Public Private Collaboration Model in Spatial Data Infrastructure: Potential Elements

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***Abstract*—The rapid development of Geospatial Technology locally and globally spurs the development of Spatial Data Infrastructure (SDI), mainly developed to help managing the growth of spatial data. Although the use of spatial data is reported as 'vast growth', SDI initiative is still reported to be below maturity due to low quality of data in terms of completeness and consistency, non-existence of custodian policy and information sharing act, and poor human capacity. These affected the full potential of spatial data as the main source to be used in development and decision-making activities. The availability of business centric data at the private sector further encourages the effort to collaborate these entities to gauge the full potential of SDI initiative. A conceptual model is proposed to solve issues in public-private collaboration in Spatial Data Infrastructure. The conclusion on exposure, acceptance, and spatial data sharing is based on the analysis of the outcome from the interview with seven entities related to spatial data infrastructure initiative. The outcome indicates that though the use is high, effectiveness of the geospatial technology is reported low due to the quality and heterogeneous data. Furthermore, the potential elements for collaborating public and private entities are proposed to optimise the utilisation of geospatial information, and create the synergy to spur the growth, hence sustaining the SDI initiative.**

Keywords*—Public-Private Collaboration Model, Spatial Data Infrastructure, GIS, SDI, Collaboration Elements*

1. Introduction

The use and sharing of geospatial data have increased in most countries. It has become a part of human activities, where an element of geospatial is essentially used while working, travelling and planning. The use of geospatial data can be seen in a variety of fields, including land-related analysis, environment, educational, health, administrative, and government [1],[2],[3],[4].

Geospatial Information System (GIS) is a tool that can be described as an information system that captures, stores, manipulates, and displays geospatial data [5]. GIS helps to utilise sources, time, knowledge, and cost. To ensure the effectiveness of geospatial data especially in decision-making, an effective data sharing and distribution management is crucial. Thus, the concept of Spatial Data Infrastructure (SDI) has emerged to ensure the rapid growth of geospatial data is manageable [6]. SDI is a collection of technologies, policies, and institutional arrangement that facilitate the availability of and access to geospatial data [7]. Moreover, SDI provides a basis for geospatial data discovery, evaluation, and application for users and providers within all levels of public, private, non-profit sector, academia, and ordinary citizens.

Opposing from the government's viewpoints, where the focus is on developing fundamental geospatial data, most private agencies create and maintain rich value-added business centric geospatial datasets [8]. Due to the high cost in developing geospatial data, most of these data remain private and are not publicly accessible. Moreover, these data are designed to fit specific business user requirements [5]. Even though these geospatial data are mostly restricted, they are still required for enhancing the decision-making process [9],[10]. Therefore, this situation motivates most SDI adopters to collaborate with the private sector.

Existing collaboration initiatives mostly focus on geospatial data collection activities as the product-based model is especially implemented in developing countries [5],[9],[10],[11]. Parallel with the evolvement of the SDI initiative, the use has extended from merely collecting and developing geospatial data, to manipulating, value-adding, and maintaining the geospatial data [5],[9],[10],[12]. As such, collaboration initiatives have become more

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complex. In addition, relevant and accurate information mostly reside at the private sector [5],[9],[13]. Until now, the main focus of existing studies on collaboration is more towards understanding the framework, mechanism, and motivation [5],[14],[15],[16]. Focus on institutional, such as human capacity, organisation readiness, and adoption, is minimal [9]. Arising from this, the collaboration between public and private sectors is crucial, especially in developing countries, in order to help improve and sustain the SDI initiative [9],[18].

To address the current challenges and to enhance the effectiveness of the SDI, Malaysia government SDI initiative is choose as the case study. An interview with seven (7) various agencies with different roles and responsibility on GIS initiatives is conducted to gathered information on the exposure and acceptance of GIS technology and strategies in developing shared platform for geospatial data. Later, the data is analyst and based on the findings, a conclusion and suggestion is highlighted. Further, from literature review, incorporating the findings, a foundation model with potential elements are proposed.

2. Methodology

A few interviews were conducted by involving respondents from seven (7) agencies that consist of one GIS coordinator agency, five (5) main fundamental geospatial data provider agencies, and one key agency for public service delivery. Information regarding the exposure and acceptance of the GIS technology, and strategies in developing shared platform for geospatial data in their organisation are gathered. This qualitative research is selected as it provides the opportunity to obtain an in-depth understanding of the context within the exposure, acceptance, and sharing platform for geospatial data. Generally, a case study approach allows innovation and technology practice by practitioners to be studied rather than developing initial wisdom to the ideas [19]. This is further supported by [20], who highlighted on the suitability of the case study when it involves complex interactions such as advance technology, inter-organisation collaboration, and management information system.

The semi-structured interview questions, which consist of fifteen (15) questions, are listed in Table 1 and the interviewees were asked in a semi-structured format.

Table 1. List of the Interview Questions

Component	Sub-Component
(A) Exposure	Q1: Is there any specific unit/department to maintain the GIS technology in your organisation? Q2: Is there any policy implemented in handling geospatial data? Q3: Is there any standard used in managing geospatial data? Q4: Is there any geospatial data sharing culture in between your organisation? And with other agencies? Q5: Is there any collaboration between your agency and the private sector in managing geospatial data? Q6: Is your organisation have a geospatial database?
(B) Acceptance	Rating from 1 to 5, lower to most high. Q7: How do you rate your organisation's involvement in the GIS technology? Q8: How do you rate the use of geospatial data in decision-making in your organisation? Q9: What do you rate the growth of GIS technology in your organisation? Q10: How do you rate the effectiveness of GIS implementation in your organisation? Q11: How do you rate the data sharing activity in your organisation?
(C) Shared Platform Data Model	Q12: To your knowledge, is there any proper data model in geospatial data sharing activities? Q13: To your knowledge, do practitioners in Malaysia use the same standard in developing their model? Q14: In your opinion, is there a need for all agencies to share their data? Q15: In your opinion, is there a need to develop one collaborated data model to be used by all players in GIS technology?

Basically, the questions were addressed based on several factors for the purpose of the analysis. First, the questions are to identify whether GIS players are exposed to GIS technology's main components, such as availability of specific GIS units, any policy used in handling geospatial data, any standard used in developing geospatial data, the existence of sharing culture internally and with other agencies, collaboration with the private sector, and the existence of a geospatial database.

Secondly, the level of acceptance in GIS to agencies, where the second component is to rate the agencies' involvement in GIS technology, the use of geospatial data in decision-making, the growth of GIS, the effectiveness of GIS implementation, and data sharing activity. Finally, the existence of a shared platform for geospatial data sharing, such as the availability of a data sharing model, the standardizing of geospatial data standard use, and the needs of data sharing.

3. Case Study Description

The government of Malaysia had recognised geospatial information as a necessary resource that supports the economic, social, and environmental interests of the nation. The demand for accurate, up-to-date, relevant, and accessible geospatial information at the various levels of government in Malaysia is critical for the successful delivery of many government services [21],[22]. Not only in the government, the private sector has started to move towards spatially-enabled data to improve the service and support the growth of their business. The mission of the SDI initiative in Malaysia is to facilitate, coordinate, and manage the geospatial data infrastructure through the development of policies, standards, technology research and development, and skilled human resources by providing customer-focused, cost-effective, and timely delivery of geospatial data towards realizing a Spatially-Enabled Government in Malaysia [23],[24],[25]. One of the main issues in the implementation of the SDI initiative in Malaysia is the institutional problems, which include geospatial data sharing, availability of policy, and availability of good quality of geospatial data especially for decision-making [25]. This is one of the notable hurdles faced by most SDI implementers in most countries, regardless it is a developed or developing country [9],[10].

4. Analysis

Table 2 depicts a summary of the interview outcome. It can be seen that the GIS players in Malaysia are: (i) well exposed to the GIS technology; (ii) have their own specific GIS units to handle geospatial data in their organisation; (iii) follow a standard when developing their geospatial data; and (iv) appear that they are sharing their geospatial data internally and in between agencies (Q1)(Q3)(Q4). Even though they are following a standard when developing their geospatial data, there is less evidence to show that it is the same standard used among geospatial data providers.

All agencies claimed that there is no proper policy to be followed especially in data sharing activities (Q2), where it has given an impact on their services as a government agency. According to most of the respondents, usually they have to reject geospatial data requests due to data security issues. And yet, there is no collaboration with the private sector in managing the geospatial data (Q5). Additionally, it has been highlighted by a few respondents that it is preferable to have a collaboration with the private sector, especially in the utilities sector. Another finding shows that most of the agencies are still managing their geospatial data in a file-based system, while only a few are already developing their own geospatial database to manage their data (Q6).

Next, the findings also show that the level of acceptance of the GIS technology is above median. This is reflected by all respondents rating 'highest' (5) for GIS involvement (Q7), above median (3&4) for the growth of geospatial data in their organization (Q9), effectiveness of GIS implementation (Q10), and data sharing activities (Q11). On the other hand, the level of geospatial data use in decision-making is quite low (Q8), where all respondents explained that this is due to the non-existence of a policy. Therefore, only non-restricted data is available for sharing, where such data carries less information, making it unsuitable for decision-making purposes. It is explained on the conflict between the non-existing policies in Component A and the high rate on data sharing activities in Component B.

Finally, the finding in Component C shows that all agencies agree there is no proper model in sharing geospatial data in Malaysia, and most agencies are using their own standard instead of following the same standard (Q12) (Q13). It is also highly recommended by all agencies to enforce the needs on sharing geospatial data and the development of a shared platform for geospatial data (Q14) (Q15), as this helps to benefit all GIS players in terms of reducing money, effort time, and improve services.

Table 2. Respondents' Opinion on the Awareness and Exposure of Geospatial Data Sharing and the Need of a Shared Platform for Geospatial Data.

**C	Qty	*R1	*R2	*R3	*R4	*R5	*R6	*R7
(A)	1	Y	Y	Y	Y	Y	Y	N
	2	N	N	N	N	N	N	N
	3	Y	Y	Y	Y	Y	Y	N
	4	Y	Y	Y	Y	Y	Y	N
	5	N	N	N	N	N	N	N
	6	Y	N	N	N	Y	Y	N
(B)	7	5	5	5	5	5	5	NA
	8	2	2	2	3	4	3	NA
	9	4	4	3	4	5	4	NA
	10	2	4	3	4	4	4	NA
	11	3	4	4	4	3	3	NA

**C	Qty	*R1	*R2	*R3	*R4	*R5	*R6	*R7
(C)	12	N	N	N	N	N	N	N
	13	N	N	N	N	N	N	N
	14	Y	Y	Y	Y	Y	Y	Y
	15	Y	Y	Y	Y	Y	Y	Y

*Respondent **Component

In summarising the findings, although most of the agencies in Malaysia are well exposed to the GIS technology and the use of geospatial data, and have a high acceptance to this technology, the optimal and beneficial use of geospatial data, i.e. for decision-making, are far from reach. This situation is contributed by the non-existence of a sharing policy, which has made an impact on the sharing of relevant geospatial data for decision-making. The possibility of a variety of standards used due to a non-existing shared platform model is also a possible contributing factor to this.

Besides, the finding also shows that the agency that coordinates the GIS technology (*R1) reports that the effectiveness in the GIS technology is very low (rated 2 for Q10). While, the key agency for public service delivery (*R7) reported having zero exposure in the GIS technology. According to the respondents, as a streamliner, they did not develop their own data, but they are given a mandate to manage other agencies' data with minimal authority on the data. Due to this situation, it is difficult to collaborate and manage all agencies to follow the same standard and policy. Therefore, the agency that is responsible in streamlining the GIS technology needs to be given the mandate to create and govern policies related to geospatial technology and data. In short, the conceptual model for collaborating public and private sectors is strongly required for a quantum leap of the SDI initiative and to give more understanding in the future development of geospatial data that contributes to the successful implementation of the SDI initiative.

5. Discussion

The absence of a concrete policy on data sharing, quality geospatial data, an authority for coordinating agencies, and GIS as one of key agendas in the government, leaves a vacuum for the successful implementation of the SDI initiative. Even though the growth of the GIS technology and the high level of technology acceptance provide a solid basis for utilising the geospatial data for the betterment of the people and country, the lack of the abovementioned issues hampers the realisation of this. Therefore, through studies in the literature review and previous practices, and considering the findings from the result analysis, potential elements have been derived to develop a public-private collaboration model in SDI initiative. Although there are numerous factors that impact the collaboration initiative, this proposed model focuses on human capacity factors as it is one of the main contributions to ensure the fit-to-use aspect of the data for decision-making; thus, improving the quality in terms of consistency and completeness [9],[10],[26],[27]. The continuum of transforming data to information that can be used for decision-making shows the close relation between human and the output. Despite the growth in the technology of capturing, storing, and manipulating of the data, human factor contributes the most on the final output [28].

6. Collaboration Model

To ensure the fit-to-use aspect of the spatial data for decision-making, two criteria are considered the utmost important, which are the richness of the data attribute, and the interoperability of the data [29]. The richness of the attribute relates to the value-addedness of the data to ensure related and meaningful information is embedded to the specific spatial data; while interoperability explains how the same spatial data can be used with zero or minimal modification by various users with various platforms and requirements [29].

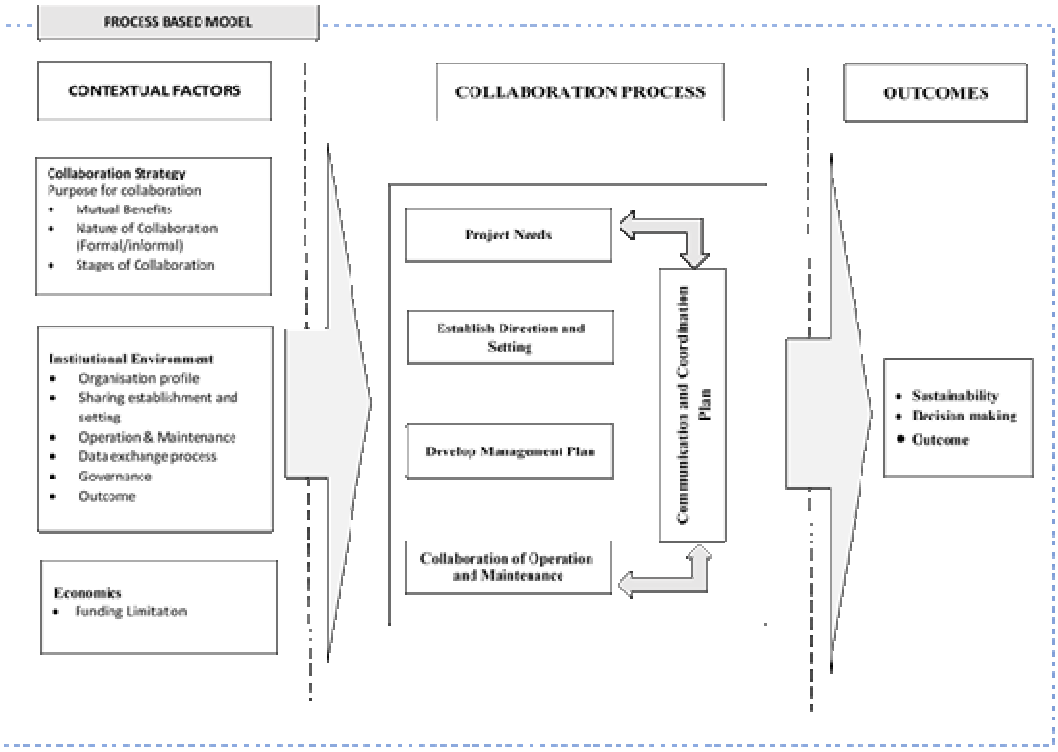

Figure 1. Foundation Model and Elements

This model is developed based on a process-based model [17],[29],[30] as a model foundation. In regards to the progress of the spatial data technology from developing the spatial data to manipulating the data for decision-making, the process-based model is compatible to ensure the effectiveness of the SDI initiative [17],[30]. This model consists of three main components: i) contextual factors; ii) collaboration process; and iii) outcomes [5]. Furthermore, a variety of authors [5],[14],[16],[31] have highlighted a number of potential elements that enable the development of the public-private collaboration model. Refer to Figure 1 for the proposed foundation model and the elements.

6.1 Contextual Factor

This is the first dimension that includes collaboration strategy [14], institutional environment [5],[31], and economics [31]. This dimension explains the needs to identify the character of the collaborating entities. In order to collaborate between different entities that have different environments and requirements, it is necessary to understand the institutional environment. Adapting from [5], a factor such as organisation profile, sharing establishment, operation and maintenance, data exchange process, governance, and outcomes were included in the variables. Besides, a collaboration strategy adopted from [14] is also implemented in the study to identify the purpose of collaboration, type of agreed mutual benefits, nature of collaboration practice, and level of collaboration. This strategy is adopted to identify the level of existing collaboration practices in the target entities [5],[16]. Nevertheless, an input on the economics factor is also crucial [31], especially in developing countries, as the cost of spatial data development is very high and often burdens the SDI implementers. As such, a constraint on economics such as funding is crucial to be adhered to ensure this constraint does not impede the collaboration initiative.

6.2 Collaboration Process

This dimension includes factors in project needs, direction setting, operation and maintenance [5],[16], management plan, communication, and coordination [17]. These factors that comprise of management, integration, archiving, and distribution can help to improve the SDI initiative. In addition, proper spatial data management and sharing help to generate high quality spatial data [32],[17]).

Most studies of the collaboration model had minimally discussed the mode of collaboration. Therefore, this study tries to fill this gap by including the mode of collaboration in the model.

Hence, two types of collaboration mode are proposed, namely Buy-up data sharing model and Roll-up data sharing model [33]. In the Buy-up model, the funding will be shared among the organisations. For example, the SDI initiative will fund a project to buy imagery data at the lowest resolution, while other entities will increase to use higher resolution imagery depending on their requirements. This model suits a large coverage data and one-time production. On the other hand, the Roll-up model is where the data is developed at the entity level and enforced by SDI in terms of standard. This model suits the ongoing data capture, such as a federal road developed by SDI that covers all states, value-added by entities based on their unique business centric data and information. These two models could help to improve the SDI initiative in terms of completeness and consistency, value-added data, standard, and funding issues [9],[10],[26],[27].

6.3 Outcome

This is the last dimension in this model, where under this dimension, several factors of performance were considered in this study, namely, sustainability, decision-making, and access [5]. These factors are included to measure the collaboration initiative.

7. Conclusion

In conclusion, the proposed model is expected to add another theoretical dimension to the current requirement on the applicability of collaborating public and private entities in SDI initiative. The findings on the applicable elements and consideration for developing the public-private collaboration model may help to provide an additional understanding to the body of knowledge for future projects on spatial data, specifically in SDI initiative. This would also lead to more studies and proposed solutions to the current limitations that hinder the full potential of any SDI initiative. Besides, it is suggested to investigate on the critical success factor that may advance or limit the collaboration and conduct an in-depth study on organisational requirement to establish a good collaboration model. Since this study is limited to federal agencies that act as a main contributor in SDI initiative, further investigation on local level agencies is crucial to observe a bigger perspective as SDI is a national level initiative. By addressing the above key obstacles, the effective collaboration between public and private sectors would be achieved; thus, help to reach the full potential, especially in improving the geospatial data quality and further sustaining the SDI initiative.

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