

# **UNIVERSITI PUTRA MALAYSIA**

ENABLING MARINE SPATIAL DATA SHARING IN MALAYSIA USING A COLLABORATION MODEL

**MOHAMMAD ZAKRI BIN TARMIDI** 

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By

MOHAMMAD ZAKRI BIN TARMIDI

Thesis Submitted to the School of Graduates Studies, Universiti Putra Malaysia in Fulfilment of the Requirements of the Degree of Doctor of Philosophy

June 2016

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

# ENABLING MARINE SPATIAL DATA SHARING IN MALAYSIA USING A COLLABORATION MODEL

By

#### MOHAMMAD ZAKRI BIN TARMIDI

#### June 2016

#### Chairman: Associate Professor Abdul Rashid Mohammed Shariff, PhD

#### **Faculty: Engineering**

Spatial data sharing has become important in managing sustainable planning and development of marine areas, which involve the GIS implementation in the organization, at national and regional level. However, there are limitations in implementing spatial data sharing especially from institutional aspects including institutional collaboration, in identifying stakeholders, understanding their jurisdictions, and GIS capacity in facilitates spatial data sharing. The institutional collaboration involves organizational management in implementing GIS and partnership engagement between marine organizations. This research is an attempt to develop a conceptual collaboration model to enable spatial data sharing in Malaysia's marine organizations, which integrate three disciplinarians knowledge's; marine GIS, marine SDI and collaboration engagement process. For data collection and analysis, an exploratory sequential mixed method design was selected. Exploratory sequential mixed method design combined qualitative-quantitative study in data collection and analysis sequentially. This method analysis combined case studies as qualitative method and survey as a quantitative method for data collection and analysis sequentially. Case studies method used semi-structured interview as data collection instrument, with aim to identify the critical issues in implementing GIS and spatial data sharing in Malaysia's marine organizations. The interview was conducted with sixteen respondents from eleven organizations from Malaysia's marine and coastal agencies. Thematic and Strength, Weakness, Opportunities and Threats (SWOT) analyses was selected to categories the critical issues and limitations in marine GIS and spatial data sharing implementation, especially in organizational management and technical aspects. Themes analysis was selected to categorized each issues into specific themes, and SWOT analysis selected to categorized the issues into internal (Strength and Weakness) and external (Opportunities and Threats) factors that affecting marine spatial data sharing in Malaysia. The results of case studies show that there were critical issues in GIS implementation in the organizations, issues in organizational implementation and partnership engagement to enable spatial data sharing within and between marine organizations. For survey method, questionnaire was selected as an instrument for data collection, with aim to identify the critical issues in GIS and spatial data sharing implementation and the relationship between these issues with the implementing of spatial data sharing and partnership engagement. The questionnaire was sent to 48 marine organizations in Malaysia, and received 84.4% overall response. Results from questionnaire was analyse in two part, descriptive and inferential analysis. Descriptive analysis used to understand respondent's background and knowledge in implementing GIS. Results show 86.8% respondents used GIS more than 3 years, 7.9% using GIS less than a year and 2.6% used GIS between one to two years. Results also shows most of respondents understand the importance of spatial data sharing, with 60.5% understand the definition of spatial data sharing, 68.4% aware on the circular on spatial data sharing, 63.1% have knowledge on MaCGDI role, but not aware on the MyGDI implementation (36.84%). For inferential analysis, the results show correlation between respondent's duration time using GIS with respondent's knowledge on GIS (r = -0.373, p < 0.05) with r critical = 0.321. Besides that, the results also show the significant correlation between respondent's knowledge on GIS data with knowledge on GIS technologies (r = 0.665, p < 0.05) with r critical is 0.321 for n = 38. The results also shows the correlation between respondent's knowledge on GIS with the implementation of spatial data sharing (r = 0.671, p < 0.05, n = 38) where r critical is 0.321. The next result show there is significant correlation between spatial data sharing implementation with cooperation in the organization (r = 0.729, p < 0.05) for r critical is 0.321 for n = 38. The last result show correlation between spatial data sharing implementation with collaboration with other organizations (r = 0.636, p < 0.01) where r critical is 0.321 at n = 38. Results from the questionnaire showed the issues with spatial data sharing implementation is on institutional and partnership engagement, and shows the significance of collaboration process between organizations and the need for proper planning on GIS in the organization to successfully implement marine spatial data sharing in Malaysia. Findings from result of mixed method shows there were five indicators in enabling spatial data sharing between Malaysia's marine organizations; (1) spatial enablement and GIS knowledge improvement, (2) the need for GIS strategic planning and development, (3) the need for effective communication within organization, (4) the need of knowledge on spatial data sharing and (5) partnership engagement in enabling spatial data sharing. From the findings, a conceptual collaboration model was proposed to facilitate the marine spatial data sharing, which consist of three main components: (1) marine GIS strategic planning, (2) marine SDI strategies and (3) collaboration strategy. Marine GIS strategic planning consists of four indicators; GIS people empowerment, GIS technologies improvement, GIS data improvement and GIS organizational empowerment. Marine SDI strategies consists of five indicators; people, data, technologies, policies and standard. Collaboration strategy consists of three main indicators; collaboration engagement, capacity building and information management. The proposed collaboration model then was validated using Delphi method, which gets opinion from expert group, on the usability and practicality of the model in Malaysia. Output from the Delphi method shows that the experts agreed that the collaboration model is practical and able to be implemented in Malaysia. This model has important theoretical strength because it explicitly framed the relationship between internal ability of organization in implementing GIS and spatial data sharing and the external ability of collaboration between organizations. This model will be useful and of interest to marine organizations communities that use spatial data and GIS to facilitate their usage.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

### MEMBOLEHKAN PERKONGSIAN DATA SPATIAL MARIN DI MALAYSIA MENGGUNAKAN MODEL KOLABORASI

Oleh

#### MOHAMMAD ZAKRI BIN TARMIDI

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#### Pengerusi: Profesor Madya Abdul Rashid Mohammed Shariff, PhD

Fakulti: Kejuruteraan

Perkongsian data spatial telah menjadi penting dalam pengurusan lestari untuk perancangan dan pembangunan kawasan marin, yang melibatkan perlaksanaan GIS dalam organisasi, di peringkat nasional dan serantau. Akan tetapi, terdapat kekangan dalam perlaksanaan perkongsian data spatial terutamanya dari aspek institusi yang melibatkan pengurusan organisasi dalam perlaksanaan GIS dan dalam penglibatan kerjasama antara organisasi marin. Penyelidikan ini adalah usaha untuk membina model konseptual kolaborasi bagi membolehkan perkongsian data spatial antara organisasi marin di Malaysia, yang menggabungkan tiga disiplin ilmu; marin GIS, marin SDI dan proses penglibatan kolaborasi. Untuk tujuan pengumpulan dan analisis data, kaedah rekabentuk campuran penerokaan dipilih, yang menggabungkan kaedah kajian kes dan tinjauan untuk pengumpulan dan analisis data secara berturut-turut. Kaedah kajian kes menggunakan temubual separa berstruktur sebagai instrumen pengumpulan data, dengan tujuan untuk mengenalpasti isu kritikal dalam perlaksanaan GIS dan perkongsian data spatial di antara organisasi marin di Malaysia. Temu bual telah dilakukan dengan enam belas responden daripada sebelas organisasi marin dan pantai di Malaysia. Analysis tema dan SWOT telah dipilih untuk membahagikan mengikut kategori isu-isu kritikal dan kekangan dalam perlaksanaan marin GIS dan perkongsian data spatial, terutamanya dalam aspek pengurusan organisasi dan teknikal. Hasil analisis kajian kes menunjukkan terdapat beberapa isu kritikal dalam perlaksanaan GIS dalam organisasi, isu dalam perlaksanaan pengurusan organisasi dan penglibatan kerjasama untuk melaksanakan perkongsian data spatial di dalam dan di antara organisasi marin. Untuk kaedah tinjauan pula, kali selidik telah dipilih sebagai instrument pengumpulan data, dengan tujuan untuk mengenalpasti isu kritikal dalam perlaksanaan GIS dan perkongsian data spatial, dan perhubungan antara isu-isu ini dengan perlaksanaan perkongsian data spatial dan keterlibatan kerjasama. Kaji selidik telah dihantar kepada 48 organisasi marin di Malaysia, dan mendapat respon 84.4% secara keseluruhannya. Analisis deskriptif digunakan untuk memahami latarbelakang dan pengetahuan responden dalam perlaksanaan GIS. Keputusan menunjukkan 86.6% responden menggunakan GIS lebih dari 3 tahun, 7.9% menggunakan GIS kurang dari setahun dan 2.6% menggunakan GIS antara satu hingga dua tahun. Keputusan juga menunjukkan kebanyakan dari responden memahami keperluan untuk melakukan perkongsian data spatial, dengan 60.5% memahami definisi perkongsian data spatial, 68.4% meyedari pekeliling untuk perkongsian data spatial, 63,1% mempunyai pengetahuan berkenaan peranan MaCGDI, tapi tidak mempunyai menyedari tentang perlaksanaan MyGDI(36.8%). Untuk analisis inferential, keputusan menunjukkan terdapat perhubungan antara masa penggunaan GIS dengan pengetahuan responden berkenaan GIS (r = -0.373, p < 0.05) dengan kritikal r = 0.321. Selain itu, keputusan juga menunjukkan terdapat hubungan yang signifikan antara pengetahuan berkenaan data GIS dengan pengetahuan dengan teknologi GIS (r = 0.665, p < 0.05) dengan kritikal r 0.321 untuk n = 38. Keputusan juga menunjukkan perhubungan antara pengetahuan berkenaan GIS dengan perlaksanaan perkongsian data spatial (r = 0.671, p < 0.05, n = 38) dengan r kritikal adalah 0.321. Keputusan seterusnya menunjukkan terdapat perhubungan antara perlaksanaan perkongsian data spatial dengan kerjasama dalam organisasi (r = 0.729, p < 0.05) untuk r kritikal adalah 0.321 untuk n = 38. Keputusan terakhir menunjukkan perhubungan antara perlaksanaan perkongsian data spatial dengan kolaborasi dengan organisasi lain (r = 0.636, p < 0.01) di mana r kritikal adalah 0.321 pada n = 38. Hasil daripada soal selidik ini menunjukkan terdapat beberapa isu dalam perlaksanaan perkongsian data spatial, iaitu isu institusi dan penglibatan kerjasama, dan ianya juga menunjukkan kepentingan untuk proses kolaborasi antara organisasi dan juga perancangan teliti untuk GIS dalam organisasi untuk menjayakan perlaksanaan perkongsian data spatial di Malaysia. Penemuan daripada hasil kaedah rekabentuk campuran ini menunjukkan terdapat lima indikator untuk melaksanakan perkongisan data spatial antara organisasi marin di Malaysia: (1) penambahbaikan keupayaan spatial dan pengetahuan GIS, (2) keperluan untuk perancangan dan pembangunan strategik GIS, (3) keperluan untuk mempunyai komunikasi berkesan dalam organisasi, (4) keperluan untuk keupayaan pengetahuan berkenaan perkongsian data spatial, dan (5) penglibatan kerjasama dalam melaksanakan perkongsian data spatial. Daripada penemuan ini, satu model konseptual kolaborasi telah dicadangkan untuk membantu perkongsian data spatial marin, yang mengandungi tiga komponen utama; (1) perancangan strategik marin GIS, (2) strategi marin SDI dan (3) strategi kolaborasi. Perancangan strategik marine GIS mengandungi empat indikator; memperkasakan personel GIS, penambahbaikan teknologi GIS, penambahbaikan data GIS dan memperkasakan organisasi GIS. Strategi marine SDI mengandungi lima indicator; personel, data, teknologi, polisi dan standard. Strategi kolaborasi pula mengandungi empat indicator; penglibatan kerjasama, penbinaan keupayaan, pengurusan maklumat dan komunikasi berkesan. Model kolaborasi yang dicadangkan disahkan menggunakan kaedah Delphi, yang mana pendapat daripada sekumpulan pakar diambil kira, dari segi kebolehgunaan dan praktikal untuk perlaksaan model tersebut di Malaysia. Hasil daripada kaedah Delphi menunjukkan kumpulan pakar ini bersetuju dengan tahap praktikal model ini dan kebolehgunaan model ini di Malaysia. Model ini memberikan sumbangan untuk pembangunan SDI. Dari segi teori, model ini mempunyai kekuatan yang penting kerana ianya menjelaskan perhubungan antara keupayaan dalaman organisasi dalam melaksanakan GIS dan perkongsian data spatial, serta kebolehan luaran oleh kolaborasi antara organisasi.

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I certify that a Thesis Examination Committee has met on 28 June 2016 to conduct the final examination of Mohammad Zakri Tarmidi on his thesis entitled "Enabling Marine Spatial Data Sharing in Malaysia Using a Collaboration Model " in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

# **Desa Ahmad, PhD** Professor Ir Faculty of Engineering Universiti Putra Malaysia

(Chairman)

#### **Biswajeet Pradhan, PhD**

Assoc Prof Faculty of Engineering Universiti Putra Malaysia (Internal Examiner)

#### Mohammad Firuz Bin Ramli, PhD Assoc Prof

Department of Environmental Science Faculty of Environmental Studies Universiti Putra Malaysia (Internal Examiner)

# Abbas Rajabifard, PhD

Professor University of Melbourne Australia (External Examiner)



**ZULKARNAIN ZAINAL, PhD** Professor and Deputy Dean School of Graduate Studies Universiti Putra Malaysia

Date: 23 August 2016

This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

# Abdul Rashid Mohamed Shariff, PhD

Associate Professor Faculty of Engineering Universiti Putra Malaysia (Chairman)

# Ahmad Rodzi Mahmud, PhD Associate Professor Faculty of Engineering Universiti Putra Malaysia

# Zelina Zaiton Ibrahim, PhD

(Member)

Associate Professor Faculty of Environmental Studies Universiti Putra Malaysia (Member)

# **BUJANG BIN KIM HUAT, PhD** Professor and Dean School of Graduate Studies Universiti Putra Malaysia

Date:

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Abdul Rashid Mohamed Shariff, PhD Chairman of Supervisory Committee

Ahmad Rodzi Mahmud, PhD Member of Supervisory Committee

Zelina Zaiton Ibrahim, PhD Member of Supervisory Committee

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# LIST OF ABBREVIATIONS

ANZLIC	Australia and New Zealand Land Information Council		
APSDI	Asia-Pacific Spatial Data Infrastructure		
ARSM	Malaysian Remote Sensing Agency		
ASDI	Australia Spatial Data Infrastructure		
BGS	British Geological Survey		
CoE	Centre of Excellence		
CSDI	Canada Spatial Data Infrastructure		
DASN	National Environmental Policy		
DEM	Digital Elevation Model		
EBM	Ecosystem-Based Management		
EB-MSM	Ecosystem Based Marine Geospatial Management		
EEZ	Exclusive Economic Zone		
EIA	Environmental Impact Assessment		
ETeMII	European Territorial management Information Infrastructure		
FGDC	Federal Geographic Data Committee		
FIG	International Federation of Surveyor		
G2G	Government to Government		
GIS	Geographic Information System		
GNSS	Global Navigation Satellite System		
GPS	Global Positioning System		
ICSM	Intergovernmental Committee on Surveying and Mapping		
ІСТ	Information and Communication Technologies		
ICZM	Integrated Coastal Zone Management		
IDS	Integrated Data System		
IHO	International Hydrographic Organization		
INSPIRE	Infrastructure for Spatial Information in Europe		
IOC	The International Oceans Commission		
IS	Information System		
ISMP	Integrated Shoreline Management Plan		
IT	Information Technology		
IWK	Indah Water Consortium		

JMM	Malaysian Meteorological Department
JUPEM	Department of Survey and Mapping Malaysia
MaCGDI	Malaysian Centre of Geospatial Data Infrastructure
Marine SDI	Marine Spatial Data Infrastructure
MGDI	Marine Geospatial Data Infrastructure
MKN	National Security Council
MoA	Ministry of Agriculture
MOSTI	Ministry of Science, Technology and Innovation
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MSP	Marine Spatial Planning
MyGDI	Malaysian Geospatial Data Infrastructure
MyNODC	Malaysian National Oceanographic Data Centre
NOAA	National Oceanic and Atmospheric Administration
NOD	National Oceanographic Directorate
NSDI	National Spatial Data Infrastructure
OGC	Open Geospatial Consortium
OSA	Official Secret Act
PCGIAP	Permanent Committee on GIS Infrastructure for Asia and the Pacific
PHN	National Hydrographic Centre
PSMA	Public Sector Mapping Agency Inc.
R&D	Research and Development
ROI	Returns on investment
SDI	Spatial Data Infrastructure
SWOT	Strength, Weakness, Opportunity and Threats
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
UMT	Universiti Malaysia Terengganu
UNCLOS	United Nation Convention on the Law of the Sea
VHF	Very High Frequency
WWW	World Wide Web
XML	Extensible Markup Language



## **CHAPTER 1**

#### **INTRODUCTION**

## 1.1 Introduction

Marine areas cover almost two-thirds of the Earth. These marine areas possess abundant resources which require proper management and conservation in order to sustain and optimize the resources for the future (UN (2012). The marine areas are responsible for providing source of food, hydroelectric power supply, medium of transportation as well as oil and gas, among others. Hence, these resources must be well-managed to ensure the optimum usage and minimal wastage. Given the diversity contained in these areas, there are economic, social and environmental needs to effectively manage it (Binns et al., 2003).

However, management of marine information is challenging due to the integration of important issues, including the institutional management and arrangement, legal and technology-related problems (Sutherland & Nichols, 2006). Issues associated with institutional management include the cooperation and agreement between agencies, complex web of national and international government legislation, and delimitation of boundaries (Binns et al., 2005). Technically, a good information system is needed to manage all resources with proper data collection, storage and detailed database to ensure smooth integration of spatial and non-spatial data.

Osborne and Pepper (2007a) proposed a specialized marine-based spatial data infrastructure to enhance marine administration and management by enabling data sharing between organizations, namely land, coastal and marine management stakeholders. Marine spatial data infrastructure (SDI) encompasses the policies, technologies, standards and human resources necessary for effective collection, management, access, delivery and utilization of geospatial marine data in a global community (Coleman & McLaughlin, 1998). Some of the data that can be gathered and determined from the marine environment include international maritime boundaries, internal maritime boundaries, federal/state boundaries, administrative and jurisdictional boundaries as well as tenure boundaries (Rajabifard, 2004). The data is obtained from several agencies, including government, private, research and educational institutions for different objectives and purposes.

Malaysia has developed Malaysian Geospatial Data Infrastructure (MyGDI) to enable spatial data sharing between Malaysian land organizations. MyGDI is intended to enhance awareness about data availability and improve access to spatial information by facilitating data sharing among participating agencies (Hanifah, 2012). MyGDI started as National Land Information System (NaLIS), focusing on land information, and currently there are plans to include marine organizations as part of MyGDI stakeholders.

To enable marine spatial data sharing in Malaysia, several issues must be managed, including policy, legal, technical and institutional aspects (Abdullah et al., 2015a).

Policy issues are related to complexity of rights, restrictions and responsibilities in managing and administering marine areas that requires alignment between marine spatial data sharing policy with national policy practiced by the specified country. On the other hand, technical issues involve baseline for spatial data, complicated three-dimensional nature of marine areas and issues related to maintenance of spatial data.

As for legal issues, major constraints include the complex web of state and Commonwealth legislation, in addition to the need to have a GIS-based person to write and define the boundaries. Enforcement is another big problem, but it was resolved with the establishment of Malaysian Maritime Enforcement Agency (MMEA) in 2005, which is intended to be the sole maritime enforcement agency in Malaysia, under the establishment of Malaysia Maritime Enforcement Agency Act 2004 (Basiron, 2012; Malaysia, 2004). Meanwhile, institutional issues that arise are associated with identification of stakeholders in managing marine area, availability of marine spatial data availability and compatibility, as well as the need to appoint leading organizations to facilitate spatial data exchange.

#### 1.2 Research Problem

The focus of Malaysia's spatial data sharing initiative (MyGDI) is to resolve marine data management issues and spearhead development of SDI components, with the help of several newly-established policies, guideline, standards and web portal. However, the understanding of the partnership engagement in facilitating marine spatial data sharing is arguably lacking (Mohamed Shariff et al., 2011). Lack of partnership engagement, especially in terms of knowledge across Malaysia's marine organization resulted in autonomous, heterogeneous, duplicated and distributed marine spatial information management across all jurisdictions (Omar et al., 2015). It led to a serious situation, whereby the Malaysian marine administrators and organizational stakeholders did not know they had to collaborate to develop marine SDI (Abdullah et al., 2015c). While research on collaboration model focused on land spatial information at the national level, there is no such model to coordinate the partnership engagement for a marine spatial data sharing (Mohamed Shariff et al., 2011). Additionally, MyGDI development focuses on land information, cutting back on the progress and implementation of spatial data sharing in marine and coastal areas (Hanifah, 2010a).

The collaboration process and engagement require the stakeholders to understand how to implement the collaboration engagement, the capacity building needed for collaboration, how to manage engagement information and how to effectively communicate between stakeholders. Previous studies by Hamzah (2013) and Abdullah et al. (2015) proved that for spatial data sharing implementation, there is no proper implementation of collaboration engagement process, lack of organizational and personnel knowledge, as well as individual skills in conducting engagement process, poor management of engagement-based information, inadequate understanding of the purpose of collaboration process, and lacklustre communication between stakeholders.

Therefore, there is a need to study partnership engagement process and management model that can be applied to enable spatial data sharing between marine organizations in Malaysia.

# 1.3 Research Questions

Based on the research problem, several questions have been developed;

- 1) What are the implementation-based issues and limitations associated with current theory in current marine spatial information system?
- 2) How does spatial data sharing facilitate the improvement of marine spatial information system in Malaysia marine organizations?
- 3) What are the motivations for Malaysia's marine organizations to share spatial data?
- 4) What are the practices done to enable marine spatial data sharing in Malaysian organizations?
- 5) How does exchange of spatial data occur between Malaysia's marine organizations, in terms of legal, technical and organizational aspects?
- 6) How does the collaboration process facilitate spatial data sharing between Malaysian marine organizations?
- 7) What are the factors contributing to successful spatial data sharing collaboration between Malaysian marine organizations?
- 8) How are the current practices of spatial data sharing and collaboration integrated in developing spatial information system in the organizations?
- 9) Can a generic collaboration framework be developed in order to guide future marine spatial data sharing?
- 10) How can the model development be assessed with current practices?

# 1.4 Research Aim

The aim of this study is to develop a spatial data sharing collaboration model to enable and support the sharing of spatial information between marine organizations, hence contributing to the marine SDI development in the context of Malaysian marine environment.

## 1.5 Research Objectives

From the research problem and research aim, the research objectives of this study are as follows:

- 1. To determine the critical issues that affect the implementation of marine spatial information system and spatial data sharing partnership practices between Malaysian marine organizations and relevant stakeholders.
- 2. To develop a collaboration model to enable and facilitate marine spatial data sharing in Malaysia.
- 3. To evaluate and assess the contribution of collaboration model to the marine SDI development.

#### 1.6 Research Scope

This research focuses on partnership engagement process to enable marine spatial data sharing between Malaysian marine organizations, yet at the same time does not overlook other components in development of marine SDI. The respondents in this study are marine organizations in Malaysia, focusing on the federal agencies which have higher jurisdiction and prospect in implementing spatial information system and spatial information sharing rather than the associated bodies and agencies at the state and local level. The organizations involved in this research are government institutions, private organizations, research institutes and higher education institutions. This research is built upon previous researches done by Binns (2005), Strain (2006), Vaez (2010), Warnest (2005) and McDougall (2006) who emphasized on the importance of performing studies related to partnership engagement to enable marine spatial data sharing and development of spatial data infrastructure.

# 1.7 Conceptual Research Framework

The concept of the research begins with the understanding of the issues in marine area management, the principles and structures of marine spatial data infrastructure. This study focuses on the marine management principles including technical, legal, spatial data and institutional principles. To facilitate marine management, marine spatial data infrastructure is proposed as a platform to share the marine spatial information, complete with marine SDI components including spatial data, technologies, standards, policies and people. This study also identifies the issues and limitations in implementing marine SDI within the Malaysian context. Figure 1.1 shows the conceptual research framework for this study.



Figure 1.1: Conceptual research framework

## 1.8 Thesis Structure

This thesis is divided into six chapters. **Chapter one** provides the information on the background of the research, research problem, research questions, research objectives and research scope. **Chapter two** discusses the latest literatures associated with the topic, critically reviewing notable studies done on marine spatial information system, marine spatial data infrastructure and the background of collaboration and cooperation in enabling spatial information sharing. **Chapter three** explains the research methodology, including the explanation of exploratory sequential design for mixed-method research.

**Chapter four** highlights and deliberates the results of the case studies and survey analyses performed in this study. **Chapter five** explains the collaboration model that has been proposed based on results of literature review and mixed methods analyses. The collaboration model is then validated using Delphi technique for verification, by utilizing opinions from experts. **Chapter six** concludes the thesis, by summarizing all the findings, achievement of research objectives and pinpointing research limitations. Suggestions for future research, research contribution and overall conclusion are also explained in the last chapter.

## 1.9 Chapter Summary

This chapter presented the background of the research and introduced the problem statement, research aim and objectives. The research problem was justified and the research approach was introduced. The thesis structure was outlined and some limitations of the work were discussed. The next chapter discusses the Malaysian marine administration and management, spatial data infrastructures, and the collaboration process toward enabling spatial data sharing in Malaysia through critical and thorough literature review.

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