IOP Conf. Series: Earth and Environmental Science **494** (2020) 012004 doi:10.1088/1755-1315/494/1/012004

Towards a Collaborative Strategy for Land and Marine Geospatial Data Integration: A Review

MA Rosly*, A Ahmad*, Z Tarmidi*, Z Khair and N Zulkifli***

*Department of Geoinformation, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia

**School of Human Resource Development and Psychology, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia

adlyquantum88@gmail.com

Abstract. Malaysia is among the countries in Southeast Asia surrounded by sea, apart from Thailand, Singapore, Brunei, Indonesia, Philippines and a few others, with about 515,000 kilometres squared land at sea level skirting Malaysia along 4,809 km of coastlines. Improving the management of coastal areas is important to improve the sustainability of the areas, and one way to achieve this is through collaborative management by integrating land and marine spatial data. This paper highlights the importance of bringing in the concept of collaboration between agencies and addresses issues related to the realization of integration of dataset sharing between land and marine. The concept of collaboration, past studies related to development of collaboration strategies, issues and problems in collaboration, as well as success factors in the collaboration process are discusses in this paper to demonstrate the importance of building a collaborative strategy model to enable the integration of geospatial datasets between land and marine.

1. Introduction

The coastal area is a meeting between land and sea [1,2]. All countries located in Southeast Asia are surrounded by sea except Laos. The coastal area is a very crucial spot because it hosts a diversity of human activities such as fisheries, industrialization, exploration of natural resources, tourism and recreation, as well as transportation [3,4]. Figure 1 shows Malaysia's coastline, which includes Peninsular Malaysia, Sabah and Sarawak, where the total distance of the coastline is 4,809 km.

Figure 1. Malaysia's Coastline [5]

The surface of the coast is studied from two aspects. The first is the physical aspect and the second is the legal and institutional aspect [2]. The physical aspect of the coastal surface is very complex as it is constantly, dynamically fluctuating over a short period of time [6]. The process of change is due to natural effects such as tidal events, weather changes, as well as climate change [6]. The legislative or institutional aspect is also an important aspect of the coastal surface [2,4]. Coastal areas are managed by various agencies and departments [2]. Thus, it is inevitable that there will be an overlap between different agencies of the area [1] that can generate redundancy in the administrative process. Enforcement activities in the area also becomes difficult due to the lack of administrative area [3,7]. Moreover, there are many costs wasted due to repetition of work. This will further reduce the sustainability of the coastal areas. Therefore, coastal surfaces should be managed more effectively so that sustainable development can be achieved in the future in terms of environmental, social and economic stability in the country [8].

The objective of this paper is to review coastal zone management and some relevant issues. It discusses the concept of integrated spatial data sharing and the concept of collaboration in developing an integrated spatial data sharing between land and marine interface. This paper also highlights motivations, barriers and factors of a successful collaboration between agencies.

2. Coastal Zone Management in Malaysia

The coastal area is an important area to focus on when advancing the growth and development of a country. All states in Malaysia are surrounded by sea. For Peninsular Malaysia, the surface area of the coastal area is 131,590 km squared, with a total distance of 2,031 km [5], while for Sabah and Sarawak, the surface area is 198,160 km squared and has 2,778 km of total distance. This gives a total area of 329,750 km squared and a total distance of 4,809 km [5].

Malaysian governance comprises the federal government as well as the state governments [9]. The central administrative affairs are under the parliament while the states are under the respective state halls. Likewise, the coastal areas are governed inter-agency, the overlap occurring between agencies involved in land and marine at the governmental level and at state level [2]. The state government has jurisdiction over the coast area for the distance that extends from low-water mark up to 3 nautical miles [3], while the federal government's jurisdiction starts from the 3 nautical miles of the state's governance to the exclusive economic zone (EEZ) and the Continental Shelf [3,10].

To manage the coastal areas, there are three (3) basic issues that are of concern to policy makers, researchers, as well as involved agencies. The most important and critical issue is the natural feature of the coastal surface. As previously mentioned, the ever-changing physical characteristics of the coastal

areas result in the difficulty of determining the coastline more clearly [2]. This lack of clarity on the definition of coastal surfaces complicates the enforcement process on the coastal surface areas. Enforcement is very important to monitor marine-related activities such as fisheries, industrialization, marine crimes and marine safety [3]. That is why technical issues must be resolved in dealing with coastal administration issues and problems. In this case, the use of data is very important.

There are significant differences in the reference system of existing data, between the horizontal and vertical types of system. In addition, existing data is not based on a spatially enabled concept in which the data can provide location information to facilitate and assess the problem more clearly. Existing data also does not include the dynamics of coastal and fishery population, and biological data [4].

The next issue, those of the institutional and legal type, is very crucial because it involves organizations and agencies. The overlap between different governance levels such as the federal government, state governments and local governments [9] makes it is difficult to come up with a decision to achieve an objective. Similarly, collaboration and lack of collaboration also become one of the factors of inefficiency in the institution [2,11]. The legislation for the management and administration of existing coastal areas does not complement each other, especially when it involves two interfaces between the ground and marine surfaces [12,13]. Hence, it affects monitoring activities on coastal areas, regulation and enforcement on national security affairs, as well as the construction of policies for national development [14,15]. Therefore, the integration of data sharing would address the abovementioned issues on management and administration of coastal areas. The data becomes more meaningful and complete with spatially enabled data. Spatially enabled data should be shared between land- and marine-related agencies and would become an asset that is very important for any agency as well as policy makers [3,4,16].

3. Need for an Integrated Spatial Data Sharing

To achieve spatially enabled governance, the assemblage of spatial data should move towards an integrated partnership especially for land and marine agencies [17–19]. Nearly 80% of the existing data is based on spatially enabled data [20–23]. The various data are obtained in various ways and they evolve in accordance with the technological developments. For example, remote sensing satellites provide image data [24–26], UAVs supply RGB image-like data [27,28], GNSS satellites provide data positioning [29–32], and so on. Therefore, the data obtained by each agency should be shared between each other. This is how the concept of sharing information is spatial, or known as spatial data sharing.

3.1. Spatial Data Sharing Concept

The concept of spatial data sharing constitutes a framework that includes data, policies, standards, technology and people as pillars in the exchange of data [33,34]. Spatial data infrastructure (SDI) was created to facilitate administrative affairs by reducing the efforts in the process of obtaining high-cost spatial data [3,9,17]. With SDI, the data can be coordinated with each other in terms of quality and accuracy. Additionally, the infrastructure can reduce duplication of agency resources such as human resources, finance and effort [6,35,36]. Indirectly, the partnership process can create collaboration which helps in achieving the objectives of the agencies involved [17,37].

In the management and administration of coastal areas, the spatial data used is more complex [38,39]. Hence, there is a need to create an integrated spatial data sharing to bridge the gap between terrestrial surface spatial data and the marine spatial data [4,40]. So far, existing spatial data sharing exists separately between the land and marine. Thus, with the integrated data sharing, spatial data can be stored continuously and seamlessly across governance and jurisdictions.

3.2. Integrated Spatial Data Sharing Concept

The purpose of SDI is to produce seamless data exchange [33]. However, existing SDI works in separate environments [4]. This problem affects the homogeneity of the data exchange on coastal environment. Previously, SDI had focused on land or terrestrial environment. After that, marine SDI was proposed as an extension of land SDI which covered the marine interface. As a result, SDI could not achieve its main objective and purpose. The enhancement and integration of the existing SDI should focus highly on the coastal environment to achieve the integrated spatial data sharing. Because the coastal environment spatial data is complex due to dynamically marine changes, most of the data should be updated short-term, rather than depending on land-based data. Figure 2 shows the essential components of the spatial data sharing concept.

Figure 2. Spatial Data Sharing Concept [3]

3.3. Development of Integrated Spatial Data Sharing

In enhancing and upgrading the existing SDI to achieve an integrated SDI, each fundamental component of SDI should be viewed and understood in its entirety. Table 1 shows the issues and strategies to integrate land and marine spatial data sharing according to each component.

Table 1: Issues and Strategies to Integrate Land and Marine Spatial Data Sharing [2–4]

Component	Issues	Integration Strategies
Data Framework	-Separate datum between the two interfaces -Different accuracy and quality -Different scale and format of data	-Provide standards on spatial data collection -Provide standards on spatial data accuracy and integrity
Data Standard	-Separate standards between land and hydrography data	-Malaysia's national standard should comply with the international standard
People	-Lack of collaboration between stakeholders -Lack of understanding and awareness of spatial data integration	-Should have a clear collaboration and engagement -Should have clear and effective communication
Policies	-Unalignment between agencies' policies	-Should have unified and seamless policies among agencies
Technologies	-Technologies not interoperable between agencies	- Need to centralize and synchronize the data exchange system or framework

4. Collaborative Integrated Spatial Data Sharing

Previous studies focused on separate interfaces such as land-based agencies and marine-based agencies. To achieve an integrated spatial data sharing between land and marine agencies, it is important to have a collaborative partnership. Collaboration is a key factor for the success of developing and maintaining spatial data sharing, particularly for an integrated environment [3,37]. The cooperation must be between those from various backgrounds and disciplines working towards the same objective [3], which is sustainable development. With that, efficient and applicable management could be accomplished, and human resources, financing and funding and added value to the data could also be achieved from the collaborative environment.

4.1. Collaborative Concept

There are various definitions of collaboration. Initially, it could be defined as agencies participating to reach the same goal and achievement [10,11]. Collaboration can also be defined as cooperation between agencies in resolving an issue [41,42]. Essentially, collaboration is the process of building an understanding between participators and agencies in achieving the same objective.

4.2. Motivations of Collaboration

It is important to identify the motivations of forming a collaboration. Several motivations in a collaboration process have been identified from previous studies, the major motivations being technical competence, absorptive capacity and organizational extension [43]. Internal motivation among participants [44] and trust between agencies and willingness to participate [45,46] have also been highlighted as motivations of collaboration.

In order to strengthen the engagement between agencies, effective communication between the participants should be implemented such as the enhancement of dialogues and interactions [47]. This is essential to build trust and good relationship among agencies [48]. The technological aspect is also important in motivating the collaboration process. The key to a successful collaboration in this aspect is interoperability whereby information can be shared among various agencies [49,50]. The decision-making process could also be optimized.

4.3. Barriers of Collaboration

Before developing a collaborative environment, it is essential to identify the barriers and issues that have hampered, and would hamper, the collaboration process. Based on previous studies, the major issues and barriers are limited resources of the organizations, unbalance in stakeholder power and opposed objectives [41,42]. All these barriers could be categorized as institutional barriers.

Meanwhile, some of the policy issues are low capacity for collection region, absence of concrete policy on data sharing, quality of the geospatial data, appointment of authority for the coordinator agency, right of privacy and confidentiality and lack of awareness of open data and its benefits [42]. The technical barriers that have been identified are lack of ability to access the data, lack of quality of the data and messy data format and lack of data exchange standardization [7]. All of the barriers identified above should be minimized and understood carefully in order to build collaboration in spatial data sharing in the integrated environment.

4.4. Factors of a Successful Collaboration

In order to overcome the barriers in collaboration, it is important to understand what makes a successful collaboration. Based on previous studies, trust among agencies, balancing of power, shared common vision, clear understanding among agencies and existence of leadership can be identified as successful factors in building a collaboration [3,11,41,48]. Another study also highlighted that a successful

collaboration in spatial data sharing should have a mutual understanding, having a lead agency and representative among agencies [3,11].

Another study showed that goodwill, transparency, mutual needs and organizational culture are necessary for the success of a collaboration [37,41], and so are defined business goals and technical capacity [41].

4.5. Strategies to Overcome the Barriers in Collaboration

Based on the synthesis of the previous studies, strategies to overcome the barriers of collaboration can be formulated. The first strategy is to identify the capacity of the agencies in both the organizational and technical aspects [3,11]. With this, issues such as financial constraints could be resolved properly. In addition, the process of establishing an engagement requires defined goals, trust and, most importantly, transparency [37,41]. This process should be accomplished through effective communication among the agencies so as to overcome issues like opposed objectives among agencies [19].

In the collaboration process, having a lead agency is very important to establish structure among the agencies [3]. This would also solve the barrier of unbalanced power among agencies. The lead agency should arrange a clear and effective communication in terms of the medium and interoperability of the system to communicate among agencies [48]. Improvement of knowledge is another strategy to overcome the barriers in collaboration [42]. It can be divided into two (2) aspects: organizational and technical. In term of organization, awareness among the agencies should be improved especially on the importance of spatial data sharing, while from the technical aspect, skills and understanding of the system's operation should be developed and improved as well.

5. Conclusion

Coastal zone management should be understood properly especially in terms of spatial data sharing among agencies. It is important to have an integrated spatial data sharing between land and marine interfaces, and its implementation would enable coastal sustainability for the community. Agencies should have a strong desire to collaborate with each other through an integrated spatial data sharing. Developing collaborative strategies, understanding the motivations, and identifying the barriers and factors of a successful collaboration should be undertaken between the agencies. The collaborative strategies could be applied to improve the integrated spatial data sharing, and with a solid sharing environment, coastal issues could be resolved properly.

6. References

[1] Longhorn R A 2004 Coastal spatial data infrastructure *GIS Coast. Zo. Manag.* 1–14
[2] Idrees M O I 2015 Challenges in coastal spatial data infrastructure implementation: A review *South African J. Geomatics* **4** 369–83
[3] Tarmidi Z M 2016 *Enabling Marine Spatial Data Sharing In Malaysia Using A Collaboration Model* (Universiti Putra Malaysia)
[4] Vaez S S 2010 *Building a seamless SDI model for land and marine environments* (Citeseer)
[5] Department of Irrigation and Drainage 2017 Coastal Management
[6] Vaez S S, Rajabifard A and Williamson I 2009 Seamless SDI Model–Bridging the Gap between Land and Marine Environments *SDI Converg.* **239**
[7] Tarmidi M Z, Shariff A R M, Ibrahim Z Z, Mahmud A R and Hamzah A H 2014 Issues and challenges in managing Malaysia's marine spatial information sharing *XXV International Federation of Surveyors Congress 2014*
[8] Christie P 2005 Is Integrated Coastal Management Sustainable? *Ocean Coast. Manag.*
[9] Hamzah A H, Mohamed Shariff A R, Mahmud A R, Nik Yusof N M Z and Mohd Ali H 2010 Data Sharing Issues in SDI Implementation at National Land Administration For Country Multi-Government *GSDI 12 World Conference* pp 1–10
[10] Abdullah N M, Omar A H and Yaakob O 2016 Today's problem, tomorrow's solutions:

Lay theory explanations of marine space stakeholder management in the Malaysian context *Mar. Policy* **73** 162–71
[11] Abdullah N M, Omar A H, Desa G and Rambat S 2015 Towards the development of a framework for sustainable marine space governance: A proposal for collaborative design approach *J. Teknol*
[12] Smallwood C B and Beckley L E 2012 Spatial distribution and zoning compliance of recreational fishing in Ningaloo Marine Park, north-western Australia *Fish. Res.*
[13] Davis K, Kragt M, Gelcich S, Schilizzi S and Pannell D 2015 Accounting for enforcement costs in the spatial allocation of marine zones *Conserv. Biol.*
[14] Jentoft S and Chuenpagdee R 2009 Fisheries and coastal governance as a wicked problem *Mar. Policy*
[15] Nursey-Bray M J, Vince J, Scott M, Haward M, O'Toole K, Smith T, Harvey N and Clarke B 2014 Science into policy? Discourse, coastal management and knowledge *Environ. Sci. Policy*
[16] Masser I, Rajabifard A and Williamson I 2008 Spatially enabling governments through SDI implementation *Int. J. Geogr. Inf. Sci.*
[17] Marwick B 2012 A framework for a national land information infrastructure *A Natl. Infrastruct. Manag. L. Inf.*
[18] McDougall K and Professor Iams Williamson and Dr A R 2006 A Local-State Government Spatial Data Sharing Partnership Model to Facilitate SDI Development *Dep. Geomatics, Sch. Eng. Cent. SDI L. Adm.* **PhD Thesis** 332 pages
[19] McDougall K, Rajabifard A and Williamson I P 2005 What will motivate local governments to share spatial information? *Proceedings of the 2005 Spatial Sciences Institute Biennial Conference 2005: Spatial Intelligence, Innovation and Praxis (SSC2005).*
[20] Densham P J and Goodchild M F 1989 Spatial decision support system: A research agenda *GIS/LIS'89*
[21] Li Q and Li D 2014 Big data GIS *Wuhan Daxue Xuebao (Xinxi Kexue Ban)/Geomatics Inf. Sci. Wuhan Univ.*
[22] Lee J G and Kang M 2015 Geospatial Big Data: Challenges and Opportunities *Big Data Res.*
[23] Liu Z, Guo H and Wang C 2016 Considerations on Geospatial Big Data *IOP Conference Series: Earth and Environmental Science*
[24] Ma Y, Wu H, Wang L, Huang B, Ranjan R, Zomaya A and Jie W 2015 Remote sensing big data computing: Challenges and opportunities *Futur. Gener. Comput. Syst.*
[25] Zhang L, Zhang L and Kumar V 2016 Deep learning for Remote Sensing Data *IEEE Geosci. Remote Sens. Mag.*
[26] Liu J, Li J, Li W and Wu J 2016 Rethinking big data: A review on the data quality and usage issues *ISPRS J. Photogramm. Remote Sens.*
[27] Luo F, Jiang C, Yu S, Wang J, Li Y and Ren Y 2017 Stability of Cloud-based UAV Systems Supporting Big Data Acquisition and Processing *IEEE Trans. Cloud Comput.*
[28] Mohamed N, Al-Jaroodi J, Jawhar I, Noura H and Mahmoud S 2018 UAVFog: A UAV-based fog computing for Internet of Things *2017 IEEE SmartWorld Ubiquitous Intelligence and Computing, Advanced and Trusted Computed, Scalable Computing and Communications, Cloud and Big Data Computing, Internet of People and Smart City Innovation, SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI 2017 -*
[29] Praveen P, Jayanth Babu C H and Rama B 2016 Big data environment for geospatial data analysis *Proceedings of the International Conference on Communication and Electronics Systems, ICCES 2016*
[30] Chen H, Jiang W, Ge M, Wickert J and Schuh H 2014 An enhanced strategy for GNSS data

processing of massive networks *J. Geod.*
[31] Rizos C, Lim S, Musa T A, Ses S, Sharifuddin A and Zhang K 2009 Atmospheric remote sensing using GNSS in the Australasian Region: From temperate climates to the tropics *International Geoscience and Remote Sensing Symposium (IGARSS)*
[32] Norazmi M F Bin, Opaluwa Y D, Musa T A and Othman R 2014 The Concept of Operational Near Real-Time GNSS Meteorology System for Atmospheric Water Vapour Monitoring over Peninsular Malaysia *Arab. J. Sci. Eng.*
[33] GSDI 2004 *Developing Spatial Data Infrastructures: The SDI Cookbook*
[34] Rajabifard A 2010 Data Integration and Interoperability of Systems and Data *Crit. issues Glob. Geogr. Inf. Manag. with a Detail. Focus. Data Integr. Interoperability Syst. Data* 1–14
[35] Nebert D D and others 2004 Developing spatial data infrastructures: The SDI Cookbook *GSDI Assoc. http//www. gsdi. org/docs2004/Cookbook/cook-bookV2. 0. pdf* 19
[36] Strain L, Rajabifard A and Williamson I 2006 Marine administration and spatial data infrastructure *Mar. Policy* **30** 431–41
[37] McDougall K 2006 A Local-State Government Spatial Data Sharing Partnership Model to Facilitate SDI Development *Dep. Geomatics, Sch. Eng. Cent. SDI L. Adm*
[38] Paiman T and Asmawi M Z 2015 The Practice of Coastal Management Initiatives in Using Geographical Information System in Selangor, Malaysia *3rd Int. Conf. Biol. Chem. Environ. Sci.* 23–8
[39] Paiman T and Asmawi M Z 2017 GIS APPLICATION IN COASTAL MANAGEMENT: THE PERSPECTIVES OF GOVERNMENT AGENCIES IN SELANGOR *Plan. Malaysia J.* **15**
[40] Vaez S, Rajabifard A, Binns A and Williamson I 2007 Seamless SDI Model to Facilitate Spatially Enabled Land Sea Interface *The National Biennial Conference of the Spatial Sciences Institute, Proceedings of SSC*
[41] Warnest M and Rajabifard P I W and D A 2005 A Collaboration Model for National Spatial Data Infrastructure In Federated Countries *Dep. Geomatics, Sch. Eng. Cent. SDI L. Adm.* **PhD Thesis** 279 pages
[42] Alshehri S A F 2011 National spatial data infrastructure collaboration for the Kingdom of Saudi Arabia
[43] Kamal M R, Singh, Dalbir Singh V and Ahmad K 2012 Factors Influencing Interdepartmental Information Sharing Practice In Electronic Government Agencies *Knowl. Manag. Int. Conf.* 4–6
[44] Juell-Skielse G and Enquist H 2012 *Re-conceptualizing Enterprise Information Systems*
[45] Wheeler P and Peterson J 2010 Exploring stakeholder views regarding spatial information and enabling technology use for ICZM: A case study from Victoria, Australia *Coast. Manag.* **38** 1–21
[46] Toots M 2016 ICT-Driven Co-Creation in the Public Sector: Drivers, Barriers and Success Strategies *Electron. Gov. Electron. Particip.* **23** 368–75
[47] Pomeranz E F, Needham M D and Kruger L E 2013 Stakeholder Perceptions of Indicators of Tourism Use and Codes of Conduct in a Coastal Protected Area in Alaska *Tour. Mar. Environ.* **9** 95–115
[48] Tarmidi Z M, Shariff A R M, Mahmud A R, Ibrahim Z Z and Hamzah A H Integration of collaboration framework for enabling marine spatial information sharing
[49] Gourmelon F, Le Guyader D and Fontenelle G 2014 A Dynamic GIS as an Efficient Tool for Integrated Coastal Zone Management *ISPRS Int. J. Geo-Information*
[50] Georis-Creuseveau J, Claramunt C and Gourmelon F 2017 A modelling framework for the study of Spatial Data Infrastructures applied to coastal management and planning *Int. J. Geogr. Inf. Sci.*

7. Acknowledgements
The author gratefully acknowledges the Ministry of Education for sponsoring this article as part of a research under the MyBrain15 scholarship. The author sincerely thanks all referees for their suggestions to improve the manuscript.