1	3.8	195.0
	Std. Residual	-0.7	-2.2	-0.2	5.3	-1.1	-0.1	-0.1	0.0	0.6	
Other development	Count	11	7	0	1	1	19	3	15	1	58
	Expected Count	22.0	5.5	1.0	3.0	.9	6.3	2.1	16.1	1.1	58.0
	Std. Residual	-2.3	0.7	-1.0	-1.2	0.1	5.0	0.6	-0.3	-0.1	
Public park and environment	Count	24	10	3	109	1	17	34	37	30	265
	Expected Count	100.3	24.9	4.5	13.8	4.0	28.9	9.8	73.5	5.2	265.0
	Std. Residual	-7.6	-3.0	-0.7	25.6	-1.5	-2.2	7.7	-4.3	10.9	
Residential	Count	158	88	0	4	1	81	21	603	6	962
	Expected Count	364.3	90.5	16.4	50.1	14.6	104.8	35.6	266.9	18.8	962.0
	Std. Residual	-10.8	-0.3	-4.1	-6.5	-3.6	-2.3	-2.4	20.6	-3.0	
Tourism	Count	24	63	43	44	7	38	50	13	13	295
	Expected Count	111.7	27.7	5.0	15.4	4.5	32.1	10.9	81.8	5.8	295.0
	Std. Residual	-8.3	6.7	16.9	7.3	1.2	1.0	11.8	-7.6	3.0	
Total	Count	1373	341	62	189	55	395	134	1006	71	3626
	Expected Count	1373.0	341.0	62.0	189.0	55.0	395.0	134.0	1006.0	71.0	3626.0

4.4. Participant Mapping Effort

The PGIS mapping effort results are presented in Table 7. The mean number of PGIS markers placed and the time spent mapping by the *facilitated* group were significantly larger and longer than for the *self-administered* group. The *facilitated* sampling group mapped more points on average ($\bar{x}$=19.93) than the self-administered group ($\bar{x}$=16.08). A chi-square test of independence was performed to examine whether the types of mapped attributes (i.e., values versus preferences) were related to the sampling group (see Table 8). The relationship was significant (X^2 =37.641, *df* =1, *p* <.0.05) indicating that the *self-administered* sampling group mapped significantly more values (residual=4.5) and significantly fewer preferences than expected (residual=-3.8) relative to the *facilitated* group. The *facilitated* group spent more time mapping, averaging 8.5 minutes compared to approximately 6 minutes for the *self-administered* group. The *facilitated* group mapping effort was similar to the mapping effort reported for random household sampling groups in other internet PPGIS surveys (Brown et al., 2012), but greater than for park visitors who were recruited on-site but who completed the PGIS survey later at home. Thus, the mode of recruitment and participation influenced both the overall mapping effort (number of markers, time) and the type of markers mapped.

Table 7: Participant Mapping Efforts by Sampling Group.

Sampling group	Number of mapped markers	Range of mapped markers	Total mapping time (h:min:s)	Mean number of markers per participant	Mean total mapping time (min:s)	Mean time per marker (min:s)
Facilitated	5820	1 to 49	17:35:35	19.93	8:33	0:26
Self-administered	386	2 to 41	2:21:06	16.08	5:53	0:22

Table 8: Contingency Table Showing the Relationship between Sampling Group (*Facilitated* and *Self-administered*) and Type of Mapped Attributes.

			Mapped attributes		
			Place values	Development preferences	Total
Sampling group	Facilitated	Count	2362	3458	5820
		Expected Count	2419.5	3400.5	5820.0
		Std. Residual	-1.2	1.0	
	Self-administered	Count	218	168	386
		Expected Count	160.5	225.5	386.0
		Std. Residual	4.5	-3.8	
Total		Count	2580	3626	6206
		Expected Count	2580.0	3626.0	6206.0

5.   DISCUSSION

The purpose of the study was to evaluate the type and quality of spatial information generated by PGIS methods in a developing country that has historically lacked effective public participation for local land use planning. We evaluated the quality of the PGIS data using the criteria of logical consistency with existing zones in the Perlis, Malaysia development plan and mapping effort by mode of recruitment/participation (*facilitated* versus *self-administered*). There was logical consistency between mapped place values and preferences with land use zones. These results are significant because spatial zoning information was not provided with the PGIS mapping interface and PGIS participants were unaware of zoning categories or their spatial boundaries. And yet, participants made logical mapping choices indicating knowledge of appropriate land uses given the intrinsic features of places and zones in the state. These results were consistent with a similar PPGIS study and analysis from Australia where residents were able to identify place values and development preferences that were logically related to land use zones contained in the regional development plan (Brown, 2006).

Had the mapped results showed inconsistency with land use zones, the interpretation would be more ambiguous. In this study, the participants were able to generally match place values and preferences with current land uses, supporting the conclusion that a non-expert public in Malaysia can interpret digital based maps and effectively communicate local knowledge about place to bridge the knowledge gap with experts (Zolkafli et al., 2017). If the mapped values and preferences had deviated significantly from current land use zones, it would have been less clear whether participants did not understand current land uses or whether they did understand, but wanted to see changes in land use. In the latter scenario, text-based survey questions following the mapping activity can assist in the appropriate interpretation. Inconsistency between mapped place values and preferences with land use zones can provide an important diagnostic for planning authorities, indicating the need for more intensive engagement with the public over proposed land uses.

The areas identified as having the highest potential for land use conflict were logically related to current land use zones in the plan. Community facility and residential areas had the largest conflict potential indices, driven by housing development preferences being mapped in community facility zones and vice versa. From a normative planning perspective, one would expect community facilities to be located proximate to residential areas. A contributing factor to this mixing of preferences was the spatial scale at which the values and preferences were mapped by participants. Although the PGIS interface could zoom to large-scale maps of the study region, the default mapping scale for the PGIS interface was not sufficiently large to provide for highly accurate marker placement in smaller areas associated with urban zones. The higher potential for conflict found within agricultural zones in the study area was not unusual given the conversion of agricultural land to urban areas continues to be globally contentious, including Malaysia.

An evaluation of mapping effort, as a proxy for spatial data quality, showed that the *facilitated* PGIS process produced better mapping outcomes compared to the *self-administered* PGIS survey. The PGIS mapping effort was greatest in the *facilitated* sampling group, with the number of markers and response time falling within the range of mapping effort reported in other

PPGIS studies (Brown, 2017). This finding can be attributed to the active recruitment and engagement with the participants. Participants were aware that technical assistance was available if needed. In the absence of direct engagement with PGIS participants, the *self-administered* mapping results indicate that PGIS will produce poorer data quality in the Malaysian context.

Participant recruitment was acceptable with a participation rate of about 70 percent of individuals contacted. However, an important finding of this study was the refusal and absence of Malaysian minorities in the PGIS process. Given that a key purpose of PGIS is to include marginal and under-represented populations, this deficiency must be addressed by increasing trust in the process, and by removing language and cultural barriers to minority participation. In this study, the sole facilitator was from the dominant Malay ethnic group. Future implementation of PGIS should include facilitators from ethnic groups that match the diversity of the target population. A complementary strategy would seek to establish cooperation with community leaders to assist in PGIS participant recruitment. Encouragement from community leaders to participate can be very effective, especially in developing countries, because people respond positively to the advice of local leaders (Ramirez-Gomez et al., 2013).

6.   CONCLUSION

As observed by Heijden and Heuvelhof (2012), effective public participation requires more than a virtuous purpose—it requires getting the mechanisms of participation right as well. In the Malaysian context, this would translate into (1) active rather than passive recruitment of public participants, (2) use of a *facilitated* mode of PGIS participation, and (3) timely feedback to participants to encourage further participation in local planning. Omar and Leh (2009) found that organized workshops appeared to be an effective method for engaging the public, thus the combination of PGIS in a facilitated workshop setting would appear ideally suited for participation. Planning authorities would organize PGIS workshops in the initial stages of plan preparation using community leaders to facilitate the recruitment of participants. The facilitated PGIS workshops should be augmented by the recruitment process described herein where PGIS mapping stations are set up in convenient locations within the planning area to expand the number and diversity of participants. The key point is that PGIS recruitment should be active, reaching out to people where they live and work without depending exclusively on planned events such as facilitated workshops. The final PGIS need—providing timely feedback to participants—is not unique to the Malaysian context, but is essential to all forms of public participation. Participants want to know how their participation influenced planning outcomes (Brown and Chin, 2013). Trust is established (or broken) through a reciprocal relationship where participants provide local knowledge and planning authorities show how the information was used in plan development.

While the legal requirements for public participation in Malaysia set minimal standards, the laws provide discretion for planning authorities to use expanded and enhanced participatory methods such as PGIS. This study demonstrated that PGIS can be an effective method to generate quality spatial information provided participant recruitment is active rather than passive, and that the PGIS process is facilitated, especially because computer and internet access and proficiency varies considerably among sociodemographic groups and regions of the country. The novelty of

PGIS as a participatory method can help stimulate first-time public participation in Malaysia, but developing a stronger culture of participation in Malaysia for land use planning will require sustained effort over time. Future research should examine how Malaysian planning authorities—the gatekeepers—view the quality and potential benefits of PGIS data to determine whether PGIS has any real prospect for decision support in land use planning compared to traditional expert-driven processes.

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