

# **Diffusion of Regional Spatial Data Infrastructures: with particular reference to Asia and the Pacific**

**Abbas Rajabifard**

**Submitted in total fulfilment of the requirements  
of the degree of Doctor of Philosophy**

**March 2002**

**Department of Geomatics  
Faculty of Engineering  
The University of Melbourne**

---

This thesis is dedicated to Asia and the Pacific region,....

*...for its continued progress in building a culture of regional cooperation  
and decision-making to increase the quality of life of member nations,  
support environmental protection and facilitate sustainable development.*

## **Abstract**

The development of a Regional Spatial Data Infrastructure (Regional SDI) is much more challenging than the development of a National SDI initiative within a nation. This is mainly because of the voluntary nature of cooperation at a multi-national level and participation in a Regional SDI initiative. As a result, despite considerable interest and activities, the development of an effective and comprehensive Asia-Pacific Regional Spatial Data Infrastructure (APSDI) is hampered by a lack of support from member nations which results in this initiative remaining only an innovative concept. Based on this situation, the aim of this research is to design an improved conceptual model for Regional SDI and an implementation strategy. It is proposed that this problem can be partly addressed by increasing the level of awareness about the nature and value of SDIs; improving the SDI conceptual model to better meet the needs of nations; and by identifying key factors that facilitate development by better understanding the complexity of the interaction between social, economic and political issues.

To achieve this aim, the research strategy is designed in such a way to meet the objectives and the hypothesis of the research, namely ‘the involvement of member nations in a Regional SDI can be improved by increasing awareness, identifying user needs and by developing a new conceptual model of the Regional SDI’.

With this in mind, the concept and nature of SDIs is discussed in detail in order to facilitate their development and progressive uptake and utilisation by different jurisdictions. The research then sets the scene, providing the political and historical context of Asia and the Pacific region and regional activities, and discusses the concept and nature of Regional SDIs with an emphasis on current Regional SDI initiative in Asia and the Pacific region. It is argued that although the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), the coordinating committee of the APSDI, has moved some way toward the development of the APSDI, there are other issues which need to be discussed and resolved before moving forward. These issues are the low rate of participation in PCGIAP activities, the organisational structure of PCGIAP and the APSDI conceptual model.

In order to discuss these issues, a review of diffusion theory is provided to establish the necessary theoretical background in support of the applicability of this theory as a framework for this research. The research then reports the findings of the case study including the results of two questionnaires and a pilot project on regional administrative boundaries. Based on data presented, evidence is identified in support of hypothesis.

The thesis then discusses future directions of SDI development by introducing two models, namely a product-based and process-based model, as a new perspective. Both models have value, but contribute to the evolution and utilisation of the SDI concept in different ways. They provide different frameworks for dealing with intra-jurisdictional mandates to promote spatial data access and sharing. But in some circumstance it is a combined approach that can offer most potential for developing effective SDIs.

Finally, three major classes of factors and four recommendations, together with a framework for a regional communication network, are presented and discussed to facilitate the development of the APSDI initiative. It is argued that the adoption and implementation of these recommendations can assist PCGIAP to overcome the problem of low participation and speed up the progress in the development of the APSDI initiative.

Although this research focuses on the development of a Regional SDI initiative in Asia and the Pacific region, the results and lessons learned in this research – especially the key factors influencing the diffusion of a Regional SDI - can also be used and applied in other regions, and potentially other jurisdictional levels.

## DECLARATION

This is to certify that

- (i) *the thesis comprises only my original work,*
- (ii) *due acknowledgment has been made in the text to all other materials used,*
- (iii) *the thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies, appendices and footnotes.*

---

Abbas Rajabifard  
March 2002

## ACKNOWLEDGMENTS

I wish to gratefully acknowledge the support of The University of Melbourne, the National Mapping Division, Geoscience Australia, and the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP).

Particular thanks go to Professor Ian P. Williamson, my supervisor and mentor, for his patience and support and for challenging me to fulfil my potential.

I would like to thank Messrs Peter Holland, Drew Clarke, Bob Irwin, Glenn Johnstone, John Manning and all other friends in National Mapping Division, Geoscience Australia for advising me and generally supporting my research.

I would like to thank Professor Ian Masser, Professor Harlan Onsrud, Dr T.O. Chan, Professor David Coleman and Associate Professor Zorica Nedovic-Budic, for sharing their concepts and reference materials with me, and showing me the directions for my research.

I would also like to thank the members of the Centre of the Spatial Data Infrastructures and Land Administration at the Department of Geomatics, the University of Melbourne, namely Dr Francisco Escobar, Mr Malcom Park, Mr Daniel Steudler, Mr Neil Brown, Ms Serryn Eagleson, Mr Mathew Warnest, and specially Ms Jessica Smith and Ms Lisa Ting for their support and friendship during the course of this research. Special thanks are due to Mrs Mary-Ellen Feeney and her husband Mr Denis Fernandez, with whom many hours were spent, sharing ideas and developing concepts and friendship – all of which I look forward to pursuing in future. Also special thanks to my close friend Payam Ghadirian for all his support and help and thanks to Ms Lillian Cheung for all her administrative support.

Appreciation is particularly extended to the late Professor John Estes for advising me and supporting my research.

Gratitude is also due to all the PCGIAP members, and those SDI practitioners, managers, researchers and consultants who have shared their experience with me and made this thesis possible.

The highest gratitude must be addressed to my late father, and especially my father in-law Dr Mohammad Jafar Olfat, for their strong support, encouragement and for generally supporting my study and always being with me. Their, and the love of my extended family have made this achievement meaningful.

The last but certainly not the least thank you Haleh and Pedram, my beloved wife and son, for your understanding, great patience, support and encouragement, and being the source of inspiration to keep me going. My name is written on the first page of this work, but your names are written on every page – because there was not one moment of this journey that you were not with me.

# CONTENTS

ABSTRACT .....	iii
DECLARATION .....	v
ACKNOWLEDGMENTS .....	vi
CONTENTS .....	viii
LIST OF TABLES .....	xi
LIST OF FIGURES .....	xii
LIST OF APPENDICES .....	xiv
ACRONYMS AND ABBREVIATIONS .....	xv
<b>CHAPTER 1 INTRODUCTION .....</b>	<b>1</b>
1.1 BACKGROUND .....	1
1.2 RESEARCH QUESTION, HYPOTHESIS AND OBJECTIVES .....	3
1.2.1 RESEARCH PROBLEM .....	4
1.2.2 HYPOTHESIS .....	4
1.2.3 OBJECTIVES .....	4
1.3 OVERVIEW OF RELEVANT RESEARCH .....	5
1.4 SUMMARY OF THE RESEARCH DESIGN AND METHODOLOGY .....	10
1.5 SOURCE OF DATA .....	13
1.6 STRUCTURE OF THE THESIS .....	14
1.7 CHAPTER SUMMARY .....	17
<b>CHAPTER 2 THE NATURE AND CONCEPT OF SDI .....</b>	<b>18</b>
2.1 INTRODUCTION .....	18
2.2 THE NEED FOR SPATIAL DATA .....	18
2.2.1 SHARING SPATIAL DATA .....	20
2.2.2 IMPORTANCE OF SPATIAL DATA/INFORMATION TO THE ECONOMY AND SOCIETY .....	21
2.3 SPATIAL DATA INFRASTRUCTURE .....	21
2.3.1 SDI DEFINITIONS .....	21
2.3.2 SDI – THE NATURE, COMPONENTS AND GLOBAL DRIVERS .....	26
2.3.3 OBJECTIVES IN DEVELOPING AN SDI .....	30
2.3.4 CURRENT SDI INITIATIVES .....	30
a) <i>National Level</i> .....	31
b) <i>Regional Level</i> .....	40
c) <i>Global Level</i> .....	47
2.4 CHAPTER SUMMARY .....	49
<b>CHAPTER 3 SDI HIERARCHY .....</b>	<b>51</b>
3.1 INTRODUCTION .....	51
3.2 AN SDI HIERARCHY .....	51
3.3 HIERARCHICAL SPATIAL THEORY .....	52
3.3.1 DEFINITION OF HIERARCHY .....	52
3.3.2 PURPOSE AND LEVELS OF A HIERARCHICAL STRUCTURE .....	53
3.3.3 HIERARCHICAL REASONING .....	54
3.3.4 PRINCIPLES OF HSR .....	54
3.3.5 PROPERTIES OF HIERARCHIES .....	55
3.4 APPLYING HIERARCHY THEORY ON SDIS .....	56
3.4.1 DIFFERENT VIEWS ON SDI HIERARCHY .....	56
3.5 RELATIONSHIPS AMONG DIFFERENT SDIS .....	59
3.6 HSR AND AN SDI HIERARCHY .....	62
3.7 SDI PARTNERSHIPS AND GLOBAL DRIVERS .....	64
3.8 CHAPTER SUMMARY .....	65
<b>CHAPTER 4 ASIA-PACIFIC REGION AND REGIONAL SDI ACTIVITIES: A CASE STUDY .....</b>	<b>67</b>
4.1 INTRODUCTION .....	67
4.2 BASIC CHARACTERISTICS OF THE REGION .....	67
4.3 REGIONAL COOPERATION IN ASIA AND THE PACIFIC REGION .....	68



4.4	THE NEED FOR A REGIONAL SDI .....	73
4.4.1	THE CONCEPT OF REGIONAL SDI .....	75
4.5	REGIONAL SDI INITIATIVE IN THE ASIA-PACIFIC REGION .....	77
4.5.1	ORGANISATIONAL STRUCTURE AND OPERATION OF PCGIAP .....	78
4.5.2	ASIA-PACIFIC SPATIAL DATA INFRASTRUCTURE (APSDI).....	81
4.5.3	THE APSDI CONCEPTUAL MODEL .....	82
4.6	MAJOR ACHIEVEMENTS AND PROGRESS .....	84
4.7	DISCUSSIONS .....	85
4.8	CHAPTER SUMMARY .....	89
<b>CHAPTER 5 DIFFUSION OF SPATIAL DATA INFRASTRUCTURE .....</b>		<b>91</b>
5.1	INTRODUCTION .....	91
5.2	BACKGROUND .....	91
5.3	DEFINITIONS OF DIFFUSION .....	92
5.4	INNOVATION .....	94
5.4.1	TYPES OF INNOVATION .....	94
5.4.2	SDI AS AN INNOVATION .....	95
5.4.3	CHARACTERISTICS OF INNOVATION .....	95
5.5	COMMUNICATION CHANNELS .....	96
5.6	TIME .....	97
5.6.1	ORGANISATIONAL INNOVATION PROCESS .....	98
5.6.2	VARIED RATE OF ADOPTION .....	99
5.7	SOCIAL SYSTEM .....	100
5.8	SDI DIFFUSION .....	100
5.8.1	PARADIGM .....	103
a)	<i>Diffusion Paradigm</i> .....	103
b)	<i>Implementation</i> .....	104
c)	<i>Corporate</i> .....	104
d)	<i>Appropriate Technology</i> .....	105
e)	<i>Accessibility</i> .....	105
5.9	SDI DIFFUSION AND APSDI DEVELOPMENT .....	106
5.10	EXTENSION OF CURRENT APSDI CONCEPTUAL MODEL .....	108
5.11	CHAPTER SUMMARY .....	109
<b>CHAPTER 6 PILOT PROJECT ON REGIONAL FUNDAMENTAL DATASETS</b>		
6.1	INTRODUCTION .....	111
6.2	BACKGROUND .....	114
6.3	SOURCE OF DATA .....	116
6.4	TASKFORCE DEVELOPMENT NEEDS QUESTIONNAIRE .....	117
6.4.1	PRIORITIES .....	119
6.4.2	OUTCOME AND RECOMMENDATIONS .....	120
6.5	TECHNICAL QUESTIONNAIRE ON REGIONAL FUNDAMENTAL DATASETS .....	122
6.5.1	RESULTS OF THE TECHNICAL QUESTIONNAIRE .....	123
6.6	ADMINISTRATIVE BOUNDARIES PILOT PROJECT .....	127
6.6.1	GENERAL DESCRIPTION OF A PILOT PROJECT .....	128
6.6.2	AIM OF THE ADMINISTRATIVE BOUNDARIES PILOT PROJECT .....	128
a)	<i>Identified Problems</i> .....	130
b)	<i>Expected Outcomes</i> .....	130
c)	<i>Methodology</i> .....	130
d)	<i>Deliverables</i> .....	131
6.6.3	PILOT PROJECT AREA .....	132
6.6.4	RESULTS OF THE PILOT PROJECT .....	134
6.7	OVERALL RESULTS .....	137
6.8	CHAPTER SUMMARY .....	139
<b>CHAPTER 7 KEY FACTORS IN THE FUTURE DEVELOPMENT OF REGIONAL SDI .....</b>		<b>142</b>
7.1	INTRODUCTION .....	142
7.2	INFLUENCING FACTORS FOR REGIONAL SDI DIFFUSION .....	142
7.2.1	OVERVIEW .....	142
7.2.2	OVERVIEW OF PREVIOUS RESEARCH ON SUCCESS FACTORS IN DIFFUSION .....	143

7.2.3	KEY FACTORS INFLUENCING ASIA-PACIFIC SDI DEVELOPMENT.....	148
7.3	FUTURE DIRECTIONS FOR SDI DEVELOPMENT .....	153
7.3.1	BACKGROUND .....	153
7.3.2	THE PRODUCT AND PROCESS-BASED MODELS .....	154
7.3.3	RELATIONSHIPS BETWEEN SDI HIERARCHY AND DIFFERENT MODELS OF SDI.....	157
7.3.4	ASSESSMENT OF CURRENT SDI INITIATIVES .....	159
7.3.5	RELATIONSHIPS AND ROLES OF METADATA AND CLEARINGHOUSES IN AN SDI PROCESS-BASED MODEL .....	163
7.3.6	SPATIAL METADATA MANAGEMENT SERVICE AND METADATA SYSTEM.....	164
7.3.7	SPATIAL DATA CLEARINGHOUSE .....	166
7.4	RECOMMENDATIONS.....	168
7.4.1	ORGANISATIONAL RESTRUCTURE.....	168
7.4.2	REDESIGN FUTURE STRATEGY BASED ON ASIA-PACIFIC SOCIAL SYSTEM .....	169
7.4.3	MODIFY APSDI CONCEPTUAL MODEL .....	170
7.4.4	ADOPTING SDI PROCESS-BASED MODEL.....	171
7.5	CHAPTER SUMMARY .....	173
	<b>CHAPTER 8 CONCLUSION AND RECOMMENDATIONS .....</b>	<b>176</b>
8.1	THE RESEARCH .....	176
8.2	CONCLUSIONS AND RECOMMENDATIONS FOR SDI DEVELOPMENT.....	184
8.3	CONCLUSION AND RECOMMENDATION FOR THE ASIA-PACIFIC SDI.....	188
8.4	FUTURE DIRECTIONS OF RESEARCH .....	193
8.5	CONCLUDING REMARKS .....	196
	<b>REFERENCES AND SELECTED BIBLIOGRAPHY .....</b>	<b>197</b>

## LIST OF TABLES

TABLE 1.1 RELATIONSHIPS BETWEEN RESEARCH ACTIVITIES AND OBJECTIVES .....	13
TABLE 2.1 A SAMPLE OF SDI DEFINITIONS. ....	23
TABLE 3.1 GLOBAL TREND RELATIONS BETWEEN DIFFERENT LEVELS OF SDIs .....	60
TABLE 3.2 COMPARISON BETWEEN DIFFERENT SDIs BASED ON SDI CORE COMPONENTS .....	62
TABLE 4.1 WORKING GROUPS OF THE PCGIAP IN THE PERIOD 2000-2003.....	81
TABLE 4.2 PCGIAP MEETINGS AND NUMBER OF THEIR PARTICIPANTS SINCE ITS ESTABLISHMENT.....	85
TABLE 5.1 PROCESSES OF INNOVATION DIFFUSION AND ASSOCIATED OUTCOMES .....	97
TABLE 6.1 LIST OF RESPONDENT COUNTRIES TO THE TECHNICAL QUESTIONNAIRE.....	123
TABLE 6.2 AREAS AND POPULATIONS OF PILOT PROJECT COUNTRIES. ....	133
TABLE 6.3 RESULTS OF THE CASE STUDY PRESENTED TO PCGIAP. ....	138
TABLE 7.1 CURRENT SDI INITIATIVES DISPLAYING PRODUCT-BASED OR PROCESS-BASED MODELS. ....	161

## LIST OF FIGURES

FIGURE 1.1 CURRENT APPROACH FOR REGIONAL SDI DEVELOPMENT, INNOVATION, 2- COMMUNICATION CHANNEL, 3- TIME .....	9
FIGURE 1.2 MAJOR STEPS OF THE RESERACH.....	11
FIGURE 1.3 SCHEMATIC OUTLINE OF THE CHAPTERS .....	16
FIGURE 2.1 INFRASTRUCTURE AND BUSINESS PROCESS MODULES .....	26
FIGURE 2.2 NATURE AND RELATIONS BETWEEN SDI COMPONENTS .....	29
FIGURE 3.1 AN SDI HIERARCHY .....	51
FIGURE 3.2 HIERARCHICAL STRUCTURES REPRESENTED BY SQUARE SUBDIVISIONS AND BY A TREE LIKE STRUCTURE. ....	53
FIGURE 3.3 A) THE UMBRELLA VIEW OF SDI; B) THE BUILDING BLOCK VIEW OF SDI. ....	57
FIGURE 3.4 SPATIAL HIERARCHY OF DIFFERENT FUNDAMENTAL DATASETS .....	58
FIGURE 3.5 RELATIONSHIPS BETWEEN DATA DETAIL, DIFFERENT LEVELS OF SDIs, AND LEVEL OF PLANNING.....	58
FIGURE 3.6 RELATIONSHIPS AMONG DIFFERENT LEVEL OF SDIs .....	61
FIGURE 3.7 THE COMPLEX SDI RELATIONSHIPS WITHIN AND BETWEEN DIFFERENT LEVELS . ...	63
FIGURE 3.8 COUNTRIES WITH ADJACENCY AND NON-ADJACENCY AREAS . ....	63
FIGURE 4.1 CURRENT COMPLEXITY OF COMMUNICATIONS BETWEEN COUNTRIES AND REGIONAL BODIES IN THE ASIA AND PACIFIC REGION .....	75
FIGURE 4.2 REDUCED COMPLEXITY THROUGH REGIONAL SDI .....	76
FIGURE 4.3 ORGANISATIONAL STRUCTURE OF PCGIAP .....	78
FIGURE 4.4 DIFFERENT TIERS IN PCGIAP ORGANISATIONAL .....	78
FIGURE 5.1 ORGANISATIONAL INNOVATION PROCESS MODEL .....	98
FIGURE 5.2 S-SHAPED DIFFUSION CURVE .....	101
FIGURE 5.3 AN INTEGRATED FRAMEWORK FOR DIFFUSION RESEARCH SUGGESTED BY CHAN (1998) .....	107
FIGURE 5.4 CURRENT APPROACH TAKEN BY PCGIAP FOR APSDI DEVELOPMENT, BASED ON ORGANISATIONAL INNOVATION THEORY, 1- INNOVATION, 2-COMMUNICATION CHANNEL, 3-TIME.....	108
FIGURE 5.5 EXTENDED CONCEPTUAL MODEL, 1- INNOVATION, 2- COMMUNICATION CHANNEL, 3- TIME, 4- SOCIAL SYSTEM .....	109
FIGURE 6.1 RELATION BETWEEN TWO QUESTIONNAIRES AND PILOT PROJECT, AS PART OF RESEARCH METHODOLOGY . ....	112

FIGURE 6.2 CLASSIFICATION OF PCGIAP MEMBER NATIONS BASED ON ECONOMIC AND SDI ACTIVITIES. ....	119
FIGURE 6.3 TYPE OF ORGANISATION/AGENCY RESPONDED . ....	124
FIGURE 6.4 PILOT PROJECT AREA . ....	132
FIGURE 6.5 PILOT PROJECT AREA WITHIN THE DCW . ....	133
FIGURE 7.1 FACTORS INFLUENCING THE DEVELOPMENT OF A REGIONAL SDI . ....	149
FIGURE 7.2 ASIA-PACIFIC SOCIAL SYSTEM, AND SOME OF ITS INTERNAL AND EXTERNAL FACTORS. ....	150
FIGURE 7.3 PRODUCT AND PROCESS BASED MODELS FOR SDI DEVELOPMENT . ....	154
FIGURE 7.4 PROCESS-BASED MODEL FOR SDI DEVELOPMENT.....	156
FIGURE 7.5 RELATIONSHIPS BETWEEN SDI HIERARCHY AND DIFFERENT MODEL OF SDI DEVELOPMENT. ....	158
FIGURE 7.6 FOUR MAJOR RECOMMENDATIONS TO PCGIAP TO INCREASE PARTICIPATION RATE . .....	168
FIGURE 7.7 REGIONAL COMMUNICATION NETWORK. ....	173

## **LIST OF APPENDICES**

Appendix 1	Lists the conferences attended and the experts met
Appendix 1.A	Study Trip Outline 2000
Appendix 1.B	Interview Guide
Appendix 2	List of Asia-Pacific nations as defined by the UN
Appendix 3	Review of the Asia-Pacific regional organisations
Appendix 4	List of interviewed members of the PCGIAP
Appendix 5	Development Needs questionnaire
Appendix 6	Results of the Development Needs questionnaire
Appendix 7	Technical questionnaire on Regional Fundamental Dataset
Appendix 8	Report in the analysis of the results of the Technical questionnaire
Appendix 9	Rreport of the results of Administrative Boundaries Pilot Project
Appendix 10	User Guide and Specification for Administrative Boundaries Pilot Project

## ACRONYMS AND ABBREVIATIONS

Acronyms	Full Terms
AAECP	Australian-ASEAN Economic Cooperation Programs
ACU	Asian Clearing Union
ANZLIC	Australia New Zealand Land Information Council
APCC	Asian and Pacific Coconut Community
APEC	Asia-Pacific Economic Cooperation
APNIC	Asia-Pacific Network Information Centre
APRGP	Asia-Pacific Regional Geodetic Project
APSDI	Asia-Pacific Spatial Data Infrastructure
AsDB	Asian Development Bank
ASDI	Australian Spatial Data Infrastructure
ASEAN	Association of South East Asian Nations
AUSLIG	Australian Land information Group
CERCO	Comité Européen Responsables de la Cartographie Officielle
CGDI	Canadian Geospatial Data Infrastructure
CSDC	Commonwealth Spatial Data Committee
ECO	Economic Cooperation Organisation
EGII	European Geographic Information Infrastructure
EU	European Union
EUROGI	European Umbrella Organisation for Geographic Information
FGDC	Federal Geographic Data Committee
FIG	International Federation of Surveyors
GDA	GeoData Alliance
GI	Geographic Information
GIS	Geographic Information System/s
GPS	Global Positioning System
GSDI	Global Spatial Data Infrastructure
HLWP	High Level Working Party
HSR	Hierarchical Spatial Reasoning
ICA	International Cartographic Association
IMPACT	Information Market Policy ACTions
ISCGM	International Steering Committee on Global Mapping
ISO/TC 211	International Organisation for Standardisation Technical Committee 211- Geographic Information/Geomatics
ISPRS	International Society for Photogrammetry and Remote Sensing
ICT	Information and Communication Technology
IT	Information Technology
ITC	International Institute for Aerospace Survey and Earth Sciences
IUGG	International Union of Geodesy and Geophysics
MEGRIN	Multipurpose European Ground Related Information Network
NCC	National Cartographic Centre - Iran
NCGIA	National Centre for Geographic Information and Analysis
NGDI	National Geo-spatial Data Infrastructures
NSDI	National Spatial Data Infrastructure
PC IDEA	Committee for SDI in the Americas
PCGIAP	Permanent Committee on GIS Infrastructure for Asia and the Pacific
PSMA	Public Sector Mapping Agency
SAARC	South Asian Association for Regional Cooperation
SDI	Spatial Data Infrastructure
SLR	Satellite Laser Ranging
UK	United Kingdom
UM	The University of Melbourne

<b>Acronyms</b>	<b>Full Terms</b>
UN-ESCAP	UN Economic and Social Commission for Asia and the Pacific
UNRCC-A	UN Cartographic Conference for the Americas
UNRCC-AP	UN Cartographic Conference for Asia and the Pacific
URSA-NET	Urban and Regional Spatial Analysis Network for Education and Training
USA	United States of America
USGS	United States Geological Survey organisation
VLBI	Very Long Baseline Interferometry
WG	Working Group
WWW	World Wide Web



# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 BACKGROUND**

The continued advances in remote sensing, mapping and geospatial technologies, including an increasing variety of data acquisition capabilities and low cost and more powerful computing capacity, coupled with the development of geographic information system technology, have enabled and increased the demand for geographic information (SDI Cookbook 2000). As the importance of geographic information in addressing complex social, environmental and economic issues facing communities around the globe is growing, the establishment of spatial data infrastructures to support the sharing and use of this data locally, nationally and internationally is increasingly more important.

A Spatial Data Infrastructure (SDI) is an initiative intended to create an environment that will ensure that a wide variety of users, who require coverage of a certain area, will be able to access and retrieve complete and consistent datasets in an easy and secure way. Also, it can be viewed as a tool to provide a proper environment in which all stakeholders, both users and producers, of spatial data can cooperate with each other and interact with technology in a cost-effective way to better achieve the objectives at the corresponding political/administrative level.

Many countries throughout the world are developing SDIs to better manage and utilise their spatial datasets. A number of publications document the various aspects of the development of national SDIs in recent years (Masser 1998a, Onsrud 1998, Onsrud 2000, PCGIAP 2000). These countries are finding it necessary to cooperate with other countries to develop multinational SDIs to assist in decision-making that has an important impact across national boundaries.

A Regional SDI is one example of an international SDI that has potential benefits to facilitate different regional members, organisations and other regional users for sharing and using regional spatial data and simplifying their communication channels. The establishment of a Regional SDI will form a fundamental framework to exchange data across many countries in a region. This will also provide a clear picture to support and improve existing or even new bilateral and multilateral relations and structures. Further, a Regional SDI can provide the institutional framework and the technical basis to ensure the regional consistency and content of fundamental datasets to meet regional needs in the context of sustainable development.

With this in mind, through the efforts of the United Nation Regional Cartographic Conference for the Asia-Pacific region (UNRCC-AP) and following its Thirteenth Conference in 1994, the national mapping agencies in the region formed the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) in 1995 to develop a Regional SDI for Asia and the Pacific region (PCGIAP 1995).

In the same direction, in 1994 with support from the European Union IMPACT (Information Market Policy ACTions) program, the European Umbrella Organisation for Geographic Information (EUROGI) was formed. The mission of this organisation is to promote, stimulate, encourage and support the development and use of geographic information and technology at the European level and to represent the common interest of the geographic information community in Europe (EUROGI 1998). As a first effort this organisation developed a geographic information policy for Europe (GI2000 1996). This policy formed the first component of the European SDI. Following this effort and identifying the barriers to development of EU-wide datasets (GI2000 1998), and identifying challenges facing GI, EUROGI began to stimulate the development of a European GI infrastructure (EGII) in 1998. As a result of that, EGII initiative began in 1998 (EUROGI 1999a).

Due to the potential benefits of developing any type of SDI, promised and documented by these organisations (PCGIAP 1998b, GI2000 1995, EUROGI 1999b) and different researchers (Coleman and McLaughlin 1998, Chan and Williamson 1999b, Rajabifard, *et al.* 1999) along with support from international communities, the Latin American and

African regions are also starting to establish similar organisations to develop similar initiatives for their regions (Borrero 2000, Bassolet 2000).

Current progress of Regional SDI initiatives show that after many years of effort these initiatives still do not receive support from all member nations and regional organisations (Mohamed 1999, Longhorn 2000). In other words, despite considerable interest and activities, the development of an effective and comprehensive Regional SDI is hampered by a lack of support from member nations which results in these initiatives still remaining very much an innovative concept among members of different communities. This problem also can be observed in many National SDI initiatives throughout the world (Masser 1998a, Onsrud 1998).

For example, out of 55 member nations of Asia and the Pacific region, only six are active core participants, about 19 countries are occasional participants and the remaining countries have never attended any meetings. After seven years of efforts by the PCGIAP, the Asia-Pacific Regional SDI initiative still does not receive support from all member nations.

## **1.2 RESEARCH QUESTION, HYPOTHESIS AND OBJECTIVES**

Some reasons for the limited support from certain countries and regional organisations include the lack of awareness of the values of Regional SDI and the complexity of different regional issues such as diverse political, cultural and economical positions (GI2000 1998, Rajabifard *et al.* 1999). One major obstacle of gaining support to develop an SDI is defining the SDI (Barr 1998). The PCGIAP has developed a conceptual model for its Regional SDI (PCGIAP 1998b). This model comprises four broad components, namely: the *institutional framework*, *technical standards*, and *access networks* needed to acquire and disseminate *fundamental datasets*. The PCGIAP model is similar to the model of the Australian National SDI defined by the Australia New Zealand Land Information Council (ANZLIC 1996), the peak inter-governmental council for leadership and effective management of spatial data in the interests of Australia and New Zealand.

Coleman and McLaughlin (1998) identify five major perspectives of National SDI. The Australian model was classified as data-driven suggesting that the model gave a one-

sided supply-oriented view of SDI that primarily presents the values of key spatial data providers as a result. The limitation inherent in the Australian model also applies to the Asia-Pacific SDI. Strategies developed to build this Regional SDI have tended to ignore the interests and potential contributions of other stakeholders such as the non-participating members and agencies such as the Association of South East Asian Nations (ASEAN). This bias is also observed in recent National SDI research initiatives throughout the world (Masser 1998a, Onsrud 1998).

Based on this criticism, there is an obvious incompatibility between the conceptual model of current Regional SDIs with the perceived needs of the respective member nations.

### **1.2.1 RESEARCH PROBLEM**

The development of an effective and comprehensive Regional SDI is hampered by a lack of support from member nations that stems from: a lack of awareness of the benefits of a Regional SDI, the incompatibility of the current conceptual model with the perceived needs of the member nations, and the lack of understanding of the complexity of the interacting social, economic and political issues.

### **1.2.2 HYPOTHESIS**

The involvement of member nations in a Regional SDI can be improved by increasing awareness, identifying user needs and by developing a new conceptual model of the Regional SDI.

It should be noted that “*Involvement*” here means full participation and reciprocation and willingness to provide support such as human and financial resources for a Regional SDI development, and the term “*Improvement*” here pertains to increased participation by member nations (more representatives); increased number of nations having involved; and an increase in the effectiveness of participations.

### **1.2.3 OBJECTIVES**

Having defined the research problem and hypothesis, there are three main objectives of the research:

- To identify and describe the nature and components of SDIs.

- To investigate the needs of the member nations in the context of a Regional SDI.
- To identify the key factors that facilitate the development of a Regional SDI.

### **1.3 OVERVIEW OF RELEVANT RESEARCH**

Coleman and McLaughlin (1998) examined the model that had been adopted and extended by McLaughlin and Nichols (1992) for the purpose of their suggestion about the components of a SDI. According to their suggestion, a SDI should include sources of spatial data, datasets and metadata, data network, technology, institutional arrangements, policies and standards, and end-users. According to their model attention was paid to both users and suppliers of spatial data. Further, they proposed a working definition for a Global SDI by summarising a number of definitions of SDI. According to their definition, a Global SDI encompasses ‘the policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilisation of geospatial data in a global community’ (Coleman and McLaughlin 1998).

Also, Coleman and McLaughlin (1998) pointed out that the mandates and objectives of individuals or interest groups within stakeholder organisations may justify, design, implement and evaluate infrastructure building efforts from one or more of five different perspectives, namely: a data-driven perspective, a technology-driven perspective, an institutional perspective, a market-driven perspective and an application-driven perspective.

The proposed working definition for Global SDI as suggested by Chan and Williamson (1999b) is also applicable to SDIs at other political-administrative levels by extending its scale to include other levels. Onsrud (1998) provided baseline information on the nature and characteristics of the SDIs currently being developed by conducting a survey of national and regional spatial data infrastructure activities around the globe. Onsrud's survey provides an important dataset against which to measure changes in SDI activity at the national, regional and global level.

Masser (1998a) compared the development of ten national SDIs according to three main criteria: the geographical and institutional context within which spatial data infrastructure development takes place, the driving forces behind such developments

and the features of the coordinating mechanisms that have come into being to support them. The study highlighted some of the important factors that must be taken into account whenever any type of SDI development is considered.

There are also some national and international SDI initiatives that have significant potential to be relevant to this research. At the global level, there is an ongoing initiative called Global Spatial Data Infrastructure (GSDI). The concept of GSDI started to be formulated at the first conference of GSDI held in September 1996. This was taken a step further at the conference in North Carolina in November 1997 where specific questions were asked as to what GSDI was and what was the way forward (Clarke 2000).

In the GSDI initiative, regional organisations such as EUROGI and PCGIAP are playing an important role. This initiative is broadly defined as the policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives (Clarke 2000). More succinctly it means ready access to geo-spatial data at the global level (Holland 2001). In this sense a GSDI is a super-set of Regional and National SDIs. The organisational model, policy and framework as well as setting different working groups for designing and conducting research on the components of GSDI were formed in the more directed conference held in Canberra in November 1998 (GSDI 1998).

The GSDI initiative started to take shape and significant progress was recorded at its Fourth conference held in Cape Town in March 2000 and the latest conference which was held in Cartagena, Colombia in May 2001. For example, the Steering Committee of GSDI has undertaken several projects including development of an Internet tool that globally searches over 220 collections of metadata to locate geo-spatial data of interest (Holland 2001); and publication of a guide to SDI development (the SDI Cookbook). However, as Holland (1999) reported, there are many challenging issues still face the GSDI before it becomes a reality globally. Some of these challenging issues are raising the level of awareness, acceptance and support; recognising and complementing related initiatives; including all stakeholders; engaging the less developed economies of the world; maintaining enthusiasm and momentum; and delivering beneficial outcomes.

With this in mind, the recent GSDI conference (GSDI 5) formed some resolutions to overcome some of these challenging issues. For example, the conference resolved that the GSDI Steering Committee agrees to an expansion of the definition for the GSDI.

At the regional level, currently both European and Asia-Pacific Regional SDI initiatives are at different stages of development and both their coordinating organisations are directing different research about these initiatives (PCGIAP 1999a, GI2000 1999).

At the national level, the number of countries that are engaged in the development of spatial data infrastructures is growing. Masser (1998a) and Onsrud (1998) have identified some of those countries that have begun work on SDIs at this level. Some of the SDI initiatives by different countries have little to show other than good intentions while others have already built up a considerable amount of experience in formulating and implementing National SDIs. In some countries, such as Australia, Canada and the United States, there is a growing body of published material describing different parts of developing and implementing a SDI including future strategic plans. All national SDIs such as promoted by ANZLIC in Australia and the FGDC in the USA, and even lower level SDI initiatives at local and state levels such as the Victorian SDI in Australia can provide relevant experimental knowledge for this research.

As a result of developing SDIs at different political/administrative levels, a model of SDI hierarchy that includes SDIs developed at different political/administrative levels was developed (Rajabifard, *et al.* 1999, 2000b, Rajabifard 2001). Based on this model, Rajabifard *et al.* (1999) developed two views, namely the umbrella view and the building block view which explain and expand the concept and the nature of the hierarchical relationship among different types of SDIs. According to these views, the SDI hierarchy creates an environment in which decision-makers working at any level can draw on data from other levels, depending on the themes, scales, currency and coverage of the data needed.

The underpinning technology for SDI is Geographic Information Systems (GIS). In recent years, researchers have applied the theories of innovation diffusion to the study of GIS planning and implementation (Onsrud and Pinto 1991, Masser 1993, Masser and Onsrud 1993, Campbell 1996, Masser and Campbell 1996, Chan 1998). In turn Chan and Williamson (1999b) applied the generic principles derived from the study of

diffusion of GIS in a complex organisation to the development of SDIs. Based on the participation rate in the Asia-Pacific Regional SDI initiative, Regional SDI still remains an innovative concept among member nations of this region. The theories of innovation diffusion however provide a useful framework for the study of Regional SDI development in these regions.

Generally, Campbell and Masser (1995) see diffusion as the fundamental process that is responsible for the transfer of innovation from the workshops of their inventors to becoming a daily part of the lives of a large section of society. Rogers (1983) defined diffusion as a process by which an innovation is communicated through certain channels over time among the members of a social system. In particular, he used the organisation innovation process model to describe the process in which an innovation is adopted and utilised. This process is generally made up of two main stages, namely, initiation and implementation and five sub-stages.

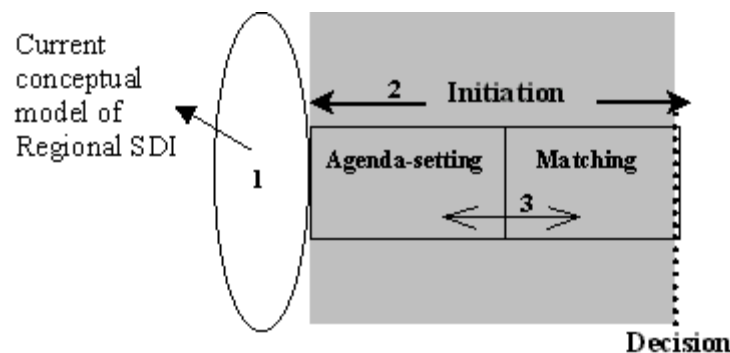
Initiation is concerned with all activities, including information gathering, conceptualising and planning, that culminate in the decision to adopt an innovation by the decision makers in an organisation (Rogers 1995). Implementation refers to the steps taken after the adoption decision that lead to utilisation of an innovation prior to its ultimate institutionalisation (Goodman 1993 as quoted by Chan 1998). Due to the similarities between a region and an organisation in terms of characteristics and behaviours, the organisational-innovation process model is the more applicable model for the subject of study on diffusion of a Regional SDI.

Based on Rogers' organisational innovation process model, Chan (1998) suggested an integrated framework for GIS diffusion research. According to this framework, any innovation such as a GIS or an SDI is a dynamic entity that is central to the diffusion process. This entity assumes multiple identities or configurations as diffusion progresses over time, as represented by the simplified staged model of the diffusion. The characteristics of this entity may change as it passes from the initial conceptual configuration, through one or more intermediate configurations, to an actual physical configuration of GIS or SDI that serves the needs of the organisation or a region. Whether diffusion has failed or succeeded, there is a feedback loop to allow the process to start all over again. Each configuration at this framework can affect and be affected



by and interact with other factors. Based on Chan's framework, in order for diffusion of a Regional SDI to be successful in the region, it is important to take into consideration the conceptual configuration of Regional SDI, the social system of the region as defined by the boundary, and the other external, organisational and personal factors which have an impact on diffusion.

But the current approach taken by the PCGIAP (as an example) suggests that the nature of the social system and many other factors as illustrated in Figure 1.1, are ignored.



**Figure 1.1:** Current approach for Regional SDI development  
Innovation, 2- Communication channel, 3- Time

In this case, the number of nations not participating in the existing Regional SDI initiative, suggest that many nations are still not aware of the concept of Regional SDI or do not fully appreciate the value of Regional SDI portrayed in the current model. In any case, the concept of Regional SDI and the conceptual model suggests that these nations have not entered the initiation stage of the organisational innovation process model.

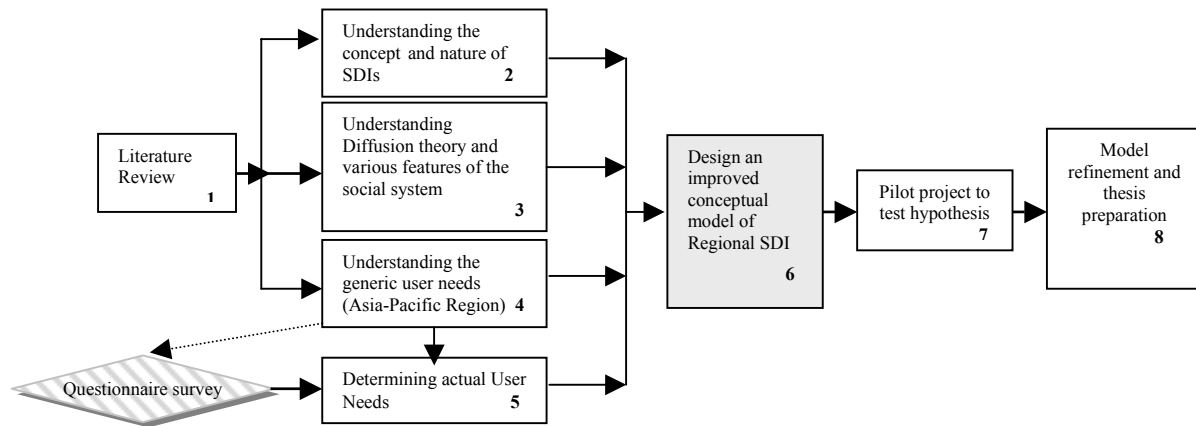
The social component of diffusion has been identified as an important component for the study of any innovations (Scott 1990, Rogers 1995, Chan 1998). Rogers (1995) defined a social system as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. Further, he allowed that the units might include individuals, informal groups, organisations, or any sub-systems. Also, he pointed out that innovation diffusion is affected by different aspects of the social system (Rogers 1995). On a similar line, Coote (1999) believes that social change is a very important

issue for analysing the impact of change on an initiative in an organisation. He further clarified that all organisations are about people. On a similar view, Scott (1990) argued for the need to study technology-organisation relationships at different levels of organisation and in different configurations of organisation. He further argued for the introduction of political, ideological, cultural and institutional factors into the causal arena. Chan (1998) pointed out that different stages of GIS diffusion are affected by a different set of success factors. He pointed to the need to conduct integrated studies involving the elements of time and social system in diffusion research.

#### **1.4 SUMMARY OF THE RESEARCH DESIGN AND METHODOLOGY**

Campbell and Masser (1995) highlighted that the speed and extent of the diffusion of an innovation is linked to social and political processes rather than the inherent technical worth of the product. From a similar perspective, the political and social issues rather than the technical issues were identified as part of inherent difficulties faced by a Regional SDI initiative (Rajabifard, *et al.* 1999, GI2000 1996). Further, Campbell (1996) recognised that among other things, diffusion of an innovation is affected by the nature of innovation, the structure of an organisation and the interplay of the two. Based on Campbell's views and considering the nature of this research which is a multi-disciplinary environment, including engineering, political theory, organisational behaviour/organisational theory and information management and information systems this research adopts the organisational innovation process model as a framework for study on the diffusion of a Regional SDI.

This research adopted a case study to investigate the hypothesis. For this purpose, Asia and the Pacific region was selected as the case study. In this context, over the period of the research, a number of activities have been undertaken to meet the objectives listed in section 1.2.3. These activities can be broadly grouped into literature review; exposure to SDI development, diffusion activities and research worldwide; data collection and data analysis; model generation; and pilot project for model validation Figure (Figure 1.2).



**Figure 1.2: Major Steps**

To establish the theoretical background for the hypothesis, a literature review was undertaken (step1) of current SDI initiatives throughout the world in terms of model, strategy and the steps toward the implementation of SDIs, as well as reviewing literature from a number of other disciplines. This review included GIS and diffusion, innovation diffusion, information technology, political science, regional politics, sociology, organisation theory and public administration. While the literature review is important, it is no substitute for discussions with key researchers in spatial data management and development to understand what the current issues are and how the issues are being tackled elsewhere. It is also important to gain a better understanding of the international trends in the management of spatial data at a multi-national level and receive first hand feedback from leaders and peers around the world about concepts that the author is developing.

With this in mind, to gain exposure, the author attended a total of 14 conferences and international meetings around the world and met with a wide range of researchers and managers to discuss various aspects of SDI development and diffusion theory. Appendix 1 lists the conferences and meetings attended and the experts interviewed. In particular, a study trip was organised to allow the author to spend one week each at the United States Federal Geographic Data Committee (FGDC) and the United States Geological Survey organisation (USGS), at the National Centre for Geographic Information and Analysis (NCGIA), Department of Surveying Engineering, University of Maine, USA, at the Urban Planning and Management Division, International Institute for Aerospace Survey and Earth Sciences (ITC), The Netherlands, and at the Multipurpose European Ground Related Information Network (MEGRIN), France. The

purpose was to widen the author's perspective on SDI development and diffusion (Appendix 1.A). During this study trip a total of 25 people were met and interviewed (see Appendixes 1 and 1.B). Some of the people met, such as Professor Ian Masser and Professor Harlan Onsrud, are world leaders in SDI and GIS diffusion research. Discussions with these people helped with the understanding of current issues of SDI development and diffusion and state of the art position of research worldwide.

The results of these discussions provided the required resources and background for taking the next three steps (steps 2, 3, 4). In step 2, were identified current levels of understanding about the nature of Regional SDI. In this step, the evaluation of the current conceptual model of Asia-Pacific Regional SDI (APSDI) was a major part.

There are many approaches to studying diffusion (see chapter 5). This research adopts the 'process' approach, in which diffusion is viewed as a set of sequential stages of events that take place in an organisation or community. The emphasis is how participation rate can increase by applying diffusion processes. With this in mind, Step 3, enhanced understanding of the various features involved in a social system as well as identifying key factors among different features of the social system, which influence the diffusion of a Regional SDI. This step is based on an expanded conceptual model of the Asia-Pacific Regional SDI which is used by the PCGIAP within a social boundary. In this environment, the interaction between the first and the fourth components of the diffusion (Regional SDI as an innovation and social system) was the main part of the study.

Step 4 permitted a clear understanding of the nature of user needs as well as regional concerns and interests. This helped with Step 5 of the research, which was an analysis of user needs to determine actual needs. This analysis was based on the generic user needs in the region and the information gathered from questionnaire surveys that were designed and used for this purpose.

The outcomes of Steps 2 to 4 led to Step 6 of the research, which is to improve the current SDI conceptual model. Using the results of previous steps helped to improve the level of understanding of the concept and the nature of a Regional SDI. This led to improving the current conceptual model as well as designing a strategy for undertaking the next step of the research pilot project. Using the improved conceptual model

developed in the previous step, a pilot project on regional administrative boundaries was conducted with the aim of testing the hypothesis of the research.

The relationships between the research activities and research objectives identified are shown in Table 1.1.

**Table 1.1:** Relationships between research activities and objectives

Objectives	Research Activities
<ul style="list-style-type: none"> <li>To identify and describe the nature and components of SDIs.</li> </ul>	Literature review and evaluation of current SDI initiatives
<ul style="list-style-type: none"> <li>To investigate the needs of the member nations in the context of a Regional SDI.</li> </ul>	Design and conduct questionnaire surveys and data analysis
<ul style="list-style-type: none"> <li>To identify the key factors that facilitate the development of a Regional SDI</li> </ul>	Literature review, questionnaire surveys and analysis, pilot project

## 1.5 SOURCE OF DATA

An important source of data for this research was the information gathered by two questionnaire surveys. These two questionnaires were circulated by the PCGIAP in Asia and the Pacific region. The first questionnaire was a "Development Needs questionnaire" which has been designed by the PCGIAP-Taskforce group (the candidate was a member of this group) and was distributed through the region in March 1999. The results of this questionnaire were reviewed and analysed at a workshop in Canberra in September 1999. The second was a technical questionnaire that was designed as a part of this research through a joint project with AUSLIG, with the aim of surveying the existing national and regional datasets and users' expectations about regional fundamental datasets. This questionnaire was distributed through PCGIAP-WG2 in June 1999 and analysed at the end of 1999.

The information gathered by both questionnaires was provided by the Secretariat of the PCGIAP. The reports of the PCGIAP meetings also provided useful data. The spatial data required for the pilot project was provided by Australian Survey and Land Information Group (AUSLIG) which held the Chair of the PCGIAP-WG2 at the time.

Further to that, the experience of the author as the National Mapping/GIS representative of Iran to PCGIAP (including five years as an Executive Board member) and as a member of the International Steering Committee on Global Mapping (ISCGM) during 1997-2001 was also useful for this research. Additionally, discussions with key researchers, leaders and managers around the world and their critical feedback were also useful. Further, the author was responsible for design and formation of the Iranian National SDI and National GIS for the years 1994-1998.

## **1.6 STRUCTURE OF THE THESIS**

The thesis is structured in eight chapters as illustrated in Figure 1.3. This figure shows a flow-diagram of the thesis, designed to illustrate the flow of knowledge stream, as well as the contributions of each chapter to fulfil the research objectives. Following is also a description of the way in which the research project develops:

Chapter 1 gives an overview of the research and thesis. It includes an introduction and broad objectives for the research. It then focuses the problem definition and identifies the research objectives and hypothesis that are addressed in this research. The research methodology is also discussed, particularly with reference to the sequence/procedure in relation to achieving the research objectives.

Chapter 2 aims to discuss the nature and concept of SDI, including the components, which have helped to build the current understanding about the importance of an infrastructure to support the interactions of the spatial data community. Several examples of how SDIs have been described are offered to aid understanding of their complexity. The need for descriptions to represent the discrepancies between the role and deliverables of an SDI and thus contribute to a simpler, but dynamic, understanding of the complexity of the SDI concept, are proposed. This chapter begins with a brief review of the need for spatial data and introduces major forces driving the development of such data. It then discusses the nature and concept of SDI.

Based on the concept and nature of spatial data infrastructures, Chapter 3 aims to demonstrate the fitness and applicability of Hierarchical Spatial Reasoning (HSR) as a theoretical framework to demonstrate the multi-dimensional nature of SDIs. The chapter begins by introducing the concept of an SDI hierarchy and follows with a review of the

concept of spatial hierarchy and its properties. It then argues that by better understanding and demonstrating the nature of an SDI hierarchy, any SDI development can gain support from a wider community of both government and non-government data users and providers. The chapter concludes by examining how current hierarchical theory can be extended to incorporate different levels of SDI initiatives.

Chapter 4 provides the political and historical context of Asia and the Pacific region and regional activities in which Regional SDI diffusion occurs. The chapter starts by giving the basic characteristics of Asia and the Pacific region and a brief description of the past and current status of geographic information in this region, followed by a review of the concept of regional cooperation in general and regional cooperation in Asia-Pacific in particular. The chapter then discusses the need for a Regional SDI followed by a discussion of this concept. Based on these discussions, the chapter reviews the Asia-Pacific Regional SDI initiative including the structure and activities of its coordinating committee and the SDI conceptual model, followed by a discussion on related issues.

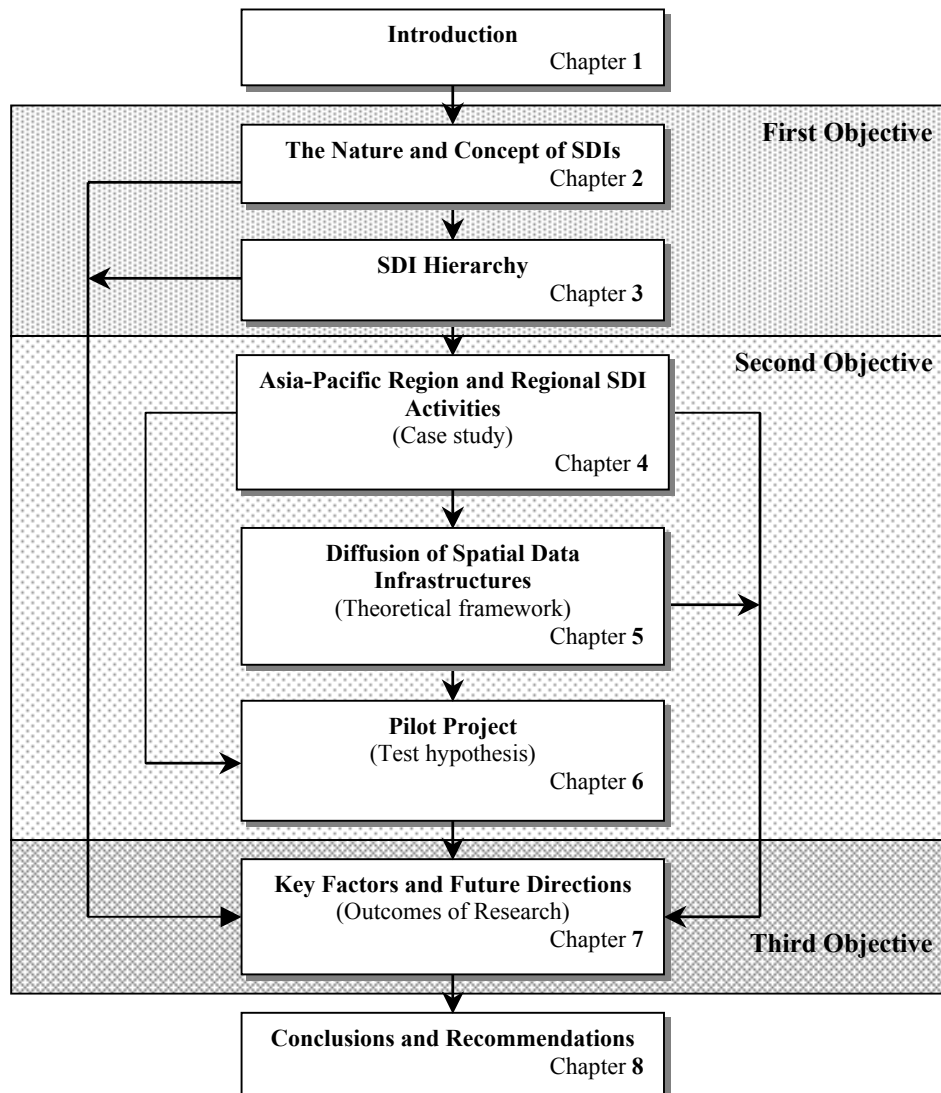
Chapter 5 provides an overview of the paradigm of diffusion, and introduces and discusses the theories of innovation diffusion based mainly on the comprehensive work of Rogers (1995). Using these theories, the current conceptual model and strategy of the PCGIAP for the development of the APSDI is discussed. Based on the results of this research, the chapter suggests an improved conceptual model for the development of the APSDI initiative.

Chapter 6 discusses the rationale, objectives, methodology and the findings of the case study, including the results of two questionnaires and a pilot project on regional administrative boundaries. The chapter provides background information about the case study including both user needs and technical questionnaires and their relationships with the pilot project as part of the research methodology. It continues by reviewing sources of data to support the aim of the pilot project and by defining the strategy for carrying out the pilot project. The aims and design of both questionnaires are explained with the key findings and outcomes presented.

Chapter 7 reports the outcomes of the research by presenting major classes of factors which influence the diffusion of a Regional SDI, and discusses the future directions of SDI development. The transition between the understanding of SDIs from product-

based to process-based approaches is investigated, with a review on the positions taken by current SDI initiatives throughout the world. Based on the possible future directions for SDIs and the identified classes of factors, the chapter presents a list of recommendations to overcome the current problem of low participation of Asia and the Pacific nations in Regional SDI development.

Chapter 8 is the concluding chapter with recommendations for future research.



**Figure 1.3:** Schematic Outline of the Chapters



## 1.7 CHAPTER SUMMARY

This chapter begins by providing a background of the importance of SDIs and diffusion research. The research questions are then described and the hypothesis of research is articulated as follows.

*The involvement of member nations in a Regional SDI can be improved by increasing awareness, identifying user needs and by developing a new conceptual model of the Regional SDI.*

Based on the hypothesis, the objectives of the thesis were then identified:

- To identify and describe the nature and components of SDIs.
- To investigate the needs of the member nations in the context of a Regional SDI.
- To identify the key factors that facilitate the development of a Regional SDI.

The scope of the research is described. This is followed by a brief account of the research methodology, which comprises literature review, understanding current nature of SDIs, various features of the social system, generic and actual user needs based on data analysis, design an improved conceptual model and model validation. The chapter concludes with a section on the structure of the thesis and provides pointers to various chapters that follow.

## **CHAPTER 2**

# **THE NATURE AND CONCEPT OF SPATIAL DATA INFRASTRUCTURE**

### **2.1 INTRODUCTION**

This chapter aims to discuss the nature and concept of SDI, including the components which have helped to build the current understanding about the importance of an infrastructure to support the interactions of the spatial data community. Several examples of how SDIs have been described are offered to aid understanding of their complexity. The need for descriptions to represent the discrepancies between the role and deliverables of an SDI and thus contribute to a simpler, but dynamic, understanding of the complexity of the SDI concept, are postulated. The chapter begins with a brief review of the need for spatial data and introduces global forces driving the development of such data. It then discusses the nature and concept of SDI.

### **2.2 THE NEED FOR SPATIAL DATA**

Spatial data are items of information which can be related to a location on the Earth, particularly information on natural phenomena, cultural and human resources such as topography including geographic features, place names, height data, land cover, hydrography; cadastre (property-boundary information); administrative boundaries; resources and environment; socio-economic including demographic; etc. (CSDC 2001). These types of data are critical to promote economic development, improve our stewardship of natural resources and to protect the environment (Executive Order 1994). People need spatial data and its derived information to establish the position of identified features on the surface of the Earth. But why is position important? This question can be viewed from different points. First, knowledge of the location of an activity allows it to be linked to other activities or features that occur in the same or nearby locations. Second, locations allow distances to be calculated, maps to be made,

directions to be given and decisions to be made about complex, inter-related issues (Mapping Science Committee 1995). Moreover, the occurrence of a national emergency resulting from a cyclone, flood, major fire and earthquake is unfortunate. However, it is apparent that some damage from these sorts of events can be avoided and fewer people are likely to die if a plan is quickly developed and implemented to address the disaster.

Also, over 80% of governmental data has a locational basis (Budic and Pinto 1999a, Lemmens 2001). Examples range from local to national, regional and global scales and address issues such as land-use planning and zoning, new schools or shopping centres, environmental regulation, emergency relief and economic developments - the potential list of uses is enormous (Masser 1998a, Mapping Science Committee 1997, GI2000 1995).

The needs for spatial data are continually increasing and changing. In most of the developed countries it is widely acknowledged that spatial data is part of the national infrastructure and extensive efforts are being expended on this (Clarke 2000). With this in mind, in the last two decades nations have made unprecedented investments in information and the means to assemble, store, process, analyse and disseminate it. Many organisations, agencies and departments in all levels of government, private and non-profit sectors and academia throughout the world spend billions of dollars each year producing and using spatial information (FGDC 1997).

The rapid advancement in spatial data capture technologies has made the capture of digital spatial data – which is the base for deriving spatial information - a relatively quick and easy process, such as satellite imagery with digital image processing techniques as well as using Global Positioning Systems (GPS). There are four principal forces identified as the drivers for most of the changes that have occurred over the past three decades. These principals are technological developments, environmental awareness, political unrest and war and peacetime economy.

Moreover, there are two major forces driving the development of spatial data. The first is a growing need for governments and businesses to improve their decision-making and increase their efficiency with the help of proper spatial analysis (Gore 1998). The importance of this issue is so high that the Australian New Zealand Land Information Council (ANZLIC), which is the peak coordinating body for the management of land

and geographic information within these two countries, views land and spatial information as an infrastructure, with the same rational and characteristics as roads, communications and other infrastructure (ANZLIC 1998). The second force is the advent of cheap, powerful information and communications technology, which facilitate the more effective handling of large quantities of spatial data.

### **2.2.1 SHARING SPATIAL DATA**

People need to share spatial data to avoid duplication of expenses, associated with generation and maintenance of data and their integration with other data. Also, it is apparent that spatial data constitutes much of the data required for physical disaster planning, management and recovery work. Given that natural and man-caused disasters will continue to occur, a major issue is the ability of various users to share and access necessary data and information to prepare for the effects and to minimise loss of life. Moreover, GIS benefits are increased by data sharing among organisations. In paper map form, data sharing is obstructed if scales differ, if projections differ, if symbologies are not uniform, if legends do not identify all map items, and so on. In digital form, most of these same problems exist and must be taken into account. Often the spatial data produced for one application can be applied in others, thus saving money by sharing data. For many organisations, building and using a GIS requires enormous quantities of current and accurate digital data. They can save significant time, money and effort when they share the burden of data collection and maintenance. This is important, not only to the organisations looking for the data, but also for the organisations with the data. The more partners there are, the more the savings and the greater the efficiency.

Furthermore, sharing data can also improve data quality by increasing the number of individuals who find and correct errors. Savings realised on the production of common data can be used for other vital areas, such as application development. In addition, resources that would be used to collect repetitive data can be diverted into quality control, data management and collection of other necessary data.

Working together in a geographic area can also provide data coverage in a common form over a wider area. This aids cross-jurisdictional or cross-organisational analysis, decision making and some types of operations. For example, adjoining jurisdictions

may have a common interest in an environmental issue. A transit operator may serve a region, rather than stopping at country boundaries (FGDC 1997). Moreover, sharing geographic data of common interest enables countries to defray some of the costs of producing and maintaining the data. But mechanisms to facilitate the use and exchange of spatial data are a major justification for developing and expanding any type of SDI.

### **2.2.2 IMPORTANCE OF SPATIAL DATA/INFORMATION TO THE ECONOMY AND SOCIETY**

The importance of spatial data and information to the economy goes far beyond the potential development of the industry itself. It has the potential to impact widely on society, due to its ability to represent a host of important characteristics spatially and thus provide support in areas as diverse as town planning, oil exploration and environmental monitoring. Spatial information has long been used in the military field as an aid to strategy and many existing structures for spatial data and information have their roots in the military. However, spatial information can help governments to make informed decisions in a wide range of other areas, from environmental protection to crime prevention. In the private sector it can aid companies in their investment and marketing decisions and help individuals to better understand the world in which they live. Thus this tool can improve the ability of many societal actors to make informed choices. The impact of this intangible aspect is difficult to measure. The economic advantages of a company choosing the best location for their factory, or of the emergency services more effectively controlling a forest fire, cannot always readily be quantified. However, they can be considerable.

## **2.3 SPATIAL DATA INFRASTRUCTURE**

### **2.3.1 SDI DEFINITIONS**

Spatial Data Infrastructure (SDI) is an initiative intended to create an environment in which all stakeholders can cooperate with each other and interact with technology, to better achieve their objectives at different political/administrative levels. SDI initiatives around the world have evolved in response to the need for cooperation between users and producers of spatial data to nurture the means and environment for spatial data sharing and development (McLaughlin and Nichols 1992, Coleman and McLaughlin 1998, Rajabifard *et al.* 1999, Rajabifard *et al.* 2000b). The ultimate objectives of these

initiatives, as summarised by Masser (1998a), are to promote economic development, to stimulate better government and to foster environmental sustainability.

SDI is fundamentally about facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community. SDI constitutes dynamic partnerships between inter- and intra-jurisdictional stakeholders. The principal objective for developing SDI for any political and administrative level, as highlighted by Rajabifard *et al.* (1999), is to achieve better outcomes for the level through improved economic, social and environmental decision-making. SDIs have become very important in determining the way in which spatial data are used throughout an organisation, a state or province, a nation, different regions and the world. In this regard, as suggested in the SDI Cookbook, without a coherent and consistent SDI in place, there are inefficiencies and lost opportunities in the use of geographic information to solve problems (SDI Cookbook 2000). In principle, SDIs allow the sharing of data, which is extremely useful, as it enables users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with generation and maintenance of data and their integration with other datasets. By reducing duplication and facilitating integration and development of new and innovative business applications, SDIs can produce significant human and resource savings and returns.

The design and implementation of an SDI is not only a matter of technology but also one of designing institutions, the legislative and regulatory frameworks and acquiring new types of skills. Balancing these elements to develop an SDI enables intra- and inter-jurisdictional dynamics of spatial data sharing (Feeney & Williamson, 2000; Rajabifard *et al.*, 2001). Moreover, SDI development requires new relationships and partnerships among different levels of government and between public and private sector entities to be established. These partnerships allow and require organisations to assume responsibilities that may differ to those of the past (Tosta 1997). With this arrangement, an effective SDI allows all cooperating bodies to access accurate and consistent spatial databases used to inform local and inter-jurisdictional decisions and to support implementation of the resulting initiatives.

An SDI has to ensure the jurisdictional consistency of content to meet user needs. Within this framework, fundamental datasets can be collected and maintained through partnerships (Jacoby *et al.* 2001). These datasets include all data necessary to understand the jurisdiction, both spatially and aspatially. To maximise the benefits from investment in data collection and maintenance from both a jurisdictional perspective and that of the individual members, it is important that SDIs are focused and coordinated. Ideally, an SDI should provide benefits for all member parties. In particular the needs of cooperating members must be met with the additional provision for other non-participating members to join. As the membership grows the data pool widens to enable the realisation of further benefits and economies of scale.

Current progress of SDI initiatives shows that SDI is understood differently by stakeholders from different disciplines or from multinational backgrounds. In this regard, researchers and various national government agencies have attempted to capture the nature of SDI in definitions produced in various contexts (Table 2.1).

**Table 2.1:** A sample of SDI definitions (Chan *et. al* 2001)

Source (reference)	Definition of SDI
Australia New Zealand Land Information Council ( ANZLIC 1996)	A national spatial data infrastructure comprises four core components - institutional framework, technical standards, fundamental datasets, and clearing house networks
Global Spatial Data Infrastructure Conference 1997 ( GSDI 1997)	Global Spatial Data Infrastructure (GSDI) should generally encompass the policies, organizational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives
Thompson (1995)	An NSDI is one which makes effective use of computer and communications technologies for the efficient acquisition, management, and dissemination of spatial data and information on a national basis.
Dutch Council for Real Estate Information (Ravi) (Masser 1998b)	The National Geographic Information Infrastructure is a collection of policy, datasets, standards, technology (hardware, software and electronic communications) and knowledge providing a user with the geographic information needed to carry out a task
European Commission (European Commission 1995)	The European Geographic Information Infrastructure (EGII) is the European policy framework creating the necessary conditions for achieving the objectives. It thus encompasses all policies, regulations, incentives and structures set up by the EU Institutions and the Member States.
Executive Order of US President (Executive Order 1994)	National Spatial Data Infrastructure (NSDI) means the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data
Federal Geographic Data Committee (FGDC 1997)	National SDI is an umbrella of policies, standards, and procedures under which organisations and technologies interact to foster more efficient use, management, and production of geospatial data.
McLaughlin and Nichols (1992)	The components of a spatial data infrastructure should include sources of spatial data, databases and metadata, data networks, technology (dealing with data collection, management and representation), institutional arrangements, policies and standards and end-users

Hoffmann (1999)	A “Spatial (data/information/knowledge/expertise) infrastructure” should be more than a geographic information infrastructure. It is the spatial integration component for an information society system, which is the important interoperability element of a future information society.
Queensland Spatial Information Infrastructure Council (Department of Natural Resources 1999)	The Queensland Spatial Information Infrastructure comprises the datasets, institutional arrangements, technical standards, products and services required to meet the needs of government, industry and the community
Victoria’s Geospatial Information Strategic Plan of the State Government of Victoria, Australia (Land Victoria 1999)	The concept of a spatial data infrastructure is extended to include more than just the data itself – it now encompasses all organisations and customers involved in the entire process, from data capture to data access, including the geodetic framework
Victorian Geospatial Information Strategy 2000-2003 of the State Government of Victoria, Australia (Land Victoria 1999)	A spatial data infrastructure is conceptualised as a comprehensive geospatial information resource—the infrastructure, the value and capability of which are driven into Victoria’s information systems and processes—the benefit, through the strategic elements of custody, metadata, access infrastructure, pricing, spatial accuracy and awareness

Whilst these existing definitions provide a useful base for the understanding of different aspects of SDI, or SDI at a snapshot in time, the variety of descriptions have resulted in a fragmentation of the identities and nature of SDI, derived for the varied purposes of promotion, funding and support. Lack of a more holistic representation and understanding of SDI has limited the ability to adapt to its evolution in response to the technical and user environment.

Existing definitions have been slow to incorporate the concept of an integrated, multi-leveled SDI. Recent research (as will be explained in chapter 3) indicates that SDI is multi-leveled in nature, formed from a hierarchy of inter-connected SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels (Rajabifard *et al.* 1999, 2000b). SDI development at a state level also suggests that an SDI is a dynamic entity; its identity and functionality change and become more complex over time (Chan and Williamson 1999b). Failing to acknowledge these characteristics of SDI, the multi-dimensionality and dynamic mechanistic and functional roles of the SDI, have rendered many descriptions of SDI inadequate to describe the complexity and the dynamics of SDI as it develops and thus ultimately constrain SDI achieving developmental potential in the future.

With this in mind, in order to understand an SDI, as suggested by Coleman and McLaughlin (1998) a first approximation of its term can be achieved by defining its components:



McKee (1996) defined “geographic” data as those data describing phenomena directly or indirectly associated with a location and time relative to the surface of the Earth.

Webster defines “data” as “factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation”. The word “infrastructure” is defined by Webster, as “...the underlying foundation or framework of a system or organisation.”

The challenge is to come up with a definition which is not too restrictive and does not artificially limit thinking. This is especially critical in an SDI for wider areas such as national, regional and global, which reflect the convergence of telecommunications, information services and information technology sectors, but yet is more than just the physical facilities used to transmit, store, process and display voice, spatial data and images.

In a broader context, Robert Pepper of the U.S. Federal Communications Commission as cited by Coleman and McLaughlin (1998) expresses this challenge in the following manner:

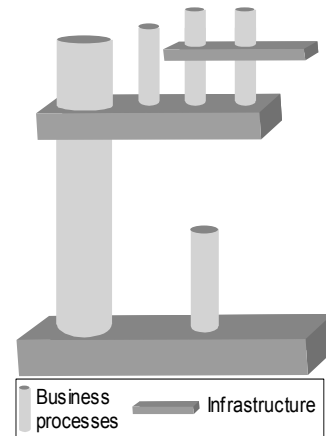
*“When we talk about infrastructure, we tend to think about wires-hardware. Infrastructure is far more than that. It is people, it is laws, it is the education to be able to use systems. If you think about the highway system, we tend to think about bridges and interstates, but the infrastructure also includes the highway laws, drivers’ licenses, gas stations, the people who cut the grass along the highways, and all of those support systems. You cannot talk about infrastructure in the telecom-information sector without also talking about the human support systems.”*

Beyond these components, Kelley (1993) believes “infrastructure” shares the following characteristics with data and information:

- It exists to support other economic or social activities, not as an end in itself;
- It incurs a relatively high initial capital cost; and
- It has a relatively long life. So, it requires long term management and commitment of funds.

In summary, an SDI is much more than data and goes far beyond surveying and mapping. It provides an environment within which organisations and/or nations interact with technologies to foster activities for using, managing and producing geographic data. Moreover, with the rapid improvement in spatial data collection and

communications technologies, SDIs have become very important in the way spatial data are used throughout a company, a governmental agency, a state or province, nation, throughout regions and even the world. They allow the sharing of data, which is extremely useful, as it enables spatial data users and producers to save their efforts when trying to acquire new datasets. Importantly it must be users or business systems which drive the development of SDIs. In turn the business systems which rely on the infrastructure in turn become infrastructure for successive business systems. Along this line, Chan and Williamson (1999b) suggested that an SDI does not exist as a single entity but as a hierarchy of modules of infrastructure linked by business processes (Figure 2.1). As a result, a complex arrangement of partnerships develop as the SDI develops.



**Figure 2.1:** Infrastructure and business process modules (Chan and Williamson 1999b)

### 2.3.2 SDI – THE NATURE, COMPONENTS AND GLOBAL DRIVERS

The design of any SDI requires an understanding of the nature of the concept, the contributing components and the impact of global drivers. Apart from rapid advances in information and communication technologies, the need to define the concept of SDI is justified by drivers such as globalisation, sustainable development, economic reform, political unrest and war, urbanisation, environmental awareness and human rights (Williamson 2000). Moreover, it is the needs of the user community that drive SDI development. These present significant influences on the changing spatial data relationships within the context of SDI jurisdictions. Reliable information infrastructures are needed to record environmental, social and economic rights, restrictions and responsibilities as well as provide spatial data to facilitate appropriate decision-making and support conflict resolution. These drivers in turn effect the resulting spatial data industry environment and SDI vision, in particular partnership concepts.

There has been a trend for countries to expand their efforts in developing SDIs through partnerships. In the 1990s national SDI development took a broad-base approach to encourage cooperation among stakeholders to pool data assets. Based on this approach, an ideal SDI should have all datasets in the corporate SDI fully integrated. Constrained

by existing technical and institutional arrangements, SDI developing agencies have focused on promoting adoption of common standards, as well as fast-tracking integration among certain strategic datasets through partnership arrangements (ANZLIC 1996, Jacoby *et al.* 2001). Partnerships are formed to create business consortia to develop specific data products or services for strategic users, by adopting a focussed approach to SDI development.

Coleman and McLaughlin (1998) identify four different perspectives of SDI, which provide an insight to the spatial data environment. These perspectives were developed to represent the varied directions of SDI initiatives, as shaped by the participant stakeholders, namely, spatial data supplier, technology supplier, spatial data and technology users and the collection of all three. Coleman and McLaughlin (1998) also point out that these groups interact widely with one another, suggesting that the SDI environment be made up of these interacting stakeholder groups.

In a similar line, the author together with his colleagues suggested a system of classification to organise the many definitions and various aspects of the nature of SDI in which to better understand the multi-dimensional nature of SDIs. The definition classification system groups the definitions of SDIs into four perspectives: identificational, technological, organisational and productional perspectives (Chan *et al.* 2001). Based on this classification, Chan *et al.* (2001) argued that the definitions fall within the first three perspectives with the organisational perspective being the most popular approach adopted by government, regional and global SDI developing agencies. However, it is the fourth perspective, the productional perspective of SDI, that is potentially most useful in facilitating SDI development and diffusion Chan *et al.* (2001).

As was summarised in Table 2.1, different views of SDI can also be derived from different countries' approach to the understanding and development of SDIs. The Federal Geographic Data Committee (FGDC 1997), defines the United States' National SDI as an umbrella of policies, standards and procedures under which organisations and technologies interact to foster more efficient use, management and production of geospatial data. It further explains that SDIs consist of organisations and individuals that generate or use geospatial data and the technologies that facilitate use and transfer of geospatial data. The Australian and New Zealand Land Information Council

(ANZLIC 1998) define a national SDI as comprising four core components: an institutional framework, technical standards, fundamental datasets and clearinghouse networks. The institutional framework defines the policy and administrative arrangements for building, maintaining, accessing and applying the standards and datasets. The technical standards define the technical characteristics of the fundamental datasets. The fundamental datasets are produced within the institutional framework and fully comply with the technical standards. The clearinghouse network is the means by which the fundamental datasets are made accessible to the community, in accordance with policy determined within the institutional framework and to agreed technical standards.

According to the Canadian Geospatial Data Infrastructure (CGDI) vision, the CGDI initiative aims to facilitate the sharing of geographic databases, provide mechanisms which transcend the copyright and licensing restrictions, permits data exchange among agencies, and includes funding mechanisms and defines the databases (Turnbull and Loukes 1997). This initiative has five inter-related technical components, namely data access, geospatial framework, standards, partnerships and supportive policy environment (Labonte *et al.* 1998).

After reviewing the varied histories and values underlying the vision of SDIs, including those cited, Coleman and McLaughlin (1998) defined the Global SDI as encompassing ‘the policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilisation of geospatial data in a global community’. The principal objective of developing an SDI is to provide a proper environment in which all stakeholders, both users and producers, of spatial information can cooperate with each other in a cost-efficient and cost-effective way to better achieve their targets. In this context, Coleman and McLaughlin regard the ANZLIC definition of SDI as data-centric, not taking into consideration the interactions between the suppliers and users of spatial data which is a key driving force in SDI development. Based on these selected samples of definitions of an SDI, it is suggested that an SDI comprises not only the four basic components identified for the Australian SDI, but also an important additional component, namely, people. This component includes the spatial data users and suppliers and any value-adding agents in between, who interact to drive

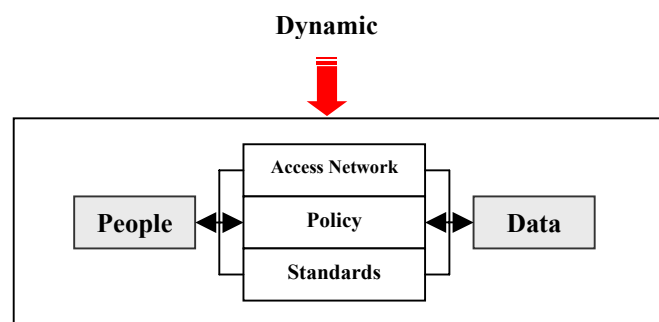
the development of the SDI. For this reason, the formation of cross-jurisdictional partnerships have been the foundation of SDI initiatives supported to date.

People are the key to transaction processing and decision-making. All decisions require data and as data becomes more volatile human issues of data sharing, security, accuracy and access forge the need for more defined relationships between people and data. The rights, restrictions and responsibilities influencing the relationship of people to data become increasingly complex, through compelling and often competing issues of social, environmental and economic management. Facilitating the role of people and data in governance that appropriately supports decision-making and sustainable development objectives is central to the concept of SDI.

Viewing the core components of SDI, different categories can be formed based on the different nature of their interactions within the SDI framework. Considering the important and fundamental interaction between people and data as one category, the second can be considered the access network, policy and standards – the main technological components. The nature of both categories is very dynamic due to the change of communities (people) and their needs, which in return require different sets of data, and due to the rapidity with which technology develops, so the need for mediation of rights, restrictions and responsibilities between people and data may change (Figure 2.2).

This suggests an integrated SDI cannot be composed of spatial data, value-added services and end-users alone, but instead involves other important issues

regarding interoperability, policies and networks. This in turn reflects the dynamic nature of the whole SDI concept. This is an issue which is also highlighted by Groot and McLaughlin (2000). According to Figure 2.2, anyone (data users through producers) wishing to access datasets must utilise the technological components. The influence of the level of SDI and the focus for the technical components have an important influence on the approach taken for aligning components towards the development of SDIs.



**Figure 2.2:** Nature and relations between SDI components

### **2.3.3 OBJECTIVES IN DEVELOPING AN SDI**

The principal objective in developing SDI for any political/administrative level is to achieve better outcomes for the specific level through improved economic, social and environmental decision-making. Also, promoting widespread use of the available fundamental spatial datasets, which is essential if the full potential of GIS technology is to be realised in supporting decision-making processes. Recognising that the cost, quality and longevity of spatial data are critical in the application of the technology, there are a number of other objectives that should be considered when developing an SDI:

- Produce standardised fundamental spatial datasets;
- Avoid unnecessary duplication of cost in developing and maintaining those data;
- Facilitate access to and application of those data;
- Enable integration of other application specific data by all users (value adding).

### **2.3.4 CURRENT SDI INITIATIVES**

Many organisations and agencies within or between different countries can participate in development and implementation of an SDI. Although different organisations have characteristic data use patterns, all organisations need different resolutions of data at different times, particularly when they are working together.

Local governments typically create and use a great deal of detailed information covering small areas that fall within their jurisdictional boundaries. They need the framework datasets of the respective countries as a base for their applications and they frequently integrate such data when they build GIS. Local governments may use data at smaller scales over wider areas, when they are working on regional issues.

State governments are characterised by the use of less detailed data covering large regions and pertaining to a particular layer. State agencies may need higher resolution data for a specific region in some projects, such as state owned lands and facilities.

At the national level, government agencies are also characterised by use of lower resolution data, frequently producing and using data that have a low level of detail and cover broad areas. They also tend to produce and use individual data themes related to their operations. But national agencies often need and produce higher resolution data,

particularly in managing national owned lands or facilities, or working on specific projects. Depending on the organisation's activities, data use may range from higher resolution data over small areas, as in facility management, to low resolution data over wide areas, as in state or national environmental studies.

At the regional and the global levels, nations are interested to cooperate with each other in different fields, such as business and economic development, global mapping, environmental management and social purposes, as well as other issues which need lower resolution data. In these levels, there are many issues, such as atmospheric pollution, global warming and water catchment management, which do not know national boundaries and transcend the national interest. These issues require spatial information at the regional and global level. To make decisions on global issues requires spatial information appropriate for these purposes. This information must be shared and integrated across national boundaries.

As a result of developing SDIs at different political and administrative levels as discussed above, a model of SDI hierarchy that includes SDIs developed at different political-administrative levels is developed and introduced (Rajabifard, *et al.* 1999, 2000b, 2001). An SDI hierarchy is made up of inter-connected SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels. The next chapter discusses this SDI hierarchy in detail.

The following sections discuss in more detail and provide more information on each of the level above a State level, as they are more relevant to this research.

#### **a) National Level**

With increasing frequency, countries throughout the world are developing SDI to better manage and utilise their spatial datasets. A number of publications document the various aspects of the development of national SDIs in recent years (Masser 1998a, Onsrud 1998). These countries are finding it also necessary to cooperate with other countries to develop regional and global (multinational) SDIs to assist in decision-making that has an important impact across national boundaries. With this background, a global survey on the status of SDI activities around the world, has been conducted by Onsrud (1998) and is updated every year on behalf of the Global Spatial Data Infrastructure (GSDI) Steering Committee (Onsrud 2000, Clarke 2000). This survey

provides baseline information on the nature and characteristics of the national and regional SDI's that are currently being developed.

Masser (1998a) and Onsrud (1998) have identified some of the countries that have begun work on SDIs at this level. Some of these countries are Australia, Canada, China, Colombia, Denmark, Finland, France, Germany, Hungary, Italy, Indonesia, Japan, Malaysia, Netherlands, Portugal, Spain, Switzerland, UK and USA, but there are claimed to be National SDI under development in about 40 countries (Rhind 2001). The number of current National SDI initiatives is more than this figure by considering that the National SDI initiatives in the Asia and Pacific region are not fully included in the above mentioned list but were reported by the PCGIAP-Taskforce Group at the 6<sup>th</sup> PCGIAP meeting held in Malaysia 2000 (PCGIAP 2000). Additionally there are a number of National SDI initiatives under way amongst the Latin American countries (Borrero 2000). The existence of these National SDI initiatives were also confirmed by Onsrud (2000) during his keynote presentation at the 4<sup>th</sup> GSDI Conference in Cape Town, 2000.

Some National SDI initiatives have little to show other than good intentions, while others have already built up a considerable amount of experience in formulating and implementing national SDIs. In some countries, such as Australia, Canada and the United States, there is a growing body of published materials describing different aspects of developing and implementing SDI, including future strategic plans. Moreover, SDI activities in these countries have focussed on encouraging communication and partnerships among the diverse collectors and users of spatial data.

Recognising that the objective of this research is the diffusion of a Regional SDI which is an initiative at a multi-national level, this chapter summarises those jurisdictional levels which are more related to the objective of the thesis. However, it should be noted that there are other jurisdictional levels within a nation (such as state and local level) which might also be active in developing SDI initiatives for their respective jurisdictional levels. These occur more when the political structure of a nation is a federated system like Australia and the USA. In these countries the development of a National SDI is mainly a matter of integration of State and Local SDIs. To this end, the



following sections will review the SDI development in these two countries in which to better realise the concept of a National SDI.

### **i) Australia**

Australia has a relatively advanced geographical information system infrastructure with well-developed policies, data and technology (Nairn and Holland 2001). Over recent years this infrastructure has been defined as the Australian Spatial Data Infrastructure (ASDI) which conforms to a large degree to other National Geo-spatial Data Infrastructures (NGDI). The Australia New Zealand Land Information Council (ANZLIC) released its discussion paper on the ASDI in 1996. Since then, there has been considerable discussion of the nature of the ASDI and how it should be implemented. There has also been a substantial amount of work done to implement various components of the ASDI.

Australia's federal system of government places a large responsibility for land management issues on state levels of government. Local government, the third tier of government in Australia, also has some responsibility in this area, especially in relation to planning of land use and provision of local services. The federal government is a large producer and user of geographic information for national applications. It plays a leading role in the coordination of the national activities of the various governments through established coordinating bodies such as ANZLIC. There are also a number of national projects undertaken by the federal government that rely on being able to access, integrate and analyse data from numerous custodians at the federal, state and local government levels.

The underlying philosophy to this approach is that fundamental geographic information is a national resource that must be managed in the national interest. The division of responsibilities between the three levels of government in Australia - federal, state and local - makes it important to coordinate geographic information activities to avoid duplication and to facilitate sharing of data across the jurisdictions. The peak coordinating council for geographic information in Australia is ANZLIC, which has representatives from all levels of government. Industry is also represented through a standing committee on industry development.

The level of autonomy of state and territory governments in Australia can sometimes cause difficulties at arriving at consistent national approaches to issues, however this autonomy has resulted in effective land management infrastructures in each jurisdiction. It is in effect a distributed, as opposed to a centralised, model. Also the relatively small number of state level governments (six states and two territory governments) makes co-ordination achievable in Australia.

The model for the ASDI is in essence a combination of the jurisdictional level spatial data infrastructures whereby the ASDI provides the “glue” to enable these jurisdictional geo-spatial data infrastructures to inter-operate. In this regard it should be noted that there are many ongoing State and Local SDI initiatives in Australia that can be addressed. For example at the State level one can reference the Victorian SDI (Jacoby *et al.* 2001) and Tasmanian SDI (Twin 2001) or to Local SDI efforts such as in Geelong (Whitworth 2001). However, the national challenge is to ensure standards are developed and applied at both the technical and policy levels so that national datasets can be derived from jurisdictional data. There will, however, always remain reasons for federal agencies to produce nationally consistent datasets where it is not feasible to simply “sew together” data available from states and territories.

The federal government coordinates its geographic information activities through the Commonwealth Spatial Data Committee (CSDC). This committee consists of the major federal government spatial data users and producers and the chairman of CSDC represents the federal government on ANZLIC. The CSDC has developed a list of framework datasets that are considered important for national applications. Framework datasets are those fundamental datasets that provide essential base information for multiple national requirements. They are the priority subset of fundamental datasets and provide the foundation on which organisations can create other datasets by overlaying their own thematic detail.

The CSDC has also embraced a process of “compliance auditing” of fundamental geographic information. This process is aimed at ensuring that fundamental geographic information meets a number of agreed compliance criteria that have been agreed by federal government. These criteria are given below. The data are nationally consistent and nationally significant. A small geographic coverage could still be nationally

significant. Moreover, a sponsor has been identified for the data which complies with ANZLIC guidelines. Data custodians have been identified. For each ASDI data layer, there may be many data custodians. Custodians comply with ANZLIC custodianship guidelines. Regarding the access arrangement, data are available “off the shelf” - accessible and readily available. Conditions of use are documented and pricing/licensing arrangements are available.

A study undertaken by Price Waterhouse in 1995 of the economic benefits arising from investment in spatial data infrastructure revealed that for every dollar invested in producing spatial data, \$4 of benefit was generated in the economy. In 1989 – 1994 these benefits were in the order of \$4.5 billion distributed across the broad spectrum of economic activities. An ANZLIC discussion paper on industry development in Australia has recently been released. This paper defines the spatial information industry as that section of the economy engaged directly or indirectly in supplying spatial attribute information of all types. Currently, the public sector dominates the supply and demand aspects of this marketplace and accounts for a majority of expenditure in products, services and data. The commercial industry consists of the participants in the various product supply chains that are formed in servicing this spatial information marketplace.

The paper also suggests that the spatial information industry appears to be emerging from a developmental phase and moving towards exploitation. Additionally some significant spatial databases are being developed in the private sector particularly in the remote sensing area. Some key indicators of the shift in industry dynamics are:

- Supply side participants beginning to reach the end of long standing data acquisition programs;
- Maturation and commercialisation of spatial information technology, in both hardware and software areas;
- Convergence of spatial and main stream information management technologies; and, perhaps more importantly
- Realisation of business benefits in traditional spatial information areas (land titles, natural resources, etc) has led to consideration and growing acceptance of low margin, high volume spatial information licensing, in direct contrast to the conventional very high margin/very low volume model.

The Federal Department of Industry Science and Resources has recognised the Spatial Information Industry as an industry with growth potential that is important in an information based economy. An Action Agenda has been established which will provide a mechanism for the Government and industry to work together to overcome barriers to growth and to ensure a whole-of government approach to the development of the industry. It will enable the industry to build on its existing strengths, generate new domestic and export marketing opportunities, enhance the development of Australia as a regional centre of excellence and encourage the creation of new technologies and products. The Action Agenda will also promote the capabilities of the industry, facilitate access to infrastructure, streamline technology diffusion between public institutions and the private sector, and encourage clustering to ensure effective competition for global market opportunities.

The increasing recognition of the importance of GIS data by government and industry is driving the development of a national GIS infrastructure known in Australia as the ASDI. The focus has changed recent times from discussion on the theory and organisation of the ASDI to implementation of its components.

Due to the division of responsibility between the various levels of government in Australia co-ordination activities are important. The NGDI is in effect a combination of the infrastructures of the various jurisdictions involved.

The development of more consistent policies for access and pricing of geographic information remains a challenge for government but is seen as one of the most important issues to be resolved. The development of a more competitive and capable GIS industry depends, to a significant degree, on improved access to GIS data held by government agencies.

Progress has been made in the implementation of a national spatial data directory and the implementation of a number of national on line atlases. Additional work is being undertaken in trialing technology and standards to enable better sharing of data. Increased interoperability across federal and state government agencies is viewed as an important future development.

Standards are being developed through national committees that will provide a higher degree of national consistency with geographic information, based on the outcomes of ISO TC/211.

The identification and auditing of framework datasets will continue to deliver more reliable data. The development of datasets comprised from data sourced from all jurisdictions in Australia is also providing better GIS data. This data availability is stimulating the GIS industry. Finally, the government has recognised the potential of the GIS industry and is actively encouraging its development through the identification and removal of obstacles to growth.

Australia has started a transition from product to more process-oriented SDI development to address some of the development challenges which occur, particularly at a National level, under the influence of a federated political system. Australia, whilst predominantly displaying product-based approaches to SDI development (also noted by McLaughlin and Coleman 1998) has recently recognised the value in taking a facilitation role for SDI development rather than that of implementation of a specific data product by itself. Based on the initial aims for Australian SDI development (ANZLIC 1996) the difficulties of coordinating many individual efforts toward SDI development, including the various stages achieved by Australian states, and awareness of the value and vision of SDI development have made the objective of alignment difficult to achieve.

More recent efforts toward ANZLIC pursuing a role of coordination have resulted in ANZLIC delegating the task of integrating and sharing different jurisdictional datasets to the Public Sector Mapping Agency (PSMA) in cooperation with the private sector. This is emphasised by the reported vision of the PSMA as “ the coordination, assembly and delivery of...national datasets from fundamental databases held by member agencies” (PSMA 2000).

PSMA originated with formation of a government consortium in 1993 to create an integrated national digital base-map for the National Census. Following success of their base map in the 1996 Census, they made it available for commercial users. Currently thousands of users in business, government, academia and recreational activities rely on their database for their solutions, as reported by PSMA (2000). As a governmental-

owned company, they function as a clearinghouse within the ANZLIC model for Australian SDI. They investigate the feasibility, facilitate the creation of and coordinate access to national spatial datasets for government and community users. In summary, PSMA plays an important role as champion and coordinating body for the development of initiatives progressing objectives of SDI developments in Australia.

## **ii) USA**

In the United States of America, discussion about the National SDI initiative started in the late 1980 primarily in the academic community (Tosta 1999) and progressed especially rapidly after the Executive Order from the President's Office was issued in 1994 (Executive Order 1994). The Federal Geographic Data Committee (FGDC) was formed in 1990 by the Office of Management and Budget to help coordinate federal geospatial data activities (OMB 1990 as cited by Tosta 1999).

By late 1992, the FGDC had evolved into a series of subcommittees and working groups to accomplish the development and coordination of standards, best practices and related programs (Reichardt and Moeller 2000). In early 1993, a major study released by the National Research Council solidified the concept of the National Spatial Data Infrastructure. That document, combined with the strong interest in federal government reform by the Vice President's National Partnership for Reinventing Government, resulted in the endorsement of formal action to establish a national spatial data infrastructure. This endorsement ultimately led to the issuance of a Presidential Executive Order 12906 in April 1994. The Executive Order called for:

- a. The establishment of a National Spatial Data Infrastructure as a key component of the National Information Infrastructure;
- b. The development and use of a National Geospatial Data Clearinghouse.
- c. Use of a national distributed framework of data for registering and referencing other themes of geospatial data.
- d. FGDC-endorsed standards for data content, classification and management for use by Federal and available to all other geospatial data producers and users.

This Executive Order established the basis for more aggressive federal efforts to advance the NSDI toward full implementation in partnership with state, local and tribal

governments, academia and the private sector where allowed by law (Reichardt and Moeller 2000).

The FGDC described the US National SDI as an umbrella of policies, standards and procedures under which organisations and technologies interact to foster more efficient use, management; and production of geospatial data (FGDC 1997). The main initiatives promoted by the FGDC included data and metadata standardisation, geospatial data clearinghouses and framework data initiatives. For Federal agencies the initiatives carried mandated components and participation. For all other communities – government agencies at state and local level, private sector organisations and academic institutions – the involvement was based on voluntary partnerships and contributions (Budic *et al.* 2001). Funding has been provided on continuous basis for test-beds and demonstration projects at all levels and for all potential groups of geospatial data users and producers. Since 1994, over 270 grants have been awarded to communities across the country to help establish metadata, clearinghouses and other National SDI practices (Reichardt and Moeller 2000). This grant program has been a catalyst in creating community incentives to implement NSDI standards and practices.

With this in mind, current progress on National SDI development in the USA shows that, following almost a decade of genuine effort and leadership, the development of the US National SDI is still challenged by implementation difficulties (Tosta 1999, Reichardt and Moeller 2000, Budic *et al.* 2001, Rajabifard *et al.* 2001). With quite a limited mandate and limited means to persuade different states, counties and local governments to fully align themselves with the intentions of the FGDC initiatives and with varying technological capacity and technological developments among the 50 states, achieving the National SDI vision is still a way ahead.

The difficulties faced in the US National SDI initiative can be analysed from different angles. Firstly, the USA is a nation of federated states where each state has its own political and administrative power. One of the challenges in the US is that it is the county and local governments, as well as some utilities, that have been chiefly responsible for the creation and maintenance of land information in the US, and there are thousands of such units across the country. Secondly, the effects of the advancement of technologies on the evolution of the SDI concept has placed increased need for

awareness of the role of technology in SDI development. Thirdly, the organisational position of the FGDC, as the coordinating committee, is problematic. The FGDC is currently under the jurisdiction of the United States Geological Survey organisation (USGS) which is itself a provider of very specific datasets for the USA. This USGS organisational structure contradicts the need for independent coordination of the varied data-providing agencies required within the scope of a National SDI for the USA.

As a result of some of the difficulties discussed, in 1999 the FGDC started to promote a new GeoData Organisational initiative aimed at creating a self-governing entity to distribute authority and responsibility among a growing network of organisations with an interest in the creation, distribution and use of geospatial data. Based on staff support from FGDC and the experiences of Dee Hock, who helped create VISA USA and Visa International, a new organisation called GeoData Alliance was established (Divis 2000).

The GeoData Alliance (GDA) is a new, innovative, nonprofit organisation open to all individuals and institutions committed to using geographic information to improve the health of communities, economies and the Earth (GDA 2001). The purpose of this organisation is to foster trusted and inclusive processes to enable the creation, effective and equitable flow and beneficial use of geographic information. Together with the purpose, the eighteen principles constitute the fundamental body of belief that will bind the GDA and its members together. The design of the GDA is chaordic. Chaordic organisations are a relatively new idea as reported by Divis (2000). A successful example of these organisations is able to combine chaos and order such that the group is largely self-creating and self-directing with no need for a huge bureaucracy to keep members in line.

This new strategy in the USA appears to show that the FGDC is moving from a product-based to a more process-based approach to SDI development in order to neutralise difficulties arising from existing approaches.

#### **b) Regional Level**

At the regional level, there are three ongoing SDI initiatives in the Asia-Pacific, Europe and the Latin American regions. These three Regional SDI initiatives are the Asia-Pacific SDI (APSDI), the European Geographic Information Infrastructure (EGII) and Spatial Data Infrastructure in Americas which are coordinated by the Permanent



Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), the European Umbrella Organisation for Geographic Information (EUROGI), and the Permanent Committee on Spatial Data Infrastructure for the Americas (PC IDEA) respectively.

The potential benefits of developing any type of SDI, promised and documented by these organisations (PCGIAP 1998b, GI2000 1995, EUROGI 1999) and different researchers (Coleman and McLaughlin 1998, Chan and Williamson 1999b, Rajabifard, *et al.* 1999) along with support from international communities is facilitating the African region to establish similar organisations to develop the same initiatives for its region (Bassolet 2000). Each of these Regional SDI initiatives is now fully operational with a stated vision, agenda and working groups. A summary of each current Regional SDI initiative is presented below except for the initiative in Asia and the Pacific region which will be discussed in more detail in chapter 4 as part of the case study.

#### **i) European SDI**

As was mentioned in chapter 1, with support from the European Union IMPACT program, the EUROGI, which is an independently funded European organisation, it was founded in 1994 as a result of a study undertaken by the European Commission to develop a European approach towards the use of geographic technologies. The mission of this organisation is to maximise the use of GI for the benefit of citizens, good governance and commerce. EUROGI promotes, stimulates, encourages and supports the development and use of geographic information and technology and acts as the voice for the European GI community (EUROGI 2000b).

But parallel to that, the EC initiated a consultative process at the end of 1994 to confront spatial data issues at a pan-European level. The EC's goal was to set up a framework within which a regional European Geographic Information Infrastructure (EGII) could be defined and established across all EU member states. Wide consultation was held throughout 1995 and 1996 and a draft Communication document, "GI2000: Towards a European Policy Framework for GI", was produced and further debated during 1997.

GI2000, as reported by Longhorn (2000), was partially a European response to the April 1994, US Presidential Executive Order creating the US National Spatial Data Infrastructure (NSDI) initiative. By September, 1994, French, Spanish, German and

(later) Dutch ministers sent letters urging stronger action in the area of geographic information, plus support for EUROGI, to improve the GI market place in Europe. In response, the Information Market Directorate, of what is now the Information Society Directorate General (DG), in Luxembourg, prepared a draft discussion document and convened a large consultative meeting in April 1995. The EC then formed a group of experts to help draft the intended communication, populated by key figures from a cross-section of the European GI community, although heavily weighted towards representatives of national mapping agencies. There were no direct representatives on this group from the remote sensing community, nor major GI user groups such as transport, agriculture, environment, health, etc.

The main recommendations for action were the identification, collection and wide dissemination of pan-European base data (topographic); strengthening the emerging national and pan-European metadata services and directories; removing such barriers to wider access to GI, as were identified during the consultation process, encouraging market growth for spatial data and the application of standards and interoperability specifications.

These issues were explored in a series of further expert and consultative meetings and numerous conferences, with many stakeholders from across the GI community participating. The main recommendation of the EC was to create a High Level Working Party (HLWP), (GI2000 1996). Apparently, based on the decisions made later, this objective was not considered sufficiently significant by the EC hierarchy to allocate the substantial internal resources required of the Commission to continue with adoption of a formal Communication. Hence, the document was sidetracked from about March 1999 until further work was suspended in October 1999 (Longhorn 2000).

GI2000 presented the status regarding European GI as one sector of a much wider information market, citing European strengths, weaknesses, barriers to greater uptake and use of GI and the potential for increased market growth if such barriers could be removed. As preparation of GI2000 progressed, it became obvious that agreement was not yet widespread within the EC hierarchy itself, that there were key issues needing action, which should then be communicated to the other EU Institutions. The GI2000 HLWP, comprising members from a broad spectrum of the GI community, under the

chairmanship of a senior EC official, would have assessed the issues, recommended ways forward and examined the means to implement the recommendations, including any financial budgets needed.

By the end of 1999, no further action was being taken on GI2000 as a draft Communication until further investigation was completed within the EC internally (Longhorn 2000). After five years of preparatory work, it seemed that the senior EC hierarchy was still not convinced that GI was sufficiently important to warrant separate action at an EU regional level, especially if this might require the expenditure of significant resources in both human and monetary terms. In order to overcome this situation, EUROGI feel that positive actions are needed to fill the current void that exist in GI strategy at the European level. With this in mind EUROGI set out a framework for such a strategy and developed a consultation document called “Towards a strategy for geographic information in Europe” and outlined a number of actions that can be taken to bring it into being. This European-GI strategy encompasses GI policy, GI infrastructures, awareness raising, promoting greater usage and capacity building as well as the more limited set of activities such as metadata, clearinghouse, a core (reference) data strategy, and the promotion of standards (EUROGI 2000a).

Parallel to the above mentioned efforts in Europe, the Multipurpose European Ground Related Information Network (MEGRIN), in conjunction with Comité Européen Responsables de la Cartographie Officielle (CERCO), is working specifically on the creation of the European spatial databases and seems to have influenced the approaches to SDI development pursued by other European countries. The current organisational changes between agencies working on the creation of the European datasets, including MEGRIN and the CERCO (forming one entity called EuroGeographics), have been to make it increasingly easier for member nations to create and share European datasets. The main aim of these two organisations to form one entity was to improve efficiency and to enjoy the potential synergy of bringing the two organisations together under a single management, the decision to combine was taken by the joint General Assemblies in the autumn of 2000 (Leonard and Luzet 2001). EuroGeographics is an independent initiative on the part of the European national mapping agencies which came into being from the beginning of 2001. EuroGeographics is managed by a Board of seven that

comprises four Members elected by their peers during the annual General Assembly and three others appointed by principal contributors – Germany, France and Great Britain.

The activities of the EuroGeographics are financed by each member paying a share of the total budgeted cost of the annual program of work. The current number of members of this organisation is close to 40 national mapping agencies from 40 countries as reported by Leonard and Luzet (2001), and its mission is to contribute towards the creation of an EGII. They recognised that the achievement of their mission will involve a number of issues – organisational, attitudinal, technological and political. By working with EUROGI and by direct liaison with politicians and officials of the EC, they are attempting to persuade them of the need both for centralised policies and for financial support for the creation of EGII.

## **ii) Regional SDI in Americas (PC IDEA)**

In 1997, during the 6<sup>th</sup> UN Cartographic Conference for the Americas (UNRCC-A), the delegates noting and recognising the rapid global emergence of national and regional spatial data infrastructures and their contribution to maximise the benefits of geographic information for sustainable development, recommended the establishment of a Permanent Committee on SDI/GIS Infrastructure in the Americas “within one year” and reporting for consideration to the following UNRCC-A meetings (Resolution 3, 6<sup>th</sup> UNRCC for Americas 1997).

In February 1998, taking advantage of the UN Working Group meeting held in Aguascalientes, Mexico the delegates representing member states from the Americas established the Committee, in an *ad-hoc* manner, with Colombia elected as *pro-tempore* chair until full formalisation of the committee was achieved within the following year (Borrero 2001). With this in mind, promoters of the committee started then by convincing Latin-American state members about the need for harmonic spatial data infrastructure at all levels and its contribution to economic, social and environmental sustainable development. These people believed that many factors contributed to the change required including awareness about the direct relation between information, economic growth and development; impact of regional and global initiatives like GSIDI and Global Map project; and increased appetite for spatial data to support project formulation and decision-making.

Facing this new situation in the Americas, 21 nations decided to formally establish their own regional permanent committee on SDI/GIS, called PC IDEA in 2000. This was the main result of an international seminar on SDI, organised in Bogota, Colombia as reported by Borrero (2001). In that seminar, the provisional statutes were adopted and three working groups for legal and economic affairs, communications and awareness and technical aspects were initially organised. The technical working group operates through five subgroups namely information policy, fundamental data, clearinghouses, standards and cadastre.

The PC IDEA was built on the experience observed in other regions, in particular, that of Asia-Pacific as reported by Borrero (2001). He summarised the vision of the PC IDEA, as “the end of spatial information isolation in the Americas”. Based on this vision, the Americas now trying hard as stated by Borrero (2001) to:

- Increase production of spatial data, impacting R &D and sustainable development;
- Migrate from local data to national SDI, leading to regional spatial datasets;
- Locate geoinformation as one strategic sector for development, by convincing decision-makers of the need to maximise benefits derived from geographic information;
- Increase knowledge capabilities for all in the American hemisphere community, by incrementing access to data and information; and
- Contribute to the development of GSDI and Global Mapping capabilities.

### **iii) African SDI Activities**

As was mentioned earlier, due to the potential benefits of developing any type of SDIs, promised and documented by different organisations and researchers and with support from international communities, the African region is also starting to establish similar organisations to develop the same initiative for its respective regions (Bassolet 2000).

In November 1999, the Interim Task Team for SDI in Africa initiated a survey on SDI programs or projects with an SDI-building component in Africa, in order to inform of possible options for creating structures to foster and harmonise SDI initiatives across the continent (NSIF 2000). The questionnaire was disseminated through UN/ECA as well as informal networks. Based on the results of this questionnaire, current spatial data activities in African countries including spatial data projects and programs tend to

involve a conscious development of different components of the African SDI initiative while not necessarily labelled as such. Further, they identified different spatial data users and producers as well as leading coordination agencies in geographic information related activities for a particular region or sector.

However, the spatial data management community, especially the surveying and mapping community in Africa believe that while there are several initiatives in Africa that can be regarded as rudiments of a holistic SDI, many of these initiatives have not really been conceptualised as SDIs as described above (Ezigbalike *et al.* 2000). They believe different African countries have focussed on different fragments of SDI. Therefore the level of development or introduction of these components varies from country to country.

In this line, as reported by Ezigbalike *et al.* (2000), most African governments recognise the need to manage their land as a resource or to optimise land use. They also recognise the importance of having relevant spatial data in order to achieve this objective. However, government departments are the major sources of spatial data. The spatial data management community addressed two main reasons for this. First, the undeveloped nature of the geo-information industry in particular and the information economy in general. Second, laws and administrative regulations that give exclusive mandates to government departments, even when they lack the capacity to satisfy the needs of the expanding user community. They believe government departments are not usually very responsive to the needs of the private users. The onus is on the user to adapt to the available data, rather than on the data producers to develop new products in response to the needs of the users.

Even within the government departments they believe data management is still a fragmented process with little cooperation between different agencies, and the flow of information between government ministries and departments is poor (Ezigbalike *et al.* 2000). This is mainly because many countries are still living in the 'mapping era' with emphasis on map management. However there seems to be tentative steps towards establishing appropriate spatial data management organisations in African countries and developing relevant indicators.

In regards to policies and standards, the reality in African countries is that these issues have not yet been addressed formally, or where they have been addressed, they are not usually adhered to, as reported by the spatial data management community. The value of information has not yet been realised and it will not be if policies and standards are not in place. With this background, members of the spatial data management community, especially the surveying and mapping community in Africa, recommended some immediate actions to overcome the shortcomings in their preparedness. They believe the shortcomings in their preparation can be regrouped into external factors outside their control and internal inadequacies, completely within their control. One of their recommendations for preparation for SDI is to emphasise more on the internal component. They believe this will ensure that when the external components are in place, they can start implementing the SDI proper.

### **c) Global Level**

At the global level, as was mentioned in chapter 1, there is an ongoing initiative known as the GSDI. The concept of GSDI started to be formulated at the first conference of GSDI held in September 1996. This was taken a step further at the conference in North Carolina in November 1997 where specific questions were asked as to what GSDI was and what was the way forward (Clarke 2000).

Within the GSDI initiative, regional organisations such as EUROGI and the PCGIAP are playing an important role. This initiative is broadly defined as the policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives (Clarke 2000). More succinctly it means ready access to geo-spatial data at the global level (Holland 2001). In this sense a GSDI is a super-set of regional and National SDIs. The organisational model, policy and framework as well as setting different working groups for designing and conducting research on the components of GSDI were formed in the more directed conference held in Canberra in November 1998 (GSDI 1998).

The GSDI is being advanced through the leadership of many nations and organisations represented by a GSDI Steering Committee. This multi-national Steering Committee includes representatives from all continents and all sectors - government, academia and

the private sector. The GSDI Steering Committee has identified a set of core goals and associated programs, to help advance awareness, acceptance and implementation of globally compatible spatial data infrastructures at the local, national and regional levels. These goals are:

- Articulate the operational environment needed to achieve Global SDI compatibility,
- Help to build compatible SDI capacity around the world,
- Educate decision-makers on the benefits of GSDI inside and outside their borders,
- Assure that different SDI related policies can be facilitated by the GSDI,
- Advance the GSDI mission until a global SDI is achieved.

The GSDI initiative started to take shape and significant progress was recorded at its 4<sup>th</sup> conference held in Cape Town in March 2000 and the latest conference which was held in Cartagena, Colombia in May 2001. For example, the Steering Committee of GSDI has undertaken several projects including development of an Internet tool that globally searches over 220 collections of metadata to locate geo-spatial data of interest (Holland 2001); and publication of a guide to SDI development (the SDI Cookbook). However, as Holland (1999) reported, there are many challenging issues still facing the GSDI before it becomes a reality globally. Some of these challenging issues are raising the level of awareness, acceptance and support; recognising and complementing related initiatives; including all stakeholders; engaging the less developed economies of the world; maintaining enthusiasm and momentum; and delivering beneficial outcomes.

With this in mind, the recent GSDI conference (GSDI 5), resulted in some resolutions to overcome some of those challenging issues. For example, the conference resolved that the GSDI Steering Committee agrees to an expansion of the definition for the GSDI as follows:

*“The Global Spatial Data Infrastructure is coordinated actions of nations and organisations that promotes awareness and implementation of complimentary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes.”*

(Resolution 1 of the GSDI 5)

Or, in regard to GSDI organisation, the conference resolves that it intends to form a public private not-for-profit organisation to guide the leadership activities for GSDI. In this regard, the Steering Committee was tasked to establish a Task Group to make



recommendations to the Steering Committee and then to implement decisions of the Steering Committee (Resolution 2 of the GSDI 5). However, as stated by Clarke (2000) the ultimate success of GSDI rests on the successful establishment of National and Regional SDIs.

## **2.4 CHAPTER SUMMARY**

This chapter begins with a brief review of the need for spatial data and data sharing and introduces major forces driving the development of such data. It then introduced and discussed the nature and concept of SDIs, including the components, by reviewing a number of the more current definitions of SDI. These reviews have helped to build the current understanding about the importance of an infrastructure to support the interactions of the spatial data community.

According to these reviews, SDI is understood and described differently by stakeholders from different disciplines and different political and administrative levels. It is argued that while they provide a useful base for the understanding of SDI, individually on their own they are inadequate for SDI development in the future. Further, it is argued that current SDI definitions are individually insufficient to describe the dynamic and multi-dimensional nature of SDI. Despite the international interest and activities toward SDI development, SDI remains very much an innovation even among practitioners. There are still doubts regarding the nature and identities of SDI, particularly in connection with how they evolve over time to meet user needs. With this in mind, this chapter discussed the concept of SDIs in such a way as to better clarify their nature to facilitate their development and progressive uptake and utilisation among members of a community (diffusion).

Based on this discussion, it is proposed that an SDI comprises not only the four basic components of institutional framework, technical standards, fundamental datasets and access networks, but also an important additional component, namely, people (human resources). The SDI includes the spatial data users and suppliers and any value-adding agents in between, which interact to drive the development of the SDI.

The chapter then discussed the needs of spatial data for different level of jurisdictions, followed with an overview of current SDI initiatives worldwide. According to this

overview, many countries are developing SDI at different levels ranging from local to state/provincial, national and regional levels, to a global level, to better manage and utilise spatial data assets.

This Chapter concludes that SDIs are a much-needed tool to better facilitate data sharing as well as jurisdictional cooperation and partnerships. However, an understanding of key SDI principles, such as the hierarchy of SDIs in a jurisdiction and the dynamic nature of SDIs, are also important but not fully understood.

# CHAPTER 3

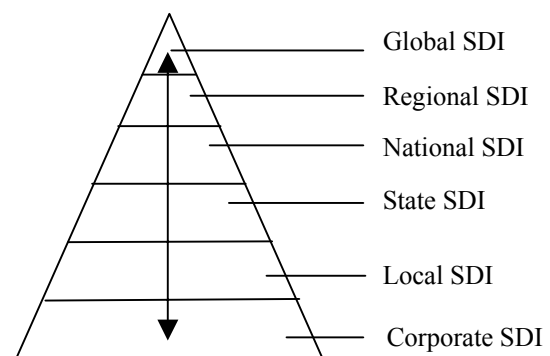
## SDI HIERARCHY

### 3.1 INTRODUCTION

Based on the concept and nature of spatial data infrastructures which were discussed in the previous chapter, the objective of this chapter is to demonstrate the fitness and applicability of Hierarchical Spatial Reasoning (HSR) as a theoretical framework to demonstrate the multi-dimensional nature of SDIs. The chapter begins by introducing the concept of an SDI hierarchy followed by a review of hierarchical reasoning and its properties. It then argues that by better understanding and demonstrating the nature of an SDI hierarchy, any SDI development can gain support from a wider community of both government and non-government data users and providers. The chapter concludes by examining how current hierarchical theory can be extended to incorporate different levels of SDI initiatives.

### 3.2 AN SDI HIERARCHY

As discussed in chapter 2, many countries are developing SDI at different levels ranging from local to state/provincial, national and regional levels, to a global level, to better manage and utilise spatial data assets. The most important objectives of these initiatives, as summarised by Masser (1998a), are to promote economic development, to stimulate better government and to foster environmental sustainability. As a result of developing SDIs at different political and administrative levels, a model of SDI hierarchy that includes SDIs developed at different political-administrative levels was developed and introduced (Rajabifard, *et al.* 1999, 2000a, 2000b). Figure 3.1 illustrates



**Figure 3.1:** AN SDI hierarchy

this model in which an SDI hierarchy is made up of inter-connected SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels. In the model, a corporate SDI is deemed to be an SDI at the corporate level - the base level of the hierarchy (Chan and Williamson 1999a). Each SDI, at the local level or above, is primarily formed by the integration of spatial datasets originally developed for use in corporations operating at that level and below.

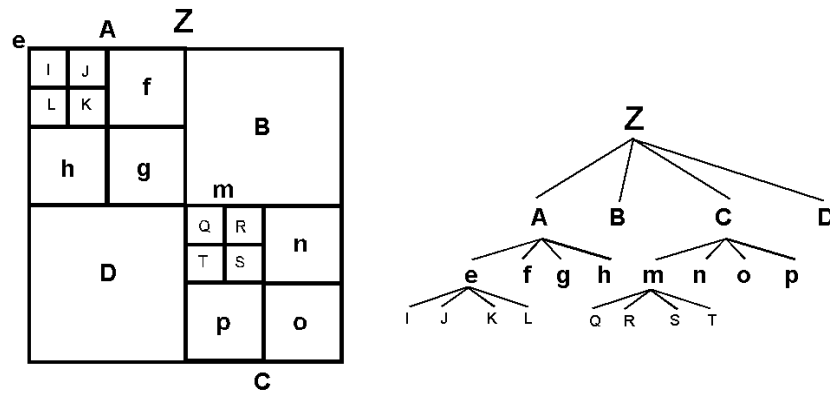
The next sections will review the concept of hierarchy theory and its properties, and will then discuss the main reasons that the hierarchy concept is applied to the SDI concept.

### **3.3 HIERARCHICAL SPATIAL THEORY**

In the past much research has been conducted toward maximising the efficiency of computational processes by using hierarchies to break complex tasks into smaller, simpler tasks (Car 1997, Timpf 1998). Hierarchical principles are used in many different disciplines to break complex problems to sub problems that can be solved in an effective manner. Examples of hierarchical applications include classification of road networks (Car 1997) and development of political subdivisions and land-use classification (Volta and Egenhofer 1993). The complexity of the spatial field as highlighted by Timpf (1998) is primarily due to space being continuous and viewed from an infinite number of perspectives at a range of scales.

#### **3.3.1 DEFINITION OF HIERARCHY**

Koestler (1968), as cited by Car (1997), used the term *hierarchy* for a tree-like structure of a system which can be subdivided into smaller sub-systems, which in turn can be further subdivided into smaller sub-systems, and so on. In Figure 3.2, an example of a hierarchical structure is given, where each new square can be divided into a set of four smaller squares. Z consists of four sub-squares. This can be recursively subdivided as long as subdivision makes sense. This hierarchical arrangement can also be represented as a tree.



**Figure 3.2:** Hierarchical structures represented by square subdivisions and by a tree like structure (adapted from Car 1997)

Hierarchies are usually distinguished by their functions, which produce different types of hierarchies. Timpf (1998) recognised aggregation, generalisation and filtering as the three most important functions to produce three different types of hierarchies. The aggregation hierarchy is built by aggregating objects. The generalisation hierarchy defines how classes are related to more generic super, or higher order, classes. The filter hierarchy filters objects according to a criterion.

### 3.3.2 PURPOSE AND LEVELS OF A HIERARCHICAL STRUCTURE

There are good reasons why hierarchies develop and persist. Decreasing the processing time of a system (Pattee 1973, Car 1997) is one reason to introduce a hierarchy: a process being a sequence of actions performed in a particular way and leading to some result, and the processing time thought of as the time needed either for development or evolution of the system. A hierarchically structured system evolves much faster than a non-hierarchical system containing the same number of elements (Simon 1973). Increasing the stability of any system is another reason to form hierarchies (Pattee 1973). Also, hierarchies break down the task into manageable portions and enhance the potential for parallel processing (Timpf *et al.* 1992). The hierarchical approach was especially adopted in the description of complex dynamic systems (Mesarovic *et al.* 1970 as cited by Timpf 1998), which Simon (1981) states have several advantages to a hierarchical structure.

With regard to the levels in a hierarchical structure, a set is divided into subsets or levels. A level is described by criteria determining which elements of the initial set belong to this level, and in turn, how this level is related to other levels in a hierarchy.

The number of levels determines the depth of the hierarchy. The number of elements on each level determines its span and in turn the span of the tree.

### **3.3.3 HIERARCHICAL REASONING**

Hierarchical reasoning is any reasoning process that applies hierarchy either to subdivide the task, problem, process or space. Hierarchical reasoning adopts the principle of using the least detailed representation to answer a question. All data are inherently imprecise, but decisions do not require perfect information, instead information that is sufficiently precise (Timpf and Frank 1997).

Hierarchical Spatial Reasoning (HSR) is defined by Car (1997) as part of the spatial information theory that utilises the hierarchical structuring of space for efficient reasoning. It is only recently, through the works of Car (1997) for way-finding, Glasgow (1995) for spatial planning and Frank and Timpf (1994) devising the intelligent zoom, that this theory has started to be applied in the spatial industry.

### **3.3.4 PRINCIPLES OF HSR**

The framework supporting HSR has three important components - representation, properties and applications. Hierarchies have been represented using alternative methods: Coffey (1981) devised triangles to represent a hierarchical structure; Car (1997) illustrates how triangles can also be represented as a tree-like structure. Although there are different representations of hierarchically organised systems, all provide the same function to breakdown the complexity of problems into smaller sub systems that can be efficiently handled and modelled.

In the past HSR research has focused on zero and one-dimensional structures to model urban systems (as points), road and drainage networks (as lines), and to a certain extent, to model simple bi-dimensional objects such as square polygons in quad-trees. Recently, research on HSR has focused on three-dimensional structures to break down the complexities of polygons in the case of Australian administrative boundary design (Eagleson *et al.* 1999). From this research it has become evident that the properties required to model polygon hierarchy are more complex than those utilised for the modelling of points or networks.

### 3.3.5 PROPERTIES OF HIERARCHIES

Hierarchies in various phenomena, both natural and artificial, have properties specific to a particular context, but they also have common properties. These common properties are general relationships among structure, movement and function that are independent of their specific context (Car 1997). Some of the properties of a hierarchical structure that are relevant to the understanding of hierarchies in general and spatial hierarchies in particular, are as follows:

- **Part-Whole Property**

In a hierarchy, an element on a higher level consists of one or more elements on the lower level. In view of a part-whole relationship, a higher level is a whole and a lower element is its part (Car 1997). For example, in Figure 3.2, quadrangle A is a whole made up of quadrangles e, f, g and h. Similarly, A is also part of quadrangle Z.

- **Janus-Effect**

An element at a hierarchical level has two different faces, one looking toward wholes in a higher level and the other looking toward parts in a lower level. This property was introduced by Koestler (1968, cited by Car 1997) as a fundamental property of all types of hierarchy. In Figure 3.2, each quadrangle is directly related to both above and below level quadrangles. Thus, e faces A but also I, J, K and L.

- **Near Decomposability**

The third fundamental property of hierarchy is called near decomposability (Simon 1973). It is related to the nesting of systems within larger sub-systems and is based on the fact that interactions between various kinds of systems decrease in strength with distance. Components that are closer to each other interact more strongly than components that are far apart, many of them being at the same level. The definition of this property does not refer to whether elements on the same level should or should not be closer and have more interaction than elements in other levels. In Figure 3.2, elements such as J or K are closer to A than to other elements on the same level such as T or Q. In the tree structure part of the same diagram, it is clear

how elements within the same level do not necessarily interact with themselves. It is believed, and it will be discussed later, that elements within the same level in the hierarchy should have a way to communicate or interact in a better way than what is already present amongst levels.

Other than properties, hierarchies may also have special functional features such as uniqueness in particular roles. A feature such as this uniqueness may distinguish one level of the hierarchy due to its inter-relatedness with the other levels of the hierarchy. This feature is known as *particularity* to the system of hierarchies.

### **3.4 APPLYING HIERARCHY THEORY ON SDIs**

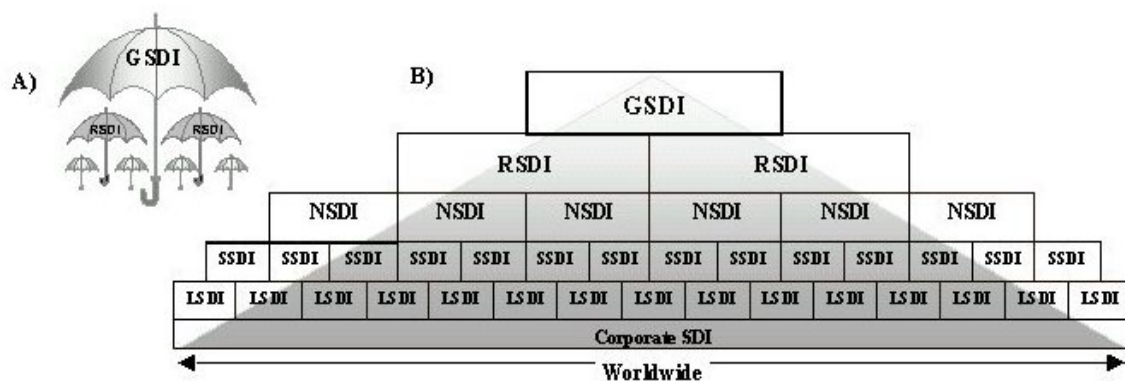
The main reason that a hierarchy concept is applied is that all common properties and reasons for developing a hierarchical structure are also applicable to SDI concepts. For example, according to the part-whole property an SDI at a high level, like a global level, consists of one or more SDIs from the lower level, such as different Regional SDIs like the APSDI in the Asia-Pacific and the EGII in Europe. Moreover, a Regional SDI is a whole for a regional level and is a part of the global level. This is also applicable to the individual components of an SDI. Alternatively, according to the Janus-Effect, any element at a hierarchical level, say a National SDI, in the SDI hierarchy has two different faces, one looking toward wholes in a higher level, in this case regional and the global levels, and the other looking toward parts in lower levels of SDIs such as State and Local levels. This is illustrated by a double-ended arrow in Figure 3.1. According to Timpf (1998), the most common function to build a hierarchy is the aggregation function. Classes of individuals are aggregated because they share a common property or attribute. This is the other reason that a hierarchical concept can be applied to SDIs since, different SDI initiatives at a certain political/administrative level can aggregate together to form the next higher level of hierarchy. This is the most common type of construction of hierarchy as introduced by Timpf (1998).

#### **3.4.1 DIFFERENT VIEWS ON SDI HIERARCHY**

The existence of hierarchical capability for SDIs will enable utilisation of the advantages of this concept. Rajabifard *et. al* (2000b) published two views on the nature of this SDI hierarchy to better describe the concept and nature of this hierarchy (Figure



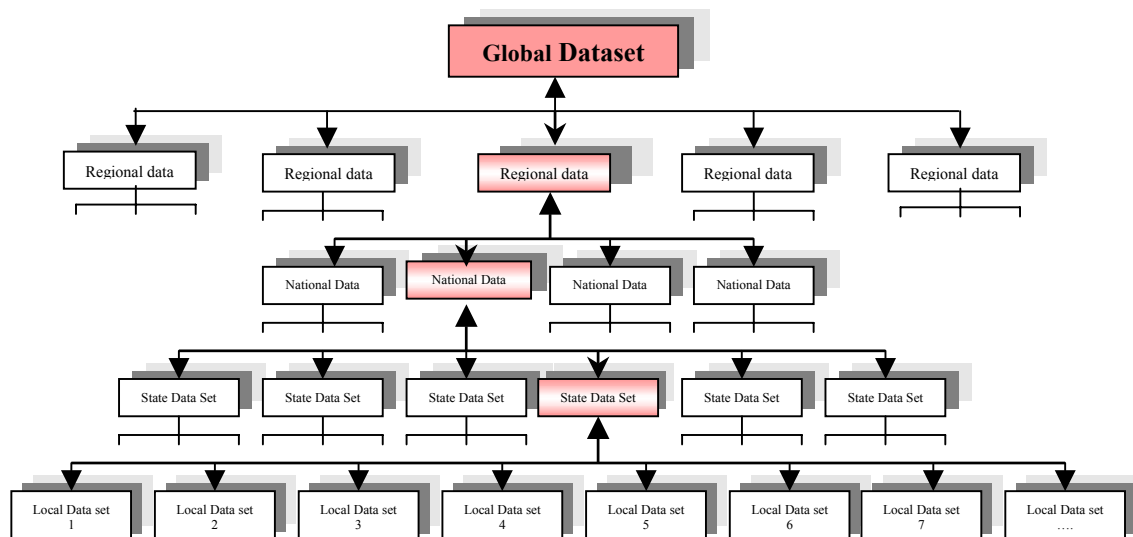
3.3). However, there is no major difference between these two views, as they both help in better understanding the concept of this hierarchy. The first view is the umbrella view (Figure 3.3A) in which the SDI at a higher level, say the Global level, encompasses all the components of SDIs at levels below. This suggests that ideally at a Global level, the necessary institutional framework, technical standards, access network and people are in place to support sharing of fundamental spatial datasets kept at lower levels, such as the Regional and National levels. This view is very similar to the global umbrella model recommended at the 3rd GSDI conference for the long-term development of the GSDI concept (GSDI 1998). However, based on this view, the global umbrella model needs to be modified. Modification is necessary to avoid possible duplication of effort and to ensure incorporation of current Regional SDI initiatives. The global umbrella model suggests each region should establish a regional organisation working on GSDI issues. These tasks could be transferred to the existing regional SDI development committees such as PCGIAP and EUROGI.



**Figure 3.3:** A) The Umbrella View of SDI; B) The Building Block View of SDI

The second view regarding the nature of SDI hierarchy is called the building block view (Figure 3.3B). According to this view, any level of SDI, for example the State level, serves as the building blocks supporting the provision of spatial data needed by SDIs at higher levels in the hierarchy, such as the National or Regional levels.

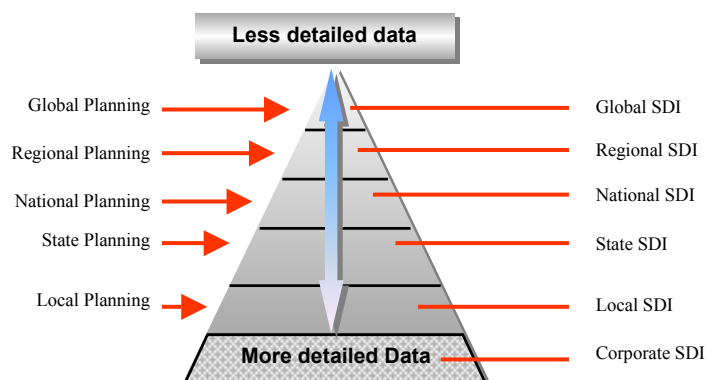
The building block view as illustrated in Figure 3.4, can be better realised by applying the model to the fundamental datasets of different levels of SDIs.



**Figure 3.4:** Spatial Hierarchy of different Fundamental Datasets

This also realises the visions of data sharing and partnerships and reduces the overall cost of data collection. Based on this view, a pyramid of building blocks can form from a Local SDI to a Global SDI.

Based on these two views, the SDI hierarchy creates an environment, in which decision-makers working at any level can draw on data from other levels, depending on the themes, scales, currency and coverage of the data needed (Figure 3.5). The double-ended arrow in this figure represents the continuum of the relationship between different levels of detail for the data to be used at the different levels of planning corresponding to the hierarchy of SDIs.



**Figure 3.5:** Relationships between data detail, different levels of SDIs, and level of planning

As Figure 3.5 illustrates, users at different levels of planning can have access and need to have access to a certain level of detail to take full advantage of using the SDI. However, it is quite difficult to define a boundary for data detail that can satisfy all user needs at a specific level. Sometimes due to the lack of availability or inaccessibility of the preferred level of data, different users may be required to compromise and use the available data to satisfy their needs.

### **3.5 RELATIONSHIPS AMONG DIFFERENT SDIs**

Relationships among different levels of SDIs are complex. This complexity is due to the dynamic, inter- and intra-jurisdictional nature of SDIs. One way to observe and map these relationships in the context of an SDI hierarchy can be to assess the impact and relationships of each component at two different hierarchical levels.

Research was conducted on this issue and included analysis of current SDI initiatives throughout the world in terms of model, strategy and the steps toward the implementation of SDIs. Further study on this issue involves reviewing documents from a number of other inter-related disciplines including political and administrative systems and different organisational structures and behaviours.

The following discussions are based on the results of this research and information derived from several specific studies conducted (Rajabifard *et al.* 2000b). The country reports of geo-information policy and strategies that were presented at the last five PCGIAP meetings and the last UNRCC-AP conference is one such study. Another was the Development Needs Taskforce survey that was conducted by the PCGIAP-Taskforce group to identify relevant assistance in NSDI activities for member countries across the Asia-Pacific region in 1999 (see chapter 6). The results of this research are presented in Tables 3.1 and 3.2.

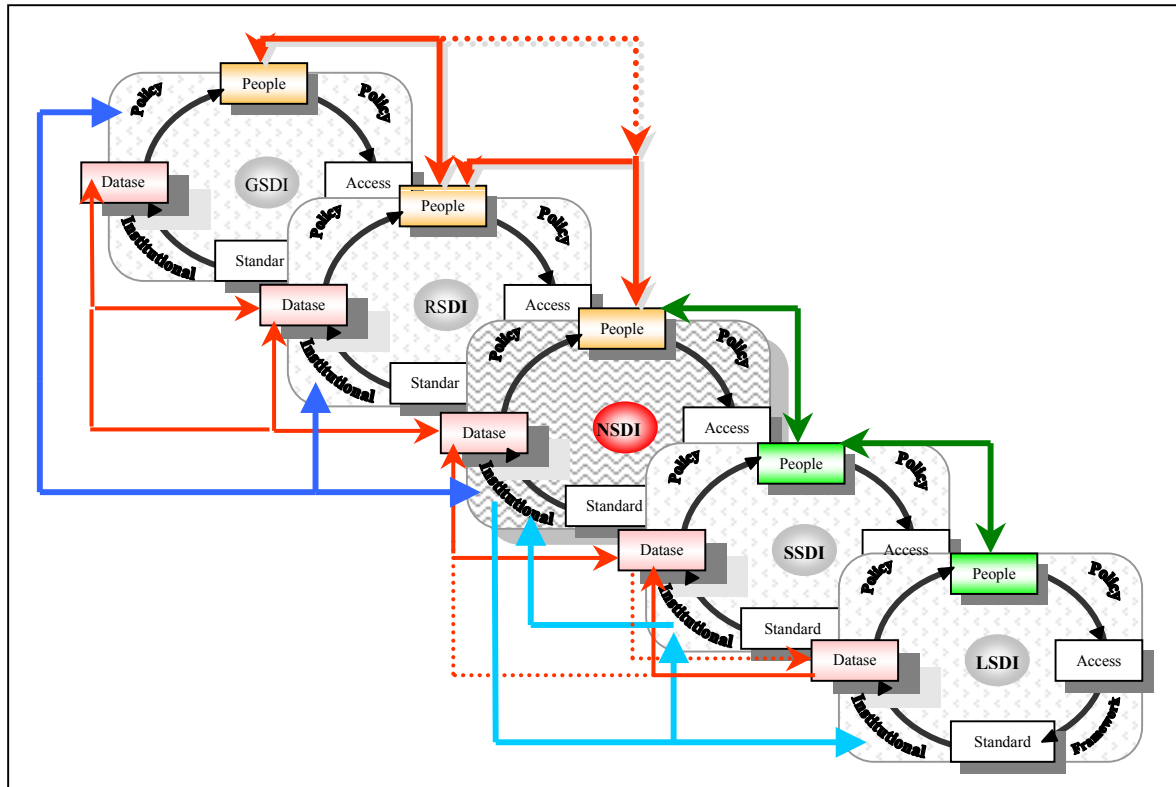
Table 3.1 demonstrates the potential direct and indirect impacts and relationships of any level of SDI on the other levels through each of the components. This represents general patterns of relations between levels of SDIs. There are however instances where the SDI relations within a country may deviate slightly from the generic global trends (Table 3.1). An instance of this is the independent functionality of Australian State SDIs.

**Table 3.1:** Global Trend Relations between different levels of SDIs

SDI Components	Local SDI	State SDI	National SDI	Regional SDI	Global SDI
<b>Policy</b>	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
<b>Fundamental Datasets</b>	L → S L → N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
<b>Technical Standards</b>	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
<b>Access Network</b>	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
<b>People</b>	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R

→ Direct impact      → Indirect impact      — No impact  
 L= Local SDI;      S= State SDI; N= National SDI; R= Regional SDI; G= Global SDI

As an example, based on the above table (Table 3.1), a National SDI has a full impact and relationships on the other levels of the SDI hierarchy through all its components. In terms of policy a National SDI has an important effect on both the upper level of SDIs (such as Regional SDI), and lower levels of SDIs (such as that at the State level). But policy at a global level has only direct impact and relationships with the Regional and the National SDIs. Or in terms of fundamental datasets, a National SDI has an important role in forming this component of the upper level of SDIs, and its datasets are created based on the datasets from the lower levels of SDIs. But the fundamental dataset at a National level can have an indirect impact on the fundamental datasets at a state level. Users at a state level might need to use national fundamental datasets for their applications before using State level datasets that are in more detail than datasets at a national level. In terms of technical standards, a National SDI has a direct influence on the State and Local SDI levels, and its position is important for the upper levels to decide on their strategies and standards. These relationships are also illustrated in Figure 3.6 in a graphic form.



**Figure 3.6:** Relationships among different level of SDIs

In a similar way, Table 3.2 provides the basic content for each component of different SDIs and possible coordinators of each of the SDIs' initiatives. It also contains a possible list of the external influencing factors on each of the SDIs' initiatives. This information can assist to identify the similarities and differences of different levels of SDIs to better manage different SDI initiatives. Moreover, it can be considered as a base for further discussion of any SDI design by different communities.

In general, according to Figure 3.6 and Table 3.2, an SDI at a National level has an important role in building the other levels of SDIs as well as more relationships with the other levels than any other level of SDI in the hierarchy. The role of a National SDI in a SDI hierarchy displays a particularity of role not present in the other levels of the SDI hierarchy. This particularity is that bottom levels of an SDI hierarchy, such as local and state levels, have no strong links to the upper levels of the hierarchy, like to the GSDI. So, there is a crucial level to the lower and higher links, which is the National SDI.

**Table 3.2:** Comparison between different SDIs based on SDI Core Components

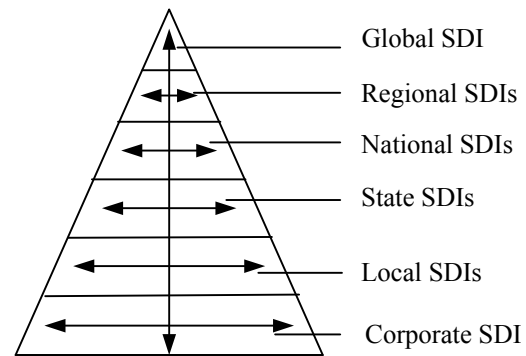
Components	Global SDI	Regional SDI	National SDI	State SDI	Local SDI
<b>Institutional Framework</b>	Custodianship, Data access, Sponsorship, Leadership, Education & Training,	Custodianship, Data access, Sponsorship, Leadership, Education & Training,	Custodianship, Data access, Sponsorship, Leadership, Education & Training,	Custodianship, Data access, Sponsorship, Leadership, Education & Training,	Custodianship, Data access, Sponsorship, Leadership, Education & Training,
<b>Fundamental Datasets</b>	Global Control Network, Elevation, Administrative boundaries, Transportation, Main Hydrologic features, Main Population places, Main Geographic names, Natural hazards,	Regional Geodetic Control Network, Elevation, Administrative boundaries, Transportation, Hydrologic features, Population places, Geographic names, Land use & land covers, Natural hazards, position of regional projects,	National Geodetic Control Networks, Topographic features, Land use & Land covers, Natural hazards, Position of national projects, Cadastral,	National & State Control Networks, Topographic features, Cadastral map, Natural hazards, Position of national & state projects,	National & Local Control Networks, Topographic features, Cadastral map, Natural hazards, Position of national & local projects,
<b>Scale</b>	Small (less detailed data)	← ~Small-Medium	Medium--Small	Medium--Large	→ Large (more detailed data)
<b>Technical Standards</b>	International Standards (ISO/TC211)	International (ISO/TC211) or Regional Standards	International (ISO/TC211) or National Standards	National Standards	National Standards
<b>Access Network</b>	Global directory system, Technology framework (WWW)	Regional Directory system, Technology framework (distributed databases)	National Directory system, Technology framework (distributed databases, WAN)	State Directory system, Technology framework (distributed databases, WAN)	Local Directory system, Technology framework (distributed databases, WAN)
<b>People</b>	Governments, Academia, global organisations (government/ non-government)	Regional governments, Academia, regional organisations,	All level of governments, Academia, Private sectors, Non-profit sectors,	All level of state governments, Academia, Private sectors, Non-profit sectors,	All level of local governments, Academia, Private sectors, Non-profit sectors,
<b>Coordinator</b>	International Steering Committee	Regional GIS & Infrastructure Committees	Federal Government	State Government	Local Government
<b>Environmental factors</b>	Legal & Administrative Issues, Political systems, Lack of Awareness, Security on spatial data	Political systems, Legal & Administrative issues, Security on spatial data, Lack of Awareness, Social & Cultural diversities, Languages, Population, Area's of countries,	Lack of Awareness of the value of SDIs, Priorities,	Lack of Awareness of the value of SDIs, Priorities,	Lack of Awareness of the value of SDIs, Priorities,

Due to the particularity of the role of National SDIs in an SDI hierarchy, any nation can better contribute to international trends of the SDI concept and can also gain advantages from the other levels of the SDI hierarchy by greater attention and sensitivity to the design, construction and implementation of their own National SDI.

### 3.6 HSR AND AN SDI HIERARCHY

Hierarchical Spatial Reasoning (HSR) provides an expandable framework to demonstrate the concept of SDI. Current properties of HSR theory have been particularly well adapted to describe the vertical relationships between political/administrative levels of SDIs. Additional to these vertical relationships there are complex relationships between SDIs within a political/administrative level, at

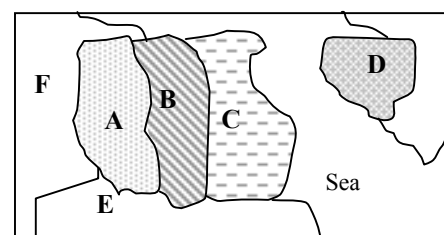
‘horizontal’ level, of an SDI hierarchy. Figure 3.7 is a concept diagram that represents the complex vertical relationships (inter) between SDIs at levels in an SDI hierarchy ( $\updownarrow$ ) as well as the complex horizontal relationships (intra) between SDIs in any one level of such a hierarchy ( $\leftrightarrow$ ). These ‘horizontal’ relationships have been less well explored within current HSR theory in respect to SDIs.



**Figure 3.7:** The complex SDI relationships within and between different levels

Recent research on SDI hierarchy has determined that current hierarchical properties, which are well utilised for modelling points and lines, requires further development to incorporate the complexities of SDI relationships and dynamics (Eagleson *et al.* 2000).

As mentioned above, additional to the vertical relationships between different levels of SDIs (Figure 3.7), there are also horizontal relationships between individual SDI initiatives within any level of an SDI hierarchy which should be taken into consideration. These relationships become more important when the respective jurisdictions are spatially adjacent and proximate. SDIs belonging to adjacent jurisdictions play more important roles and have more influence and impact on each other than on SDIs of non-adjacent jurisdictions. For example, at a regional level, the policies and standards used on preparation of fundamental datasets of country A and country B, in Figure 3.8, have more impact on each other than country A with country C or D, when they are supposed to be integrated together forming datasets of the region.



**Figure 3.8:** Countries with Adjacency and non-adjacency areas

Using a global example, the policies and standards of SDIs of the European countries have more impact on each other than they do on the policies and standards adopted for SDIs by countries from the Asia and Pacific region, or Africa. This is a result of the principles of adjacency and proximity.

Based on the above discussion, it is proposed that a new property must exist when applying HSR principles to SDI. This is a horizontal property which defines the levelled nature of SDI within a hierarchically organised system. This property states that within each level of the SDI hierarchy, any SDI is interconnected with another in the same level and has horizontal relationships with them in which they impact on each other.

This horizontal property encompasses the relationship between SDIs that are proximate as well as those that are distant. Coming back to the example on Figure 3.2 earlier in the chapter, the presence of a horizontal property will make elements at the same level like I, J, K, L, Q, R, S and T closer to each other than they are to elements one level high, even if they do not share a common intermediate upper level. In a sense, this contradicts the property of near decomposability. Further research into how HSR and its properties might be adopted into SDI is needed.

### **3.7 SDI PARTNERSHIPS AND GLOBAL DRIVERS**

The design of any SDI requires understanding the nature of the concept, the contributing components and the impact of global drivers. Apart from rapid advances in information and communication technologies, the need to define the concept of SDI is justified by drivers such as globalisation, sustainable development, economic reform, political unrest and war, urbanisation, environmental awareness and human rights (Williamson 2000). Moreover, it is the needs of the user community that drive SDI development. These present significant influences on the changing spatial data relationships within the context of SDI jurisdictions. Reliable information infrastructures are needed to record environmental, social and economic rights, restrictions and responsibilities as well as to provide spatial data to facilitate appropriate decision-making and support conflict resolution. These drivers in turn effect the resulting spatial data industry environment and SDI vision, in particular the partnerships concept.

There has been a trend for countries to expand their efforts in developing SDIs through partnerships, as data sharing is crucial to the success of SDIs. In the 1990s National SDI development took a broad-base approach to encourage cooperation among stakeholders to pool data assets. Based on this approach, an ideal SDI should have all datasets in the corporate SDI fully integrated. Constrained by existing technical and institutional



arrangements, SDI developing agencies have focused on promoting adoption of common standards, as well as fast-tracking integration among certain strategic datasets through partnership arrangements (ANZLIC 1996, Jacoby *et al.* 2001). Partnerships are formed to create business consortia to develop specific data products or services for strategic users, by adopting a focussed approach to SDI development.

### **3.8 CHAPTER SUMMARY**

Based on the nature and concept of spatial data infrastructures, this chapter introduced the concept of an SDI Hierarchy which is made up of inter-connected SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels. A spatial hierarchy relationship was then outlined among the different types of SDIs. According to this model, by combining each level of SDIs using a building block approach, it is possible to build and form the bases of the next level of an SDI Hierarchy. In other words, different levels of SDIs can build upon other supporting levels. Then, the concept, properties and reasons for using a hierarchical structure were discussed and found suitable to apply to the concept of an SDIs' development. Hierarchical Spatial Reasoning (HSR) provides an expandable framework to demonstrate the concept of SDI and represent the complexities of the different levels of SDI based on hierarchical principles.

It has demonstrated in this chapter and by Eagleson *et al.* (2000) that current properties of HSR theory have been particularly well adapted to describe the vertical relationships between political/administrative levels of SDIs. However, in addition to the vertical relationships (inter-jurisdictional relationships) there are also complex relationships between SDIs within a political/administrative level, at the 'horizontal' level (intra-jurisdictional relationships), of an SDI hierarchy. These 'horizontal' relationships have been less well explored within current HSR theory in respect to SDIs. Moreover, recent research on SDI hierarchy has determined that current hierarchical properties, which are well utilised for modelling points and lines, are not sufficient to adequately model the complexity of the relationships between and within levels of SDIs. Therefore, it has been suggested that the theory of HSR require further development in order to model an SDI hierarchy to incorporate the complexities of SDI relationships and dynamics.

Based on this discussion, it is proposed that a new property must exist when applying HSR principles to SDI. This is a horizontal property which defines the levelled nature of SDI within a hierarchically organised system. This property states that within each level of the SDI hierarchy, any SDI is interconnected with another in the same level and has horizontal relationships with them in which they impact on each other.

Further, based on the relationships among different SDIs, a particular aspect of the SDI hierarchy is also identified. This particularity suggests that an SDI at a National level has a crucial role in the development and implementation of the other levels of SDIs in the hierarchy. Therefore, those countries that are able to develop an efficient National SDI, will be well placed to contribute to the development of Regional and Global SDI initiatives as well as support Local and State/Provincial SDI initiatives.

# **CHAPTER 4**

## **ASIA-PACIFIC REGION AND REGIONAL SDI ACTIVITIES: A CASE STUDY**

### **4.1 INTRODUCTION**

As was stated in chapter 1, this research adopted a case study approach in addressing the research objectives, with Asia and the Pacific region being selected for this purpose. This chapter starts by presenting the basic characteristics of Asia and the Pacific region and providing a brief description of the past and current status of geographic information in this region. This is followed by a review of the concept of regional cooperation in general and regional cooperation in Asia and the Pacific in particular. This review includes the political and historical contexts and regional activities in order to set the scene for the case study. The chapter then discusses the need for a Regional SDI followed by a discussion of this concept. Based on these investigations, the chapter then reviews the Asia-Pacific Regional SDI initiative including the structure and activities of its coordinating committee and the SDI conceptual model.

### **4.2 BASIC CHARACTERISTICS OF THE REGION**

The Asia and Pacific region is the largest region in the world with some 60 per cent of the world's population, or 3.5 billion people and includes 55 countries as defined by the UN (Appendix 2). The countries span a wide part of the globe from Iran and Armenia in the west to French Polynesia in the east, from the Russian Federation and Japan in the north to New Zealand in the south.

The Asia and the Pacific region has emerged as the most dynamic region of the world (Fukasaku 1995). Its rapid and sustained development has created vast trade and investment opportunities, especially for the economies of its individual nations. Moreover, as Fukasaku (1995) highlighted, this region is changing fast and it is changing for the better, even recognising the economic crisis of 1997. Asia and the

Pacific region has witnessed dramatic and widespread changes due to the forces of globalisation, industrialisation and urbanisation. One of the most significant developments in Asia and the Pacific regional economy has been the rapid growth of regional cooperation. Within a few years, a number of regional initiatives have been endorsed and various forms of cooperative ventures have been established.

In this region, Geographic Information (GI) is traditionally collected and disseminated by a range of mandated national organisations according to a wide variety of national standards. A major difficulty in relation to the GI in this region is a lack of coordination. National administrations do not systematically cooperate with their equivalents elsewhere. Due to this lack of coordination, different data structures, specifications and standards are used by member nations which does not facilitate data exchange. Although networking relationships exist between nations, these are based on individual arrangements and are not reflected in an operational coordination of activities. Where there is metadata at all, different agencies within member nations maintain it using different formats and tools. More generally there is a lack of common elements that could facilitate data exchange such as compatible working scales, compatible GIS software and the completion of a regional database which could be used for standard basic information layers.

#### **4.3 REGIONAL COOPERATION IN ASIA AND THE PACIFIC REGION**

Regional cooperation creates enormous opportunities and challenges for nations. The main rationale for regional cooperation rests on the exploitation of dialogues among a group of countries, which support the efficient use of natural and human resources beyond national borders (Fukasaku 1995). This in turn shows that regional cooperation is a practical example of why spatial data is a key issue for all nations.

Regional cooperation enhances economies of scale by enlarging regional markets and increasing competition. In addition, there are other positive effects such as increases in the rate of technological transfer, improvements in the investment climate and other consumer demand dynamics. There are substantial benefits from regional cooperation in the area of infrastructure, environmental protection, technology, trade, investment and natural and human resource development.

It is well accepted that improvement of regional infrastructure linkages including transportation, communication and power supply are important for the success of regional cooperation (Tang 1995). Therefore, the success of such cooperation requires strong support and a sustained commitment from all participating governments. In most cases regional organisations need to access and use spatial data as a primary input to plan and execute these projects and programs. The importance of such access is currently an important item on many government agendas. This is particularly apparent in the mission statement of the British National Geospatial Data Framework which seeks:

*“To provide a framework to unlock geospatial information for the benefit of the citizen, business growth and good government through enabling viable, comprehensive, demand-led and easily accessed services.”*

(Nanson and Rhind 1998).

These views are also echoed in the final report of the pilot study carried out on the Canadian Geospatial Data Infrastructure. It formulated its mission in the following terms:

*“to provide easy, consistent and effective access to geographic information maintained by public agencies throughout Canada; and to promote the use of spatial information in support of political, economic, social and personal development by all Canadians.”*

(Labonte *et al.* 1998).

As far as regional cooperation is concerned, one of the most significant developments in Asia and the Pacific regional economy has been the rapid growth of regional cooperation. Within a few years, a number of regional initiatives have been endorsed and various forms of cooperative ventures have been established.

The results of these developments can be seen in the formation of many cooperative organisations such as: the Asia-Pacific Economic Cooperation (APEC), the Asian and Pacific Coconut Community (APCC), the Association of South East Asian Nations (ASEAN), the Asian Clearing Union (ACU), the Asia-Pacific Network Information Centre (APNIC), the Asian Development Bank (AsDB), the Economic Cooperation Organisation (ECO), the South Asian Association for Regional Cooperation (SAARC), the UN Economic and Social Commission for Asia and the Pacific (UN-ESCAP), the United Nations Regional Cartographic Conference (UNRCC-AP), the Waste Wise

Asia-Pacific, as well as various innovative types of subregional cooperative ventures, such as the activities of Australian-ASEAN Economic Cooperation Programs (AAECP) at a country level.

The above mentioned Asia and the Pacific regional organisations mostly work and cooperate with each other on different areas including development assistance; human resources development; economic development; science and technology transfer; political links; institutional linkages; and security issues.

The activities and functions under each of these areas were designed in some manner to give maximum return to individual parties of each cooperative organisation. Based on the review of Asia and the Pacific regional organisations by the author (Appendix 3), the main objectives of these organisations may be summarised to include:

- Acceleration of economic growth, social progress and cultural development in the region;
- Promotion of regional peace and stability;
- Promotion of active collaboration and mutual assistance on matters of common interest in the economic, social, cultural, technical, scientific and administrative field;
- Provision of assistance to each other in the form of training and research facilities in the educational, professional, technical and administrative spheres;
- More effective collaboration to improve the agricultural, industrial, trading, transport and communications sectors of the regional economy; and
- Promotion of regional cooperation for ecological and environmental protection.

As part of these objectives and trends, therefore some of the regional interests that encourage different governments to cooperate with each other and encourage them to form different regional groups, are as follows:

- |                                  |  |
|----------------------------------|--|
| • Geodetic networks,             | • Regional access to health care resources,          |
| • Regional mapping,              | • Regional resources management,                     |
| • Regional emergency management, | • Regional environmental monitoring and management , |
| • Regional security,             |  |

- Establishing a regional cooperation unit,
- Shared oceans surroundings,
- Fishing,
- Shipping and transport,
- Economic development and cooperation,
- Agricultural and forestry management,
- Partnership (initially with emphasis on technical assistance to the regional members).

These regional interests are all related to specific parts or whole areas of the region. Therefore, to achieve them, all the regional organisations need to access regional spatial data to identify regional spatial features and their characteristics to make informed decisions and to implement resulting regional initiatives. However, current research shows that in most cases all efforts by these regional organisations face similar difficulties in accessing such regional spatial datasets (Rajabifard *et al.* 1999). Further, as noted by Chan and Lee (1999), finding appropriate spatial datasets these days becomes a painful task. Even when regional users are lucky enough to find a candidate dataset, they might not understand its quality and content. Possibly, further analysis on data might produce unreliable products and misleading results if there is no further effort to study its useability. Some of the more contentious issues which caused these frustrations are:

- lack of mechanism to share data,
- conservative definitions of security pertaining to accessing spatial data, that need to expand to include non-military concepts such as economic, social and environmental security;
- traditional ways of thinking on national and regional security that are inconsistent with the information technology and satellite communications age e.g. through World Wide Web (WWW) much of the security information is already accessible;
- the lack of availability of a good and accurate regional spatial data resource, which also results from the first two reasons; and
- equitable access and dissemination of data.

The collection of spatial data is a very expensive and time-consuming part of any project. The lack of availability of reliable regional datasets results in the duplication of

effort to collect data, which exists, but is either unavailable or unknown to the current project. This is a waste of time and resources that developing nations can ill-afford. This situation is exacerbated when the national mapping and spatial data activities are the responsibility of a nation's military organisation because there tends to be a perception that sharing geographic information will affect national security.

Global advances in information technology have rendered the secrecy surrounding some spatial data redundant. For example, high-resolution (1 metre) satellite imagery has become commonplace, making the production of maps of large scales up to 1:5,000 scale, available beyond national borders and also beyond the objection of national governments. Fox (1991) also highlighted this issue in mentioning that in many Asian nations, military or bureaucratic officials classify or restrict the dissemination of spatial data. Moreover, different restrictions for limiting access are placed on individuals, businesses and government agencies. These restrictions are nominally for 'military security' but this concept is redundant with the availability of remotely sensed data from satellites and changes in military technology. It is difficult to serve the growing diversity of users with new technology when data dissemination is hampered by narrow security restrictions and 'rent seeking' by holders of data. This is an issue that has been acknowledged in Resolution 5 of the Thirteenth United Nations Regional Cartographic Conference (UNRCC-AP, Beijing 1994) on access to information for development which called upon:

*..relevant authorities in member States to authorise their national survey and mapping agencies to make more widely available, in timely, affordable and appropriate form, such spatial information as is needed by national and international agencies and organisations to enable United Nations resolutions to be effectively implemented...*

(UNRCC-AP 1994).

One of the fundamental problems is the lack of awareness of the value of geographic information and a wider definition of security that can include issues other than military ones, such as the need and use of spatial data for economic, educational, cultural, social and political systems. This lack of awareness has resulted in the lack of availability of spatial data to facilitate regional cooperation. This is one of the issues which was highlighted and demonstrated by the author in the pilot trial on regional administrative boundaries which has recently been completed for the United Nations-supported



Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). The pilot project was aimed at identifying and documenting, within a sample region (nine countries), problems and difficulties encountered when integrating regional datasets from the pilot countries. Although PCGIAP developed a set of conditions to ensure the privacy of the datasets of those countries involved, four countries out of the nine involved in the pilot study refrained from providing their datasets to the project (see Chapter 7).

Further to these problems, the World Bank has come to appreciate at least two more implications for international policy and coordination: i) the capturing, processing and supply of spatial data is quite a costly exercise and requires not only maximisation of benefits but also cost-reduction efforts to generate positive and satisfactory economic returns to public investment particularly in developing countries; and ii) design and implementation of projects and reforms in the area of land can benefit significantly from sharing experiences on what works and does not work (Byamugisha and Zakout 2000).

In summary, a fundamental problem underlying data sharing and distribution is the belief that one gains power and influence from withholding information and controlling it. This is also an issue highlighted by the SDI Cookbook (SDI Cookbook 2000). In fact, true power is held by those who distribute the information and whose information is used by senior political levels. Once this leap of faith is taken, as it has been in several countries, data sharing becomes remarkably easy. Therefore, absence of culture for sharing spatial data and standards in Asia and the Pacific region constrains the transparency and the necessary knowledge for decision-making and delays the regional spatial data users to finding information for their needs. Improving the development prospects requires the problems, potential and constraints to be identified.

#### **4.4 THE NEED FOR A REGIONAL SDI**

As was discussed in the previous sections, the primary purpose of regional cooperation is to organise economic activity in such a way as to maximise regional and individual country benefit. In today's world, regional and global cooperation that is dedicated to centralised planning on a world or regional scale as reported by Suter (1992), is increasingly important. Such organisations and groups are organic structures in which each part is expected to serve the whole. The cooperative body measures its successes

and failures not by the balance sheet of an individual subsidiary, or the suitability of particular products, or its social impact in a particular nation, but by growth in regional and global profits and market shares (Suter 1992). In addition, the regional growth must be reflected in benefits shared and enjoyed by individual members. Regional and global cooperation presents serious challenges to prevailing ideas about the world being constructed out of a collection of building blocks described as nation-states.

Other reasons for regional and global cooperation are that the major players in world economic affairs and their evolution are taking the world from a collection of separate national economies to a single global economy. Suter (1992) also supports this view and believes that there is only one economy – the global one. The process of profound and continuing structural change to global economies is also giving rise to the global village with the help of modern information and communication technologies. Some current trends in cooperation as discussed in the previous section are to promote regional peace and stability, development assistance, human resources development, political and economic facilitation, science and technology transfer, commercial facilitation, business development and the establishment of networks and institutional linkages.

Therefore, information at a regional level provides the basis for strategic decision making to respond to those mentioned trends. As an example, every day in our lives we are hearing about disasters, which impact upon us, our businesses and perhaps even our national economies. When a disaster does occur civil protection forces, environmental groups, agricultural and fisheries departments, hospitals and medical associations all ask the same questions. When will the fallout arrive? How bad is the situation? How many people will be injured or die? How long will it take to recover from the disaster? How much economic damage can be expected? Since disasters have happened before, it is expected that emergency services, analytical teams, disaster relief organisations and the like are all well prepared; but can they exchange information quickly and efficiently to enable cooperation? (GI2000, 1996).

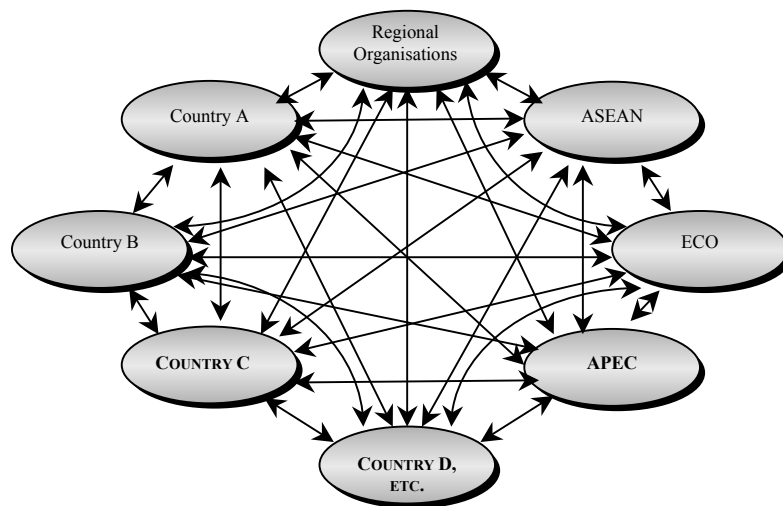
Other examples at the regional level which demand cooperation are a proposal for a new dam on a river which drains a catchment area covering millions of hectares and crossing several national boundaries; or a plan for a new industrial complex, to be built near a convenient port as reported in GI2000 (1996) which also happens to lie in an estuary of

special environmental importance. Another example requiring reactive initiative is a major flood occurring on a major regional waterway not confined to a single nation state which needs to be dealt with immediately. In these examples cross-border geographic information is a common need.

#### 4.4.1 THE CONCEPT OF REGIONAL SDI

The Regional Spatial Data Infrastructure (Regional SDI) is an initiative intended to create an environment which enables a wide variety of users who require a regional coverage, will be able to find, access and retrieve the best available and consistent datasets in an easy and secure way. Its roots are in the regional governments and their cooperation.

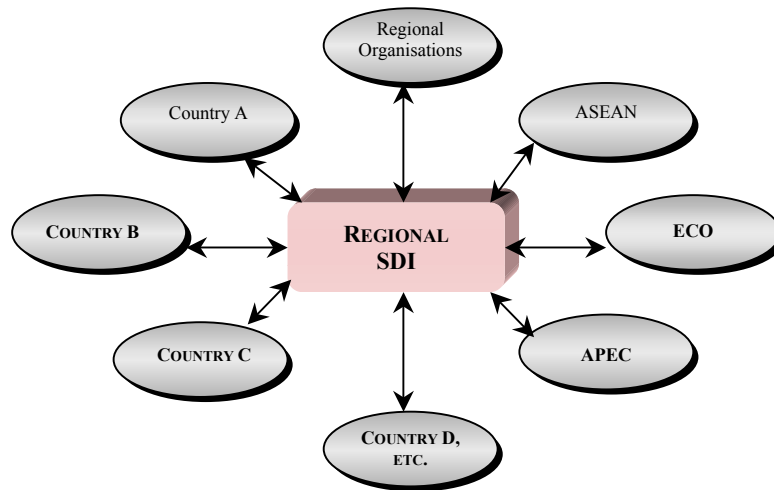
The current complexity of communications between the various countries and regional bodies in the Asia and the Pacific region as an example is illustrated in Figure 4.1. These users must develop one-on-one agreement with each and every other user within the region for sharing regional data. If there are  $n$  users a complete communication network requires  $n(n-1)$  communication channels.



**Figure 4.1:** Current complexity of communications between countries and regional bodies in the Asia and Pacific region

However, as shown in Figure 4.2, this complexity can be reduced by having a Regional SDI built upon the cooperation of the regional users. The establishment of a Regional SDI will form a fundamental framework to exchange data across many countries in a

region. This will also provide a clear picture to support and improve existing or even new bilateral and multilateral relations and structures.



**Figure 4.2:** Reduced complexity through Regional SDI

Further, a Regional SDI can provide the institutional framework and the technical basis to ensure the regional consistency and the content of fundamental datasets to meet regional needs in the context of sustainable development. Within this regional framework, the fundamental datasets can be collected and maintained through partnerships. Moreover, working together through partnerships to create regional datasets can allow people to create larger more user specific databases, as well as becoming more effective by sharing common knowledge.

The regional infrastructure should ensure that national efforts are focused and coordinated, thereby maximising the benefit from investment in data collection and maintenance from both a regional perspective and that of the individual members.

A Regional SDI ideally should provide benefits for all member nations. In particular the needs of the cooperating member nations must be met but there must exist provision for joining by previously non-participating nations. As the membership grows the data pool widens and there are further economies and benefits realised.

Much geographic data development effort is based on the developer learning from the experience of others. The Regional SDI and its fundamental datasets represent the combined results of such experience. Further benefits of a Regional SDI additional to those already outlined are:

- Reduced costs of data production and elimination of duplication of effort;
- Developing applications more quickly and easily by using existing data and data development standards;
- Provide better data for decision making;
- Save development effort by using fundamental and standardised data, guidelines and tools;
- Perform analysis, decision making and operations in cross-jurisdictional areas;
- Expanding market potential and program funding through recognition and credibility as a Regional SDI participant; and
- Providing consolidated directions to vendors regarding required technical features.

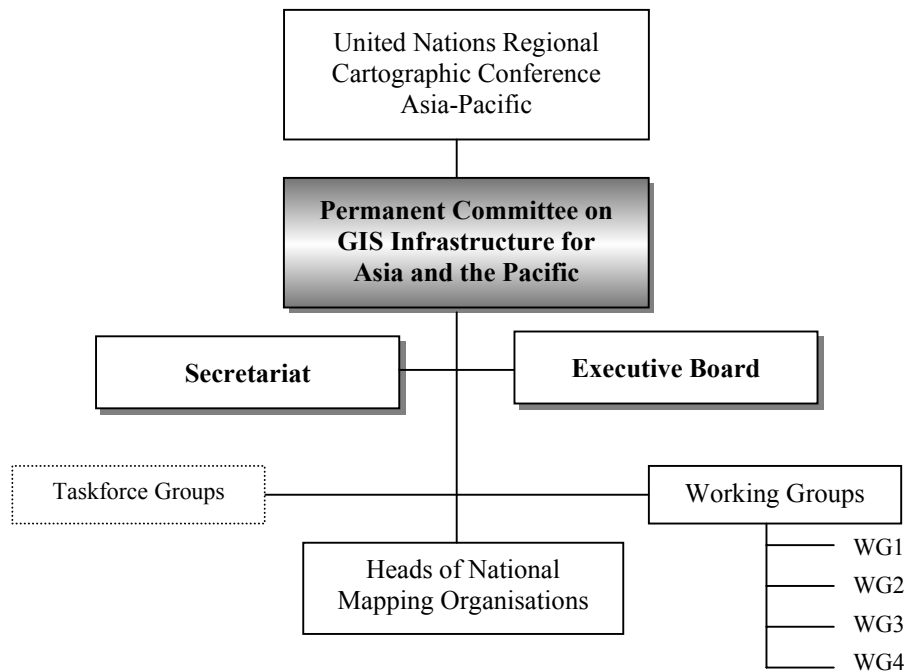
#### **4.5 REGIONAL SDI INITIATIVE IN ASIA AND THE PACIFIC REGION**

Through the efforts of the United Nation Regional Cartographic Conference for Asia and the Pacific region (UNRCC-AP, see Appendix 3) and following its 13<sup>th</sup> Conference in Beijing, May 1994, the national mapping agencies in Asia and the Pacific region formed the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) in 1995 (as a result of Resolution 16 of the Conference) to develop a Regional SDI for Asia and the Pacific region (PCGIAP 1995).

The aims of the PCGIAP are to maximise the economic, social and environmental benefits of geographic information in accordance with Agenda 21 by providing a forum for nations across the region to cooperate in the development of the Asia-Pacific Spatial Data Infrastructure (APSDI) and contribute to the development of the global infrastructure.

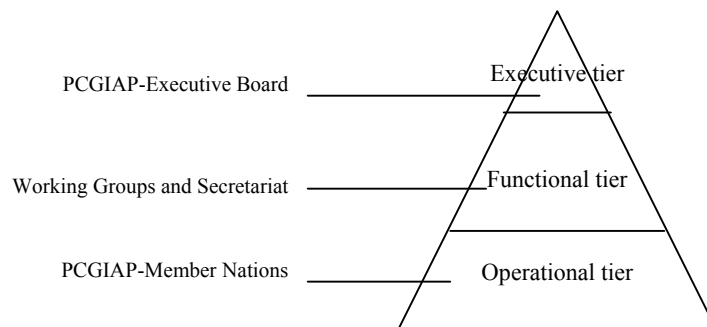
#### 4.5.1 ORGANISATIONAL STRUCTURE AND OPERATION OF PCGIAP

The organisational structure of the PCGIAP and its relation with the UNRCC-AP and other components of the Committee are illustrated in Figure 4.3. This Committee operates under the purview of the UNRCC-AP, and submits its report and recommendations to this Conference (PCGIAP 1995).



**Figure 4.3:** Organisational Structure of PCGIAP

Based on the above figure, there are three tiers in PCGIAP organisational structure, consisting of a plenary body comprising all participating member nations, a middle tier including working groups and secretariat which facilitate and implement all decisions made by the top tier body which are empowered to make decisions on behalf of the PCGIAP as a whole on operational issues (Figure 4.4).



**Figure 4.4:** Different Tiers in PCGIAP Organisational

According to Article 6 of the statutes, in addition to reporting to the UNRCC-AP, this Committee also established links with other relevant United Nations programs and international bodies such as:

- International Steering Committee for Global Mapping (ISCGM);
- United Nations Regional Cartographic Conference for the Americas (UNRCC for the Americas);
- European Umbrella Organisation for Geographic Information (EUROGI);
- GSDI Steering Committee;
- International Organisation for Standardisation Technical Committee 211-Geographic Information/Geomatics (ISO/TC 211);
- ESCAP Regional Space Applications Program (RSAP);
- United Nations Economic and Social Commission for Asia and the Pacific Regional Space Applications Program for Sustainable Development;
- International Union of Geodesy and Geophysics (IUGG);
- International Federation of Surveyors (FIG);
- International Society for Photogrammetry and Remote Sensing (ISPRS); and
- International Cartographic Association (ICA).

Recently this Committee also signed a Memorandum of Understanding with its sister Committee for SDI in the Americas – PC IDEA - addressed to promote common ground areas for SDI development at the regional level. Examples of these links are participation by the FIG as an observer at Permanent Committee meetings, participation by the Permanent Committee as an observer at EUROGI meetings and Permanent Committee representation on ISCGM.

The Permanent Committee is comprised of 55 nations in which member nations are represented on the Committee by directorates of national survey and mapping organisations and equivalent national agencies. These members shall make every effort to attend Committee meetings and take actions necessary and appropriate to develop and promote the aims of the Committee and may with the approval of the President represent the Committee at specific functions (Article 8, of the Statutes). Each member nation participating in the Committee have one vote, Subject to Rule 19 of the Statutes, decisions of the Committee shall be taken by a majority of the Representatives present

and voting. The size, experience and responsibilities of these members are varied and they have much to learn from each other.

An Executive Board, comprising representatives from ten member nations (President, Vice President, Secretary and up to seven other members), coordinates the Committee's work program. The term of the Executive Board is the period between UNRCC-AP Conferences, currently about three years. The functions and responsibilities of the Executive Board (Article 11, of the Statutes) are:

- a. to plan and coordinate the Committee work program between plenary sessions of the Committee;
- b. in consultation with the United Nations, plan and manage the activities that the Committee undertakes for the UNRCC-AP;
- c. to manage the continuing administrative affairs of the Committee;
- d. to define, monitor and assess the regional spatial data infrastructure;
- e. to make recommendations on objectives, and on activities and work programs to the Committee;
- f. to arrange and manage publications including directories, Internet sites and promotional material, and to distribute appropriate documents to Members, individuals and organisations concerned;
- g. to coordinate funding proposals to aid agencies;
- h. to prepare and submit reports on activities of the Committee to the UNRCC-AP; and to
- i. to take opportunities to give presentations to related bodies such as ISO/TC211, ISCGM, the GSDI Steering Committee and other bodies (contained in the schedule referred to under Article 6 of these Statutes), at conferences and other relevant events.

The activities and work programs of the Executive Board are supported by its Working Groups. The Working Groups are established, where required, to undertake projects in pursuit of the Permanent Committee's aims and objectives. The Executive is currently supported by four working groups as described in Table 4.1. Further, the Committee's



meetings are held in conjunction with the triennial UNRCC-AP meetings and also between these meetings.

**Table 4.1:** Working groups of the PCGIAP in the period 2000-2003

Working Group 1: <b>Regional Geodesy</b>	Responsible for the implementation of a regional, precise geodetic network and coordinating regional geodetic campaigns.
Working Group 2: <b>Regional Fundamental Data</b>	Responsible for establishing regional fundamental datasets and mechanisms for sharing these data and fostering an understanding of the benefits in using regional fundamental data.
Working Group 3: <b>Cadastral Working Group</b>	Undertaking a study of land administration issues and facilitating discussion on marine cadastres.
Working Group 4: <b>Institutional Strengthening</b>	Responsible for facilitating member involvement, education, training and subregional programs.

Regarding the financial resources to support the activities of this Committee, currently there are no specific financial resources allocated to the Committee, but according to Articles 24 and 25 of the Statutes of the Committee, this Committee may invite members to make a financial contribution, in order to achieve some special purpose or objectives approved by the Committee and the Executive Board may also invite financial support from other sponsors. This lack of financial resources may limit the scope of activities and effect on the progress in several work programs as reported by PCGIAP (Holland 1998a).

#### **4.5.2 ASIA-PACIFIC SPATIAL DATA INFRASTRUCTURE (APSDI)**

The PCGIAP is working towards the implementation of an Asia Pacific Spatial Data Infrastructure (APSDI). The Committee's vision for the APSDI is of a network of databases, located throughout the region, that together provide the fundamental data needed to achieve the region's economic, social, human resources development and environmental objectives.

Those distributed databases include geodetic, topographic, hydrographic, administrative and environmental data. They may, in the future, be linked electronically so that they

appear, to the user, as a virtual database, but they will also be linked together in a number of other important ways such as:

- they will be linked by an intra-regional institutional framework that provides mechanisms for sharing experience, technology transfer and coordination of the development of the regional fundamental datasets;
- they will be linked by the use of common technical standards, including a common geodetic reference frame, so that data from numerous databases can be brought together to create new products and solve new problems, both regionally and globally;
- they will be linked by the adoption of common policies on data access, pricing, privacy, confidentiality and custodianship;
- they will be linked by the implementation of inter-governmental agreements on data sharing; and
- they will be linked through a comprehensive and freely accessible directory of available datasets containing descriptions and administrative information that accords with agreed standards for metadata.

It is this suite of administrative and technical linkages that distinguishes the APSDI from a collection of uncoordinated datasets, and which will make it a powerful tool for the region's economic and social development.

#### **4.5.3 THE APSDI CONCEPTUAL MODEL**

As discussed above, the primary objective of the PCGIAP for development of the APSDI is to ensure that users of geographic (or spatial) data who require a regional coverage, will be able to acquire complete and consistent datasets meeting their requirements, even though the data are collected and maintained by different agencies. The issue, therefore, is to determine what is required of member nations and their datasets, to enable the data to meet regional needs.

The PCGIAP envisages a distributed network of databases, linked by common standards and protocols to ensure compatibility. Each database would be managed by custodians with the expertise and incentive to maintain the database to the standards required by the nations of the region and who are committed to the principles of custodianship.

The PCGIAP believes that the APSDI will provide the institutional and technical framework to ensure the required consistency, content and coverage to meet regional needs. The infrastructure also ensures that national efforts are focussed and coordinated, thereby maximising investment in data collection and maintenance from a regional perspective. Finally, such an infrastructure will help achieve better outcomes for the region through better support for economic, social and environmental decision making.

The PCGIAP has developed a conceptual model for its SDI initiative that comprises four core components - institutional framework, technical standards, fundamental datasets and access networks. These core components are linked as follows:

- Institutional Framework - defines the policy and administrative arrangements for building, maintaining, accessing and applying the standards and datasets.
- Technical Standards - define the technical characteristics of the fundamental datasets and enable them to be integrated with other environmental, social and economic datasets.
- Fundamental Datasets - are produced within the institutional framework and fully comply with the technical standards.
- Access Network - is the means by which the regional fundamental datasets are made accessible to the community, in accordance with policy determined within the institutional framework and to the technical standards agreed.

According to this model, the APSDI is not a centralised database but a network of fundamental spatial databases maintained by custodians and linked through the adoption of consistent standards, policies and administrative principles. In this regard, fundamental spatial data is defined as spatial data for which there is a justified need for national consistency by multiple users, in order for those users to meet their objectives. Therefore, a fundamental dataset may comprise a number of compatible databases maintained by custodians in several countries. According to the PCGIAP, it is essential for jurisdictions to retain responsibility and control over the data for their areas of responsibility if they are to participate and contribute to the development, maintenance and coordination of the APSDI.

Under the principles adopted by the PCGIAP, each member country is responsible for providing the component of the Asia Pacific SDI covering that country. That component

may be an extract from their national spatial data infrastructure (NSDI), or a stand-alone product. Whichever approach is adopted by the member nation, every endeavour shall be taken to ensure that the APSDI component reflects the most appropriate available information for regional applications.

In order to prepare, develop and implement these four components of APSDI, the PCGIAP has assigned and set up different tasks to each Working Group in such a way as to form the APSDI. With this in mind, each Working Group has developed a strategy and work plan and is currently progressing to achieve their objectives to contribute to the development of the APSDI. Although the achievement of each Working Group individually is important and each Working Group has already achieved some objectives of their work, which will be addressed in the next section, there are also some areas which need the interaction of at least two or more Working Groups, which they haven't done as yet. The main reason for these types of issues is due to undefined interaction between Working Groups and also because of unpredicted areas of the integration in relation to their achievements.

#### **4.6 MAJOR ACHIEVEMENTS AND PROGRESS**

According to the PCGIAP reports, this committee achieved some important steps toward the development of the APSDI since its establishment. For example the committee successfully implemented a regional precise geodesy network, defined a regional geodesy datum, developed and approved a policy on sharing fundamental data, developed guidelines on custodianship and in particular, the definition of APSDI. Also, projects are underway for the ultimate goal of APSDI development in the region, among which the Asia-Pacific Regional Geodetic Project (APRGP) is strengthening the regional geodetic network through annual cooperative campaigns by GPS (Global Positioning System), VLBI (Very Long Baseline Interferometry) and SLR (Satellite Laser Ranging). Surveys among member nations on the status and development needs and on fundamental datasets have also been conducted. In addition to the above mentioned activities, each Working Group has its own individual work plan comprising their current and future tasks and projects.

## 4.7 DISCUSSIONS

Although the above mentioned achievements are very important and provide a valuable contribution and will form the basis for the APSDI development, there are some other issues involved in the progress of PCGIAP which need to be discussed. These issues include the low rate of participation in PCGIAP activities, the organisational structure of PCGIAP and the APSDI conceptual model.

Current rate of participation in PCGIAP activities (Table 4.2), shows that after many years of effort the APSDI initiative still does not receive support from all member nations and regional organisations (Holland 1998a, Mohamed 1999, Rajabifard *et al.* 2000b). In other words, despite all the interest and activities by the PCGIAP, the development of this Regional SDI initiative remains very much an innovative concept among members of the community.

Based on this table and according to the report of the Taskforce group, presented at the 15<sup>th</sup> UNRCC-AP conference (see chapter 6), the maximum number of countries participating in PCGIAP meetings is 25 out of 55 member nations, which is less than half of the members. Out of this 25 participating nations only six are active core participants, with the rest being occasional participants. The remaining countries have never attended any meetings. Continuing low participation rates of member nations could lead to a loss of credibility of the PCGIAP.

**Table 4.2:** PCGIAP Meetings and number of their participants since its establishment

PCGIAP Meetings	Host Country	Year	No of Participating Countries
First (Formation)	Kuala Lumpur/Malaysia	12-14 July 1995	24
2 <sup>nd</sup> meeting	Sydney/Australia	29 September -4 October 1996	17
3 <sup>rd</sup> meeting/ 14 UNRCC-AP	Bangkok/Thailand	1-2 February 1997	13
4 <sup>th</sup> meeting	Tehran/Iran	28 February – 4 March 1998	15
5 <sup>th</sup> meeting	Beijing/China	19-22 April 1999	14
6 <sup>th</sup> meeting/ 15 UNRCC-AP	Kuala Lumpur/Malaysia	11-15 April 2000	25
7 <sup>th</sup> meeting	Tskuba/Japan	23-28 April 2001	16

The problem of participation also can be observed in many National SDI initiatives throughout the world (Masser 1998a, Onsrud 1998). As was suggested in Chapter 1, some reasons for the limited support from certain nations, regional organisations and other relevant institutions include:

- the lack of awareness of the value of SDIs;
- defining the SDI;
- the incompatibility of the current conceptual and organisational model with the perceived needs of the member nations; and
- the complexity of different regional issues such as diverse political, cultural and economical positions.

Therefore, the limited number of participants is an important issue which needs to be considered, discussed and resolved by the PCGIAP, before moving on from any important principle policy such as policy on sharing fundamental data. This is important because these kinds of policies need to be accepted and supported at least by the majority of member nations in the region not the majority of current participating nations. After approving important policy, it is expected that member nations take and apply such policy into their own existing roles and regulations for communication and cooperation with other member nations. This requires a majority of participating nations applying such an approved policy. But, the current situation shows that the achievement of such an expectation is too difficult at this stage, especially from those member nations that have never participated. In other words, sending the policy document to the member nations would not guarantee its implementation.

The implementation of such policy usually will require a long period of time and also require passing a long and challenging process within each nation by each member delegated to the PCGIAP. The members need to justify the implementation of such policy within their own respective countries.

This process is exacerbated when the national mapping and spatial data activities are the responsibility of a nation's military organisation because there tends to be a perception that sharing geographic information will affect national security.

Therefore, one of the reasons why the PCGIAP can not receive full support from all member nations is related to the PCGIAP organisational structure. Based on its organisational structure, this Committee is comprised of 55 nations in which member nations are represented on the Committee by directorates of national survey and mapping organisations and equivalent national agencies. This structure causes problems from two different points:

- (a) The PCGIAP members mainly are providers or producers of national spatial datasets and not necessarily the users of such national and regional datasets. But, one of the main promising advantages of SDIs is to facilitate sharing and access to spatial datasets by users. Therefore, it is essential to involve those potential users of regional spatial datasets and those politician concerns, in development and implementation of the Regional SDI. By involving such regional users, the PCGIAP can identify and include the user needs in the design and implementation of the APSDI. At the same time the PCGIAP can monitor its activities and progress to them to receive their support.
- (b) Based on the national reports on spatial data activities by the PCGIAP member nations, the organisational and political position and responsibilities of each national surveying and mapping organisation (which the members of the PCGIAP come from) are different from the position and responsibilities of a similar organisation in another member nation. In some nations the mapping and spatial data activities are the responsibility of a civil organisation, but in other member nations the mapping and spatial data activities are the responsibility of a military organisation. For example, in Iran, the organisational position of the National Cartographic Centre (NCC), which is the main national mapping organisation, is under the Management and Planning Organisation, the highest organisation in the country. But in South Korea, the National Geography Institute Mapping Organisation is under the Ministry of Construction and Transportation. In Japan, the Geographical Survey Institute is under the Ministry of Construction. Some of the PCGIAP members are from military organisations, because the national mapping and spatial data activities in those member nations are the responsibility of the nations' military organisations (for example India,

Thailand and Bangladesh). In Malaysia, the Director General of Survey & Mapping Malaysia, is also the Director of Military Survey.

In addition, the relationships between each PCGIAP member with other organisations in their countries are also different which is mainly related to their organisational positions. Having strong and well established relationships with other organisations are very important as such organisations and agencies may involve in different regional organisations and activities. Therefore, having good and strong relationships will facilitate the implementation and adoption of any national and regional spatial data policy.

Also, because PCGIAP members come from different backgrounds and departments, they are also likely to have different levels of knowledge of technology as well as the SDI concept – a factor which can inhibit discussion and decision-making because the less well-in-formed contributors feel unqualified to challenge other, firmly held and forcefully expressed opinions.

The other issue is the APSDI conceptual model. As it was noted in Chapter 1, a major obstacle in gaining support from certain countries and regional organisations to develop an SDI is adequately defining the SDI and its related conceptual model. Therefore, as suggested in Chapter 2, an SDI comprises not only the four core components identified by PCGIAP as institutional framework, technical standards, fundamental datasets and access networks, but also an important additional component, namely, human resources (people). This component includes the spatial data users and suppliers and any value-adding agents in between, who interact to drive the development of the SDI.

The human resources component should determine the group of people that should be involved in, and the skills required for, effective and efficient development and utilization of an SDI initiative. This component also should determine the strategy and methods to achieve those requirements such as training courses and ways to improve awareness and abilities of users so that they can better work and utilize such an initiative.

In order to have this component, an SDI coordinating agency like the PCGIAP, should assign a group of members to study and work on this component from different angles



and interact with other groups working on the other components. This group must evaluate the current situation with respect to the existence requirement of infrastructures and awareness of SDIs, and then based on the results, provide the most possible and suitable solutions for implementation and utilization of SDI initiatives.

The interaction between this human resources component with the other four components of an SDI is a direct interaction. The existence of this component is to support and to facilitate the development and implementation of the other components. This direct relationship is in such a way that any strategy and plan for development and implementation of any other component will directly effect on this human resource component and this requires the component to be revisited and structured in order to support and facilitate the implementation of other strategies and plans for other components.

The absence of this human resource component would cause the problem that the SDI coordinating agency like the PCGIAP just concentrates on four core components and develops their strategies to build the APSDI in such a way that ignores the interests and potential contributions of other stakeholders such as the non-participating members and agencies. To avoid this problem, the current APSDI model and the strategy to its development therefore need to be modified (see chapter 7).

In addition, by improving this conceptual model and defining a proper border for its social system (see chapter 5), the PCGIAP can define its future strategy by better understanding the complexity of the interacting social, economic and political issues within that border.

## **4.8 CHAPTER SUMMARY**

This chapter begins by providing the background and the basic characteristics of Asia and the Pacific region as a selected region for the purpose of the case study. It then discussed the nature and concept of regional cooperation by reviewing a number of regional organisations. These reviews have helped to build the current understanding about the importance of an infrastructure to facilitate regional cooperation.

According to these reviews, Asia and the Pacific region is a region with a diversity of factors. Therefore, any regional organisation should manage this diversity in order to

get more support in which to meet their own organisation's goals. In addition, all the regional organisations need to access regional spatial data to identify regional spatial features and their characteristics to make informed decisions and to implement resulting regional initiatives. However, it was argued that in most cases all efforts by these organisations face similar difficulties in accessing such spatial data. Then the chapter listed some of the more contentious issues and highlighted the conservative definitions of security which pertain to accessing spatial data, as the main difficulty and suggested that this attitude needs to be expanded to include non-military concepts such as economic, social and environmental security.

Based on the above arguments and criticism, the chapter then discussed and introduced the concept and nature of Regional SDIs with an emphasis on the current Regional SDI initiative in Asia and the Pacific region. It was argued that the introduction of SDI technology and the sharing of datasets across national boundaries will effect the existing environments, rules and procedures. Therefore change is inevitable for realising the value of a Regional SDI and related data sharing. With this in mind, managing change requires attention to many implementation issues identified in Asia and the Pacific region, such as: high level political support for SDI development; secured long-term funding for SDI development; well defined and focused pilot project scope; the need to manage the users and their expectations about the degree, timing and quality of data availability; the importance of cross-national communication to resolve disputes and misunderstandings; and the need to demonstrate clear progress in order to allay political concerns.

It was also argued that although the PCGIAP has achieved some steps toward the development of the APSDI which are important, and which provide a valuable contribution, there are some other issues involved which need to be discussed and resolved before moving any further forward. These issues are the low rate of participation in PCGIAP activities, the organisational structure of the PCGIAP and the APSDI conceptual model.

To improve the rate of participation, the chapter suggests the organisational structure of the PCGIAP, the current APSDI model and the strategy for its development need to be modified and restructured.

# CHAPTER 5

## DIFFUSION OF SPATIAL DATA INFRASTRUCTURE

*There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than creation of a new order of things...*

Niccolo Machiavelli, as cited by Rogers (1993).

### 5.1 INTRODUCTION

Getting a new idea adopted, even when it has obvious advantages, is often very difficult. It is noted that many innovations may require a lengthy period, often many years, from the time they are proposed to the time they are widely adopted. Therefore, a common problem for many individuals, communities and organisations as suggested by Rogers (1993) is how to speed up the rate of diffusion of an innovation. With this in mind, as discussed in chapter 4, based on the participation rate in PCGIAP activities, the development of the Asia-Pacific Regional SDI (APSDI) initiative remains an innovative concept among its member nations.

With this in mind, the theories of innovation diffusion are investigated as they provide a useful framework for the study of the development of Regional SDI and improvement of its conceptual model in this region. To this end, this chapter provides an overview of the paradigm of diffusion, and introduces and discusses the theories of innovation diffusion based mainly on the comprehensive work of Rogers (1995). Using these theories, the current conceptual model and strategy of the PCGIAP for the development of the APSDI will be discussed. Then based on the results of those discussions, the chapter suggests an improved conceptual model for the development of the APSDI initiative.

### 5.2 BACKGROUND

The underpinning technology for SDI is GIS. In recent years, researchers have applied the theories of innovation diffusion to the study of GIS planning and implementation

(Onsrud and Pinto 1991, Masser 1993, Masser and Onsrud 1993, Campbell 1996, Masser and Campbell 1996, Chan 1998). In turn Chan and Williamson (1999b) applied the generic principles derived from the study of diffusion of GIS in a complex organisation to the development of SDIs.

GIS diffusion is a recent branch of GIS research. Its groundings are the sub-disciplines of innovation and socio-technical systems in the disciplines of organisation behaviour/organisational theory and information systems (Onsrud 1995). In general, the sub-discipline of innovation studies the diffusion of new idea or practices (an innovation) among people or other adoption units in a social system (Rogers 1995).

A significant body of knowledge has been accumulated over the past five decades, covering a wide range of aspects of innovation and its diffusion. The bulk of research is concerns of knowing about an innovation by and the innovativeness of members of a social system and rate of adoption of innovations in different social systems (Rogers 1995). While the time dimension of diffusion is an important strength of innovation research, study into the structure of the social system of diffusion is relatively limited (Rogers 1995). On the other hand, socio-technical systems research has a long tradition of examining the relation between technological innovation and different aspects of the individuals and organisation/social system (Nord and Tucker 1987, Tushman and Moore 1988, Goodman *et al.* 1990, Luftman 1996).

The existing diffusion paradigm in the innovation sub-discipline, which gives breadth to innovation diffusion research as suggested by Chan (1998) can be used as the backbone for the integrated research framework. Strengths and insightful findings from socio-technical systems can be incorporated to the backbone to provide the depth to this research.

### **5.3 DEFINITIONS OF DIFFUSION**

“Diffusion” can be referred to as the process of communicating an innovation to and among the population of potential users who might choose to adopt or reject it (Zaltman *et al.* 1973, as cited by Pinto and Onsrud 1993). Gattiker (1990) views diffusion as ‘the degree to which an innovation has become integrated into an economy’. Campbell (1996) sees diffusion as ‘the fundamental process that is responsible for the transfer of

innovation from the workshop of their inventors to becoming a daily part of the lives of a large section of society'. Spence (1994) describes diffusion as 'the spread of a new idea from its source to the ultimate users'. These definitions package different concepts inherent in diffusion in such a way as to help the researchers make their points. For example: Gattiker emphasises the relation between innovation and an economy, whilst Campbell and Masser view diffusion as a process of transfer of innovation which is unidirectional in nature. Instead of viewing the target community as an economy, Campbell and Masser target is people in a section of society. Their definition gives an impression of innovation more akin to an invention. Together, these definitions capture many different aspects of diffusion. Individually, they tend to impart a biased view of diffusion and are generally not appropriate as a definition to guide research.

Rogers has followed and documented the development of diffusion research over the years (Rogers 1971, Rogers 1983, Rogers 1993, Rogers 1995). He identified many major diffusion research tradition or paradigms ranging from anthropology, through education, public health and medical sociology, communication to general economics (Rogers 1995). Based on his understanding of this multi-disciplinary research area, he provides a more generic definition of diffusion. He views diffusion as 'the process by which an innovation is communicated through certain channels over time among the members of a social system' (Rogers 1983). In particular, he used the organisation innovation process model to describe the process in which an innovation is adopted and utilised.

Further Rogers explains, it is a special type of communication, in that the messages are concerned with new ideas. Communication is a process in which participants create and share information with one another in order to reach a mutual understanding. Rogers' definition or its variations have been used by people from different disciplines over the years (Goodman 1993, Pinto and Osrud 1993, Zaltman *et al.* 1973). This definition also gives rise to four elements of diffusion, namely innovation, communication channel, time and social system, which constitute the foci of research activities in the past five decades. So diffusion is a special type of communication, in which the messages are about a new idea. This newness of the idea in the message content gives diffusion its special character. The newness means that some degree of uncertainty is involved in diffusion. Uncertainty is the degree to which a number of alternatives are perceived with

respect to the occurrence of an event and the relative probability of these alternatives. Uncertainty implies a lack of predictability, of structure, of information. In fact, information is a means of reducing uncertainty.

Moreover, the diffusion of innovations is a social process, as well as a technical matter (Rogers 1993). Rogers views diffusion as a kind of social change, which is the process by which alteration occurs in the structure and function of a social system. When new ideas are invented, diffused, and are adopted or rejected, leading to certain consequences, social change occurs. With this in mind, in the following sections, key concepts of the four elements of diffusion and associated strengths or limitations are discussed.

## **5.4 INNOVATION**

The emphasis on technology, particularly computer and information technology in the literature in recent decades leads to the often interchangeable use of the terms technology and innovation (Chan 1998). Innovation is the sap that flows in the organisation tree, and the effective management of technological innovation is what makes an organisation grow and flourish as described by Gattiker (1990). He believes an innovation is a way of thinking or an invention that is the product of this way of thinking. However, Rogers (1995) defined an innovation as an idea, practice, or object that is perceived as new by an individual or other unit of adoption. Further, he explains that newness may be expressed in terms of knowledge, persuasion, or a decision to adopt.

Based on Rogers' definition, newness is the characteristic of innovation. Newness is a concept that includes the perception of an adopter and a time element – something can be considered new by an adopter at different stages of diffusion.

### **5.4.1 TYPES OF INNOVATION**

There are many ways that have been used by different researchers to classify technological innovations. Gattiker (1990) classified the technological innovations according to their types, diffusion and relationship to its users. Some classify the innovations in terms of the state of their developments, the initial focus or outcome or effect of the innovations (Zaltman *et al.* 1973 as cited by Chan 1998). In this line,

Rosegger (1986 as cited by Chan 1998) pointed out that when distinguishing process innovations from product innovations, in industrial practice, a new product usually requires some changes and adaptation in the process technology (or vice versa). Gattiker (1990) believes that the two innovations should be seen as representing a continuum rather than a dichotomy. Both types of innovation are needed to describe the outcome of innovation and the associated organisational change. With this in mind, Chan (1998) suggests the same argument can be applied to the diffusion types of innovations mentioned above, in which the process of diffusion is such that an innovation will cause change to product, process, people and organisational structure.

It may be difficult to identify a pure type of innovation. The classification represents convenient grouping of innovation for ease of research. Innovation can assume the identify of any one type or combination of types of innovation in process of its diffusion over time.

#### **5.4.2 SDI AS AN INNOVATION**

Based on the definitions of SDI put forward by many researchers and communities (see Table 2.1 in chapter 2), SDI is often viewed as a spatial data initiative. In this sense, SDI is an outcome of technology. To those jurisdictions and communities that still do not have an SDI initiative or they are at the earliest stage of its development like the APSDI initiative in Asia and the Pacific region (see chapter 4), the present day SDI certainly represents an innovation. However little, if any at all, has been done on classifying SDI as an innovation. It is recognised that the introduction of SDI involves the interaction of people, technology and organisational structure (Cookbook 2000, Budic 2000, Budic *et al.* 2001).

#### **5.4.3 CHARACTERISTICS OF INNOVATION**

In the past as reviewed by Chan (1998), it had been assumed that all innovations were equivalent units of analysis. However Rogers (1995) showed that this assumption is oversimplified, as people perceive different innovations differently based on many characteristics. With this in mind, Rosegger (1986 as cited by Chan 1998) identifies and introduced five major categories of factors that affect the rate at which a technological innovation has become integrated into an economy. They include origin of the innovation, effects on other inputs, relationship of the innovation to the existing

production structure, change in the innovation and complementariness among innovations. Along this line, Rogers (1995) summarised five generic characteristics of innovations, as perceived by individuals, that over the years have been found to explain most of the variations in the rates of adoption of innovations.

These characteristics are relative advantage, compatibility, complexity, trialability and observability. Innovations that are perceived to have less complexity but greater relative advantage, compatibility, trialability and observability, will be adopted more rapidly. In general the factors identified by Rosegger are a subset of the five characteristics summarised by Rogers.

## **5.5 COMMUNICATION CHANNELS**

Rogers' views the communication channel as the means by which messages get from one individual to another (Rogers 1995). In diffusion, there are two main categories of communication channels. One is characterised by its nature as in mass media and interpersonal channels. The other is characterised by its source of origin as in order and internal channels. In general, mass media such as newspaper, radio and television are more effective in making potential adopters aware of an innovation. Like mass media, cosmopolite channels, which are communication channels from outside the social system of study, are more effective in raising awareness of an innovation. On the other hand, interpersonal channels are better for persuading an individual to form or change a strongly held attitude toward a new idea. Internal channels, which refer to channels from within the social system, like interpersonal channels, are more important at the persuasion stage.

In the survey by Onsrud and Pinto (1993) which they made on GIS diffusion, though not a key factor, existence of communication channels was found to have certain significance in accounting for GIS diffusion. It ranks seven out of the eleven groups of factors that account for 62% of the variation in adoption success in local government. Along this line, Budic (1993) highlighted that the result may be more meaningful if the nature and pattern of utilisation of communication channels are known. Her observation is although interpersonal channels are more effective than general communication in facilitating GIS adoption, negative messages or conflicting personal relationships can make communication with GIS users a negative predictor of success.



## 5.6 TIME

Based on the definition of diffusion by Rogers, diffusion is a process. According to the Collins Paperback English Dictionary, as cited by Chan (1998), process refers to among other things ‘progress or course of time’ and ‘a series of actions which produce a change or development’. To discuss the process of diffusion is to discuss ‘progress or course of time’ in diffusion. It involves a series of actions that produce a change or development – an outcome of diffusion in this case.

Rogers (1995) identified and studied three different processes or series of actions under the time element of diffusion. These processes are innovation decision process, organisational innovation process and varying rate of adoption among members. Associated with these processes are three different outcomes of adoption: adoption by an individual or unit of adoption, adoption by a social system (like Asia and the Pacific region), and cumulative adoption by members of a social system (Table 5.1). The concept of a process also forms the basis of the staged approach diffusion research. The staged approach views the process of diffusion of innovation as a set of stages or phases ordered along the temporal dimensions of their anticipated sequence (Zaltman 1973, as cited by Chan 1998).

**Table 5.1:** Processes of Innovation diffusion and associated outcomes

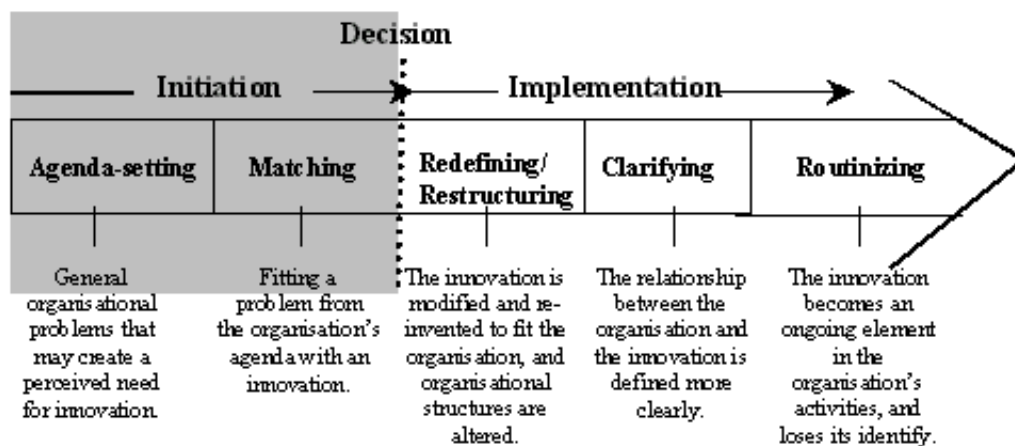
Processes	Outcomes
Innovation decision Process	Adoption/Rejection by an individual or unit of adoption
Organisational Innovation Process	Adoption and implementation by an organisation
Varying rate of adoption among members	Cumulative adoption by members of a social system

The description of the three diffusion processes in this section is based on the work of Rogers (1995). However, among these three processes, the second and the third processes are more suitable and relevant to this research, so they are discussed in more detail than the first diffusion process.

The first process of innovation diffusion is the innovation decision process. It is ‘the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision’ as defined by Rogers (1995). It includes five stages namely, knowledge, persuasion, decision, implementation and confirmation. All these stages are linked with each other by receiving information and feedback from one stage to the others through communication channels. In other words, communication channels that provide information and feedback link all these stages together.

### 5.6.1 ORGANISATIONAL INNOVATION PROCESS

Organisational innovation process is the second process in innovation diffusion. It is a staged approach to describing the process of innovation diffusion in an organisation or a community. This process is generally made up of two main stages, namely, initiation and implementation and five sub-stages (Figure 5.1).



**Figure 5.1:** Organisational innovation process model (adapted from Rogers 1995)

Initiation is concerned with all activities, including information gathering, conceptualising and planning, that culminate in the decision to adopt an innovation by the decision makers in an organisation (Rogers 1995). Implementation refers to the steps taken after the adoption decision that lead to utilisation of an innovation prior to its ultimate institutionalisation (Goodman 1993 as quoted by Chan 1998).

According to Rogers and as shown in Figure 5.1, the decision to adopt is treated as the watershed between the initiation and implementation stage. The two sub-stages of initiation are agenda-setting and matching, and the three sub-stages of implementation are redefining or restructuring, clarifying and routinizing. In the agenda-setting sub-stage an organisational or community problem that may create the perceived need of an innovation is defined. Sometimes, the knowledge of an innovation may precede the definition of a problem (Wildemuth 1992). Matching takes place when a problem from the organisation's agenda is fitted with an innovation. In this stage, planning and design of the innovation are carried out.

After a decision has been made on the acceptance of the innovation, the first sub-stage of the implementation phase, will take place. In the redefining/restructuring sub-stage of implementation both the innovation and the organisation are changed to suit each other's needs. It is often at this stage when the innovation is adopted to suit the organisation structure and reinvention takes place. It is comparable to a social construction process. The more flexible an innovation is, the better is the change for the process to succeed (Chan 1998).

Clarifying is a sub-stage in which the innovation is put into more widespread use. The meaning of the innovation is agreed, accepted and imbedded into the organisation or community through a process of interaction among the members. Routinizing is the last sub-stage when the innovation process is complete. The innovation is incorporated into the organisation and its meaning is so well known and built into the organisational structure that it loses its identity.

### **5.6.2 VARIED RATE OF ADOPTION**

The third process in innovation diffusion is the varied rate of adoption of the innovation by members of the social system. By studying the distribution of adoption of an innovation over time by members of a social system, two distinct patterns are observed. One is an S-shape curve representing the pattern of cumulative increase of adopters. The other is a bell-shape a curve that approaches a normal distribution curve, representing the pattern of distribution of new adopters. The two curves represent the two sides of the coin of distribution of adopters.

In general, for each S-shaped curve, there is an initial gestation period when the adoption is limited and slow. Once a critical mass of adoption is reached, a rapid and dramatic increase in adoption ensues, and is followed by a period of saturation in which the rate of adoption levels off. The S-shaped curve for each innovation is unique. The curves may display a gentle or steep slope, representing a slow or drastic change in the rate of adoption respectively.

## **5.7 SOCIAL SYSTEM**

The last element of the diffusion paradigm is the social system. Rogers (1995) defines a social system as a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal. The units in a system may be individuals, firms, or any other communities. A system has structure, the patterned arrangements of the units in a system, and this structure provides regularity and predictability to behaviour in a system, including the adoption of innovations. Along this line, Therborn (1994 as quoted by Chan 1998) gives a theoretical definition of social systems as:

*Social systems should be understood here in a broad sense as ensembles of interrelated elements, including institutions, modes of production, forms of life, patterns of distribution, sets of values and beliefs, and theorised systems, from dyads to the world system.*

With this in mind, by identifying critical social factors and processes in the acquisition, implementation and utilisation of a technology, it is expected that decision making responses of individuals, groups and organisations may be predicted and therefore also may be accommodated or redirected through prescriptive strategies. By identifying critical human and technical factors within classes of potential users, diffusion studies also have the potential for directing the design efforts of system developers to those system characteristics and improvements most valued by end users.

## **5.8 SDI DIFFUSION**

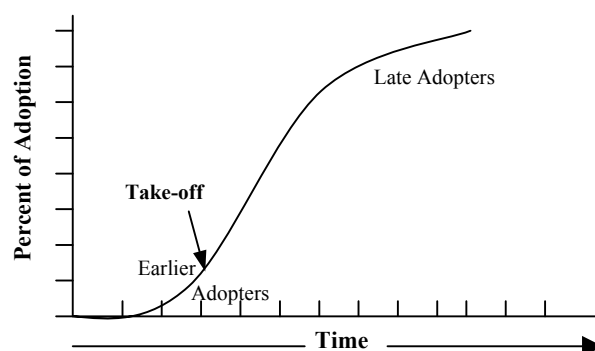
As was mentioned above, in recent years, researchers have applied the theories of innovation diffusion to the study of GIS planning and implementation (Onsrud and Pinto 1991, Masser 1993, Masser and Onsrud 1993, Campbell 1996, Masser and

Campbell 1996, Chan 1998). In 1999, Chan and Williamson (2000) applied the generic principles derived from the study of diffusion of GIS in a complex organisation to the development of SDIs. Based on the diffusion paradigm, understanding of the nature of an innovation is crucial in the success of the progressive uptake and utilisation of the innovation by members of a community (Rogers 1995). From an engineering point of view, successful design, building and management of an innovative product requires a sufficient understanding of the nature of the product (Chan *et al.* 2001).

GIS technology has had a significant influence on the need for SDI and the diffusion SDI is undergoing in different communities, therefore the research and experiences on GIS diffusion should also be applicable to SDI. SDI is an innovation that is underpinned by many GIS concepts and technologies, as well as the phenomenon of the Internet and related telecommunications and network technology. With this in mind, among the three processes in innovation diffusion as discussed above, this research adopts the generic model for innovations developed by Rogers (Figure 5.1) to facilitate the study on the diffusion of Regional SDI development. Rogers' model has the merit of being simple, well-known, comprehensive and has a sound theoretical base.

Moreover, SDI practitioners and researchers can also learn from research elsewhere on the organisational behaviour and technological innovation. An understanding of the SDI diffusion process can aid in allowing those who could benefit from an innovation, such as a new technology, to begin accruing those benefits earlier.

Current research on Regional SDI development in Asia and the Pacific region shows that, SDI development in its adoption among spatial data communities, obeys the S-shaped diffusion curve used by Rogers (1993, 1995), that characterised the behaviour of earlier and later adopters of an innovation (Figure 5.2). They argue that most of the key elements of the diffusion of innovations models, the S-shaped curve form, the notion of the critical mass which is required before



**Figure 5.2:** S-Shaped Diffusion Curve  
(Adopted from Coleman *et al.* 1966)

innovation can take off in terms of its widespread adoption, and the importance that must be attached to the activities of a limited number of champions in the early phases, can be used without any difficulty in the analysis of SDI diffusion.

This is reflected in the degree of support in different SDI initiatives as they develop. For example, as discussed in chapter 4, after seven years of development, the APSDI is still only in an early stage of adoption according to the proposed Diffusion curve. [The S-shaped diffusion curve originally found by Coleman *et al.* (1966 cited by Rogers 1993)].

There are many issues and challenges faced by SDI development initiatives throughout the world (Onsrud 1998, Masser 1998, Mohammed 1999) including the compatibility of the visions and expectations for an SDI and the development model selected, which justify the need to improve understanding about the alternative approaches that may be adopted whilst learning from current development experiences.

The different characteristics of social systems, or communities, adopting the SDI concept can be attributed to a number of variables, including the different cultures of the communities. However, the objectives behind cooperation toward SDI development are still to take advantage of common interests toward achieving certain goals. These characteristics can be seen as very similar to the organisational objectives of people working together with common interests toward achieving organisational goals.

There are at least two important differences between SDI innovations and most innovations for which the classic diffusion model has been found useful. This is due to the technology components of SDIs that make them dynamic in their nature. The first difference reflects the extent to which SDI is an evolving technology which is constantly changing over time. Under this circumstance as summarised by Masser and Onsrud (1993), reinvention is an important characteristic of the diffusion process. Secondly, SDIs need to be acquired by communities rather than individuals as is the case in much of the classic diffusion research pointed out by Rogers (1993). Because of their greater complexity there are very large differences between the way the same technology is utilised in different communities.

As suggested by Brodman (1987 as cited by Cartwright 1993), the diffusion of geographic information technology such as SDIs in the third world, will depend ultimately on four factors namely motivation, opportunity, training and support. People need motivating, because learning takes a considerable effort. People need to have an opportunity to learn about and to use geographic information technology, either on the job or through an educational institution of some kind. People need training, both in how to use the technology and what to use it for. People need help and advice in retaining and applying what they learn.

As highlighted by Burrough and Jones (1993) in countries with a strong tradition of mapping and surveying one might expect that the reservoir of expertise and data would facilitate the introduction of any geographic information technologies like GIS and SDI.

Today as pointed out by Rogers (1993), spatial diffusion research has advanced considerably and has infected the entire geography discipline, therefore, within the whole range of geographical research, the study of spatial diffusion occupies a central place.

Innovation as stated by Rogers (1993), occurs in organisations/communities, and so organisations/communities researchers also study innovation diffusion (Zaltman et al 1973, as cited by Rogers 1993). Because the diffusion approach offers one means of understanding social changes, a topic central to every social science discipline, every social science has a piece of the action. Innovation diffusion has emerged as one of the most multi-disciplinary research topics in the social sciences today (Rogers 1993).

### **5.8.1 PARADIGM**

The diffusion model is a conceptual paradigm with relevance for many disciplines (Rogers 1983). Rogers (1993) defined the paradigm as a scientific approach to some phenomena.

#### **a) Diffusion Paradigm**

The main elements in the diffusion of new ideas are: an innovation, which is communicated through certain channels, over time, among the members of a social system (Rogers 1993). The characteristics of an innovation, as perceived by the members of a social system, determine its rate of adoption. Five attributes of

innovations are: relative advantage, compatibility, complexity, trialability and observability.

A communication channel is the means by which messages get from one individual to another. Mass media channels as reported by Rogers (1993) are usually more effective in creating awareness-knowledge of innovations, whereas interpersonal channels are more effective in forming and in changing, attitudes toward a new idea.

Time is involved in diffusion in:

- the innovation-decision process, which is the mental process through which an individual or other decision-making unit passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea and to confirmation of this decision;
- innovativeness, the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system; and
- an innovation's rate of adoption.

There is need to define a regional geographic data policy and develop and implement an SDI diffusion strategy which promotes as much coordination between nations as possible.

#### **b) Implementation**

Implementation as suggested by Campbell (1993) is an on-going process involving repeated cycles of development, learning and routine use.

#### **c) Corporate**

Corporate approach as suggested by Campbell (1993) implies inter-departmental cooperation with respect to the adoption, implementation and on-going maintenance of an innovation. In this regard, a corporate approach within an SDI hierarchy means inter-governmental cooperation with respect to the adoption, implementation and on-going maintenance of different political and administrative levels of SDIs.

There are two reasons that nations might choose to collaborate with each other to develop a Regional SDI. The first is based on the pragmatic decision that given the costs of acquiring datasets and equipment. The second and more general justification for



the adoption of a corporate approach concerns the strategic and efficiency benefits to be gained from the integration of formerly isolated datasets. This approach needs to be considered as a long term cooperation between nations concerning not only the process of SDI development but also the critical issues of the maintenance and utilisation of the services and information provided.

The adoption of a corporate approach and the resulting integration of formerly isolated datasets has important implications for the ownership and control of information.

**d)      Appropriate Technology**

Appropriate technology is ultimately technology that is suitable and accessible – suitable for the job to be done and accessible to the person doing it (Schumacher 1973 as cited by Cartwright 1993). Moreover, appropriate technology is, by definition, low-risk technology. For example, based on current state of technology advancement, one of the most significant technological developments driving the changing nature of access and dissemination of spatial information has been the Internet, most prominently the World Wide Web (Millner *et al.* 2001). Although, more recent developments in advanced wireless technologies – which is the technology that combines mobile communication and data communication that provides consumers with relevant information on the Internet or Intranets through wireless devices (Pehrson, 2000 as cited by Millner *et al.* 2001), provide the capability of supporting data access from mobile phones and personal digital assistants (Smith *et al.* 2001). Therefore, the advancement in Information Technology (IT) and Information Communication Technologies (ICT) which have a radical impact on the spatial data industry should be considered as appropriate technology.

**e)      Accessibility**

Accessibility as suggested by Cartwright (1993), has at least three dimensions: physical, financial and intellectual. As far as physical accessibility is concerned, a user has to feel that he or she can physically use the services that SDI is promised to provide, whenever and wherever it is needed. The more people use the SDI, the more people become dependent on it. Second, accessible means financially accessible or affordable. Naturally, users have to be able to afford to participate in the SDI development in the first place, if they are going to use it.

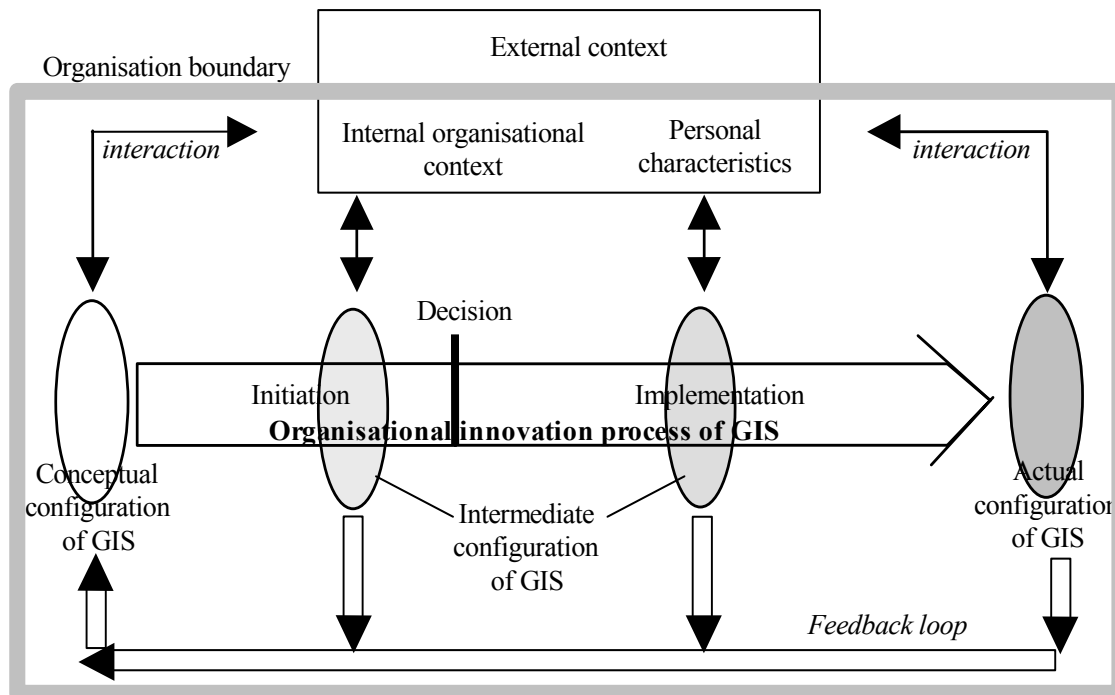
Third, accessible means intellectually accessible. The access network and the system involved in an SDI has to be easy to learn and use.

## **5.9 SDI DIFFUSION AND APSDI DEVELOPMENT**

As was mentioned in the pervious section, along with the three process innovation diffusion, this research adopts the organisational innovation process as a framework to study SDI diffusion in this region. The reason why this process is adopted is because of the objectives behind cooperation toward any SDI development are still to take advantage of common interests in achieving certain goals. These characteristics as mentioned above, can be seen as very similar to the organisational objectives of people working together. Although SDI stakeholders do not necessarily conform to the formal structure of an organisation, the motivating concepts behind cooperation toward SDI development apply at global and regional levels, as much as to individual countries, states and corporations in an SDI hierarchy, despite the more voluntary nature of the cooperation than would be found in a formal organisational structure. Therefore, taking an organisational approach can enhance understanding of the role of the social system in approaching individual SDI development strategies.

With this in mind, therefore, to apply organisational innovation process theory into SDI research, this thesis adopts an assumption as the similarities between a region and an organisation in terms of characteristics and behaviours. Based on this assumption, the organisational-innovation process model is the more applicable model for the subject of study on diffusion of a Regional SDI.

Based on Rogers' organisational innovation process model, Chan (1998) suggested an integrated framework for GIS diffusion research (Figure 5.3).

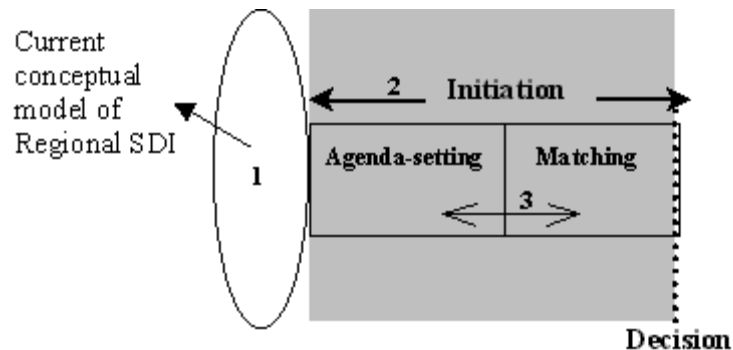


**Figure 5.3:** An integrated framework for diffusion research suggested by Chan (1998)

According to this framework, any innovation such as GIS or an SDI is a dynamic entity that is central to the diffusion process. This entity assumes multiple identities or configurations as diffusion progresses over time, as represented by the simplified staged model of the diffusion. The characteristics of this entity may change or customise as it passes from the initial conceptual configuration, through one or more intermediate configurations, to an actual physical configuration of GIS or Regional SDI that serves the needs of the organisation or a region. Irrespective of whether diffusion has failed or succeeded, there is a feedback loop to allow the process to start all over again. Each configuration of this framework can affect, be affected by and interact with other factors.

Based on Chan's framework, in order for diffusion of a Regional SDI to be successful, it is important to take into consideration the conceptual configuration of Regional SDI, the social system of the region as defined by the boundary, and the other external, organisational and personal factors which have an impact on the diffusion. But, according to the discussion in chapter 4, the current approach taken by the PCGIAP

suggest that the nature of the social system and many other factors as illustrated in Figure 5.4, are ignored.



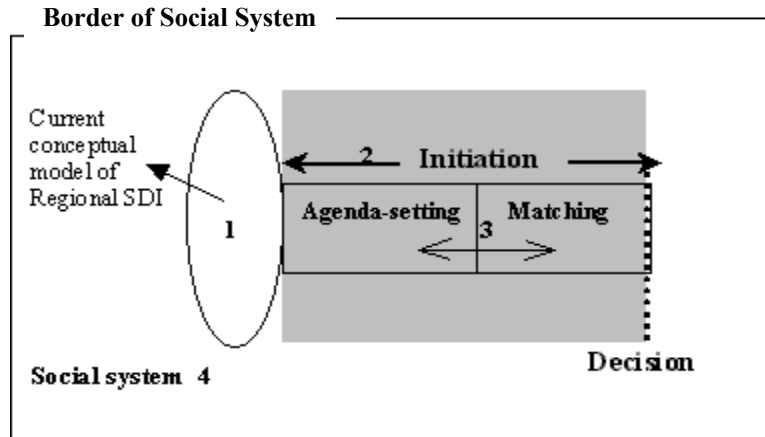
**Figure 5.4:** Current approach taken by PCGIAP for APSDI development, based on Organisational innovation theory  
1-Innovation, 2- Communication channel, 3- Time

According to the Figure 5.4, and based on Rogers' views on the elements of the diffusion process, the current approach taken by the PCGIAP (see chapter 4) has just adopted the first three elements of diffusion and missed the fourth one which is the social system.

In this case, the number of nations not participating in the APSDI initiative suggests that these nations may still not be aware of the concept of an SDI in general or do not fully appreciate the value of the Regional SDI portrayed in the current model of the APSDI. In any case, the concept of Regional SDI and the conceptual model represents that these nations have not entered the initiation stage of the organisational innovation process model (see Figure 5.1).

## **5.10 EXTENSION OF CURRENT APSDI CONCEPTUAL MODEL**

As discussed above, the social component of diffusion has been identified as an important component for the study of any innovation. In this regard, Chan (1998) pointed out that different stages of innovation diffusion are affected by a different set of success factors. He pointed to the need to conduct integrated studies involving the elements of time and social system in diffusion research. Having these suggestions, the author conducted this study on an expanded conceptual model which is the current conceptual model used by PCGIAP (Figure 5.4) within a social boundary (Figure 5.5).



**Figure 5.5.** Extended conceptual model  
1- Innovation, 2- communication channel, 3- time, 4- social system

This extended model helped to understand various features involved in Asia and the Pacific social system as well as identifying key factors among different features of the social system, which are influencing the diffusion of the APSDI initiative (see chapter 7). In this environment, the interaction between the first and the fourth elements of the diffusion (APSDI as an innovation and social system) will be the main part of this study.

## 5.11 CHAPTER SUMMARY

This chapter briefly described the current knowledge of the different aspects of an innovation by reviewing GIS diffusion research worldwide. GIS technology has had a significant influence on the need for SDI and the diffusion SDI is undergoing in different communities, therefore the research and experiences on GIS diffusion should also be applicable to SDI. SDI is an innovation that is underpinned by many GIS concepts and technologies, as well as the phenomenon of the Internet and related telecommunications and network technology.

Current research on SDI development at the regional level shows that, as with other technology innovations, SDI development in its adoption among spatial data communities, obeys the S-shaped diffusion curve found by Coleman *et al.* (1966 cited by Rogers 1993), that characterised the behaviour of earlier and later adopters of an innovation.

There are at least two important differences between SDI innovations and most innovations for which the classic diffusion model has been found useful. This is due to the technological components of SDIs that make them dynamic in nature. The first difference reflects the extent to which SDI is an evolving technology which is constantly changing over time. Under this circumstance reinvention is an important characteristic of the diffusion process. Secondly, SDIs need to be acquired by communities rather than individuals as is the case in much of the classic diffusion research.

This research adopted an organisational innovation process as a framework for the study of the Regional SDI diffusion. Taking an organisational approach can enhance understanding of the role of the social system in approaching individual SDI development strategies. To apply this process, this thesis adopts an assumption of the similarities between a region and an organisation in terms of characteristics and behaviour. Based on this assumption, the organisational-innovation process model is the more applicable model for the subject of study on diffusion of a Regional SDI.

It is also noted that like other innovations, SDI diffusion has to tackle the problem of identity of SDI. The problem has three different dimensions. Firstly, SDI may comprise a cluster of related technologies/knowledge. Secondly, the identity of SDI may be customised in the course of diffusion through reinvention to meet the needs of a specific organisation. Thirdly, SDI may have different configurations and socially constructed meaning depending on the needs and perceptions of individuals or units of adopters within a jurisdiction/social system.

As suggested by GIS diffusion research, establishing the identity of an innovation is fundamental to the diffusion research. Having this in mind, this research also confirmed that the identity of SDI as an innovation is fundamental to its diffusion research.

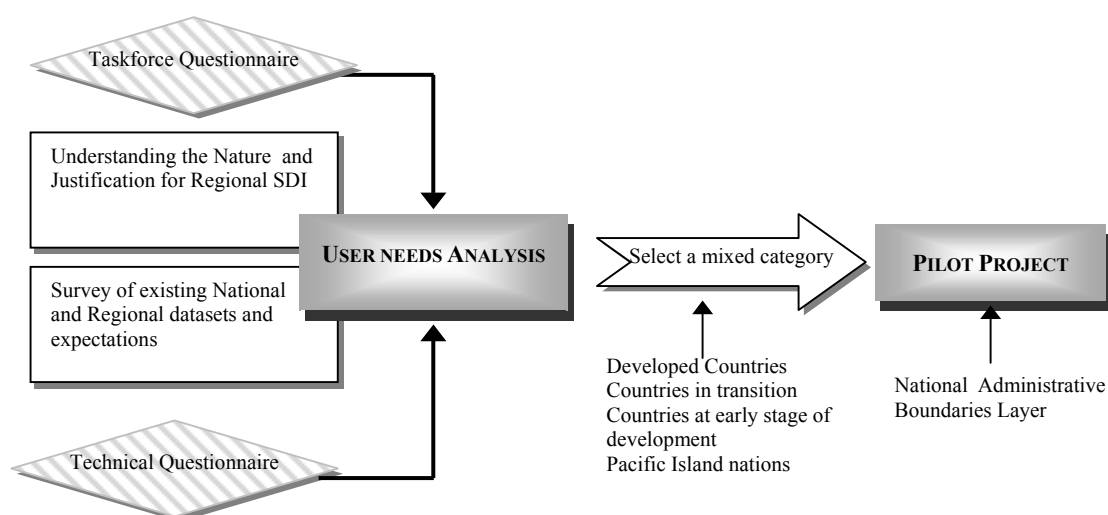
# **CHAPTER 6**

## **PILOT PROJECT ON REGIONAL FUNDAMENTAL DATASETS**

### **6.1 INTRODUCTION**

The development of an SDI initiative is a long-term process which requires a long-term vision and strategy. One suggested strategy to speed up this process is setting short-term goals and demonstrating their results to the users and other interested people as soon as they reach completion (SDI Cookbook 2000, Rajabifard and Williamson 2001). The demonstration of such results will increase awareness of the value of SDIs, which in return may effect potential support. In this way the potential users and decision-makers can see the advantages of having a functioning SDI, and they may support and get involved in its activities and support its longer process. Thus, as a short-term concern, conducting a pilot project, such as a pilot project on administrative boundaries, is a good opportunity to achieve such a strategy.

With this in mind, as described in chapter 1 and chapter 4, this research used a case study approach to assist in determining factors which influence the diffusion of a Regional SDI initiative and which could test the hypothesis of this research. The case study is done in Asia and the Pacific region. Step 4 of the research methodology was to understand the nature of user needs as well as regional concerns and interests (see chapter 1, Figure 1.2). This then enabled an analysis of user needs. This analysis has been based on the information gathered from two questionnaire surveys (Figure 6.1), that were designed and used mostly for this purpose.



**Figure 6.1:** Relation between Two questionnaires and Pilot Project, as part of research methodology

Understanding the individual member nation needs (user needs), especially their needs for National SDI development and relationships between all parties in the region, can help to improve the current conceptual model of the Asia-Pacific Spatial Data Infrastructure (APSDI) in such a way that covers the perceived need of users. Using this improved model and by running a pilot project (Figure 6.1) like integration of national administrative boundaries to generate a common layer of regional fundamental datasets (which is one of the proposed advantages of having an SDI), it is possible to show the difficulties and problems involved in such activities. In this way, member nations can understand the importance of cooperation to build a common infrastructure with other members and also the importance of their roles in such an initiative.

Using the improved conceptual model, which is designed on the results of questionnaires and the current situation in Asia and the Pacific region, it is also possible to see the reaction of member nations when demonstrating the results of such joint pilot projects and see whether they understand the importance and value of their participation and check whether it increases the number of participants or not. For these reasons, the task of identifying user needs through a Taskforce group by doing a questionnaire (as illustrated in Figure 6.1) was started in late 1998 and was analysed in September 1999, with the aim to improve the current conceptual model from the research perspective and additionally assist the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) to fulfil their vision. Following the first questionnaire, the second questionnaire was designed, distributed and analysed during 1999-2000. Parallel with



these two questionnaires, during any subsequent meetings (such as PCGIAP annual meeting and the Executive Board meetings) the author interviewed many members of the permanent committee (Appendix 4), to improve the results and to confirm some of the research findings.

The implementation of this research strategy had to go through an official communication channel of the PCGIAP due to the organisational structure and current roles and regulation of this committee. This enabled the research to be officially sanctioned by the PCGIAP and thus acknowledged as part of the activities helping PCGIAP and PCGIAP-Working Group 2 (PCGIAP-WG2) to achieve their roles and fulfil their objectives.

Therefore, by reviewing and assessing the current activities and future work-plans and strategies of the PCGIAP in general and PCGIAP-WG2 in particular, the author was able to appropriately align the plan and strategy of this research with the PCGIAP and PCGIAP-WG2 activities and then start the case study and pilot project. With preliminary dialogue with the PCGIAP established, the overall objectives and methodology of this case study and the strategy of its implementation were described to the Executive Board members at the Executive Board meeting during the 5th PCGIAP meeting in April 1999, China, after delivering and presenting a report on this research at the annual meeting (Rajabifard and Williamson 1999). After some discussion about the methodology of the research, the committee found that this research is in line with their direction, so they approved the whole strategy of the research and agreed to support it in any possible way. At the same time they acknowledged that the results of this research could assist the committee and its working groups (especially PCGIAP-WG2) to achieve their objectives (PCGIAP 1999a, PCGIAP-WG2 2000).

Having this support, the author started his activities from a research perspective at the PCGIAP-Taskforce, which allowed the author to be involved in conducting and analysing the Taskforce questionnaire survey. The Taskforce group was an official group responsible for identifying the needs of individual member nations in regards to National SDI and spatial data activities. The author was already an official member of this Taskforce group since its establishment in 1998, with responsibility for the West-Asia sub region countries which includes 16 countries (PCGIAP 1998a). Regarding the

other parts of the research, the Chair of the PCGIAP-WG2, AUSLIG, undertook a contract with the Department of Geomatics, The University of Melbourne for the design and analysis of a technical questionnaire and running the pilot project.

In the following sections, the background, methodology, different arrangements, design criteria as well as the results of the pilot project and its related activities, including two questionnaires, are discussed in detail.

## **6.2 BACKGROUND**

The Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) has a vision for an Asia-Pacific Spatial Data Infrastructure (APSDI) that is a network of databases, located throughout the region. Together, they are expected to provide the fundamental data needed by the region in achieving the PCGIAP objectives. These include economic, social, human resource development, environmental management, research, GIS analysis and planning objectives. This Committee, through its WG2, believes that the availability of fundamental data from member countries is essential to the:

- development of the Asia-Pacific Spatial Data Infrastructure;
- development of regional knowledge infrastructure;
- realisation of economic, social and environmental benefits for the region; and
- the implementation of the United Nations Conference on Environment and Development (UNCED) Agenda 21;

and further this working group (PCGIAP-WG2) believes that:

- data sharing avoids wasteful duplication of resources and facilitates data integration; and
- provides better data for decision making and thus expands market potential.

However, there is currently a general lack of transparency in Asia and the Pacific region as to what (mainly national) data exists regarding the commercial conditions of their usage and their scope and quality. In order to ensure access to data, directories are required to enable the location of existing information and its sharing for different purposes. Potential users of geographic information need to know what data exists, where it is located, who owns it and how it can be accessed and purchased. This is an

issue in line with the implementation of Resolution 5 of the Thirteenth United Nations Regional Cartographic Conference (UNRCC-AP 1994, Beijing) on access to information for development which called upon:

*..relevant authorities in member States to authorise their national survey and mapping agencies to make more widely available, in timely, affordable and appropriate form, such spatial information as is needed by national and international agencies and organisations to enable United Nations resolutions to be effectively implemented;...*

This is the background providing the justification for development of an Asia-Pacific Regional metadata directory system. However, there was a need to document the existing availability of national datasets in a standardised way to enable its collation. In order to overcome this situation, the PCGIAP-WG2 defined a project to assist its effort to fulfil its tasks regarding development of Regional Fundamental Datasets and to create a Metadata system for them. The overall objective was that member nations are made aware of the existence of regional data, can make informed decisions based on the data's fitness for a given use and can assess the suitability of the data for their regional applications.

The author has undertaken the project for PCGIAP-WG2. He was asked through the University of Melbourne to plan, conduct and analyse the results of a technical questionnaire to determine what data exists, where it is, its availability and its quality. Further, he was asked to plan, conduct and analyse the results of a pilot project dataset on administrative boundaries based on the results of the questionnaire. Then, drawing upon that analysis, determine what steps need to be taken to amend the policy on sharing fundamental data - if any - and what implications the research has for the collection and integration of other fundamental datasets in the APSDI.

This pilot project was a good opportunity for the author to address the research problem and to test the research hypothesis based on the research objectives. Based on the research problem, the lack of support from member nations stems from three key issues i) lack of awareness of the benefits of a Regional SDI, ii) the incompatibility of the current conceptual model with the perceived needs of the member nations, and iii) the

lack of understanding of the complexity of the interacting social, economic and political issues. The hypothesis states:

*“The involvement of member nations in a Regional SDI can be improved by developing a new conceptual model of the Regional SDI which better serves their needs.”*

As was discussed in chapter 4, by improving the current conceptual model of the APSDI – as a Regional SDI case study, by considering an important additional component, namely, people, it is possible to respond to the research problem with respect to the incompatibility of the current conceptual model with the perceived needs of the member nations, and the lack of understanding of the complexity of the interacting social, economic and political issues. By considering this new improved model and doing the pilot project together will lead the research to the stage that the author can demonstrate the complexity of current communication channels between member nations and the difficulties involved in individual national datasets, if they want to integrate their datasets to form regional data layers. They will correspondingly increase awareness of the value and benefits of having a functioning Regional SDI.

### **6.3 SOURCE OF DATA**

An important source of data for this case study research was the information gathered by two questionnaire surveys. These two questionnaires were circulated by the PCGIAP in Asia and the Pacific region. The first questionnaire was a "Development Needs questionnaire" which has been designed by the PCGIAP-Taskforce group (the author was a member of this group) and was distributed through the region in March 1999 (Appendix 5). The results of this questionnaire were reviewed and analysed at a workshop in Canberra in September 1999, and the final report was presented at the 15<sup>th</sup> UNRCC-AP and 6<sup>th</sup> PCGIAP meeting in Malaysia 2000 (Appendix 6). The second questionnaire (Appendix 7) was a technical questionnaire that was designed as a part of this research through a joint project with the PCGIAP-WG2, with aims of surveying the existing national and regional datasets and users' expectations about regional fundamental datasets. This questionnaire was distributed through the PCGIAP member nations in June 1999 and was analysed at the end of 1999. The result of this analysis as

was mentioned above, was presented at the same conference and meeting of UNRCC-AP and PCGIAP in Malaysia 2000.

The information gathered by both questionnaires and the results of their analysis, and the annual reports of the PCGIAP meetings all provided data to this research. Further to that, during the case study research, most of the national representatives delegated to the PCGIAP meetings were interviewed during annual and Executive Board meetings. The results of these interviews and discussions have been kept confidential. The results of the two questionnaires and interviews were important for understanding and analysis of the overall network of the systems and organisation in each member nation and their impact on their involvement in Regional SDI activities. Also, the experience of the author as the National Mapping/GIS representative of Iran to the PCGIAP (including five years as an Executive Board member) and as a member of the International Steering Committee on Global Mapping (ISCGM) between 1997-2001, were useful for this research. Additionally, discussions with key researchers, leaders and managers around the world and their critical feedback during the course of this research were also useful. Further, the author was responsible for the design and formation of the Iranian National SDI and national GIS from 1994 to 1998.

#### **6.4 TASKFORCE DEVELOPMENT NEEDS QUESTIONNAIRE**

The PCGIAP at its 4<sup>th</sup> meeting in Tehran, Iran, 1998, resolved to restructure its working groups and in doing so also introduced a Taskforce (as part of Resolution 1) to assist it in achieving its goals. The PC Executive Board convened a discussion group to help develop and refine a work plan for the Taskforce based on the following terms of reference:

- survey member countries to identify National SDI development needs (eg. geodesy, cadastral, training, technological);
- recommend programs and funding mechanisms to address these needs.

The Taskforce's Objective was:

*To Support Member Countries in the Development of their National Spatial Data Infrastructure which thereby contribute to the Development of the Asia & Pacific Spatial Data Infrastructure. (PCGIAP 1998a).*

The Taskforce had four items under its Workplan:

- Prepare an SDI strategy or discussion paper;
- Determine PCGIAP members' NSDI development needs;
- Prepare a Communication Plan; and
- Prepare a Glossary of SDI Terms.

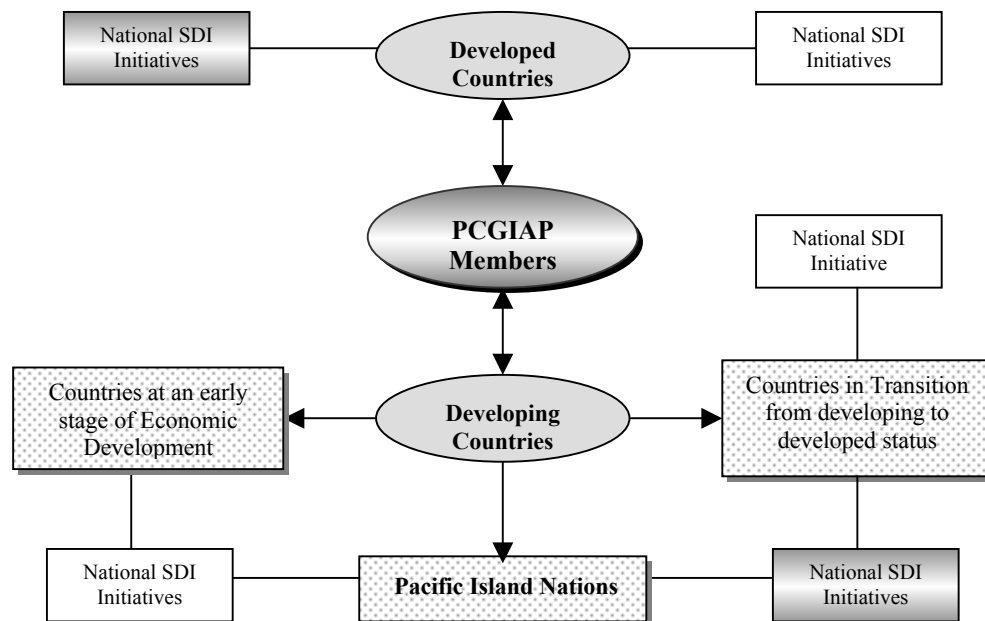
As a first step in identifying development needs the Taskforce collected, through a questionnaire, the institutional and other SDI data of its members. Further, it was the aim of the Taskforce group to gain an understanding of the challenges being faced by member nations through this questionnaire and then to develop strategies to address those challenges. With this in mind, the Taskforce group (of which the author was one of the four members of this group at the time) designed and conducted the Taskforce questionnaire survey. Thirty-three responses out of the 55 countries were received. As well the Taskforce undertook other activities such as direct visits and conducted a Pacific area workshop that helped identify the issues for appropriate development needs projects. At the Pacific workshop the PCGIAP Pacific Group was formed to represent the special and unique interests of the 19 Pacific Island member countries.

The Taskforce group conducted a workshop in Canberra in September 1999 to analyse the responses to the Taskforce questionnaire. The main points emerging from an analysis of the questionnaire survey were:

- Asia and the Pacific region is complex social and political environments, typified by competing and often conflicting priorities and motivations. Therefore, understanding the regional context is crucial for establishing Regional SDI and data sharing. Working the context is necessary for success in APSDI development;
- Countries that are either not participating in the PCGIAP or participating infrequently would prefer and benefit from closer involvement by attending meetings and joining in working group activities; and
- Countries that provided a response to the questionnaire have varying SDI development needs however the majority of the 33 countries would be in the category of requiring development assistance within the aims of the Taskforce. In this respect, in countries with a strong tradition of mapping and surveying one might expect that the reservoir of expertise and data would facilitate this category.

### 6.4.1 PRIORITIES

The stage of development of the specific country and awareness of the value of SDI initiatives has a major impact on the development of an SDI for the country. The results of this survey confirmed that different member countries have very different needs for an SDI development for their respective countries and participating to the Regional SDI initiative. This is mainly because of being in different stages of development in the region and awareness of the value of SDIs. As a result two broad groups of countries are considered: developed and developing countries. The category of developing countries is then broken into another three sub-groups: first countries in transition from developing to developed status; secondly countries at an early stage of economic development and awareness; and lastly the Oceania/Pacific Island nations (Figure 6.2). This classification also confirmed the general categories of countries suggested by Williamson (1994) with respect to the economic development in the Asia-Pacific region.



**Figure 6.2:** Classification of PCGIAP Member Nations based on Economic and SDI activities

 Country with an SDI Initiative
  Country without an SDI Initiative

Also, the responses to this questionnaire indicated the following major development needs priorities:

- Development of NSDI policy and programs;

- Map and spatial data standards;
- Coordination of spatial data activities between agencies;
- Geodesy (especially data processing but also with field activities and equipment);
- GIS (theory, system design and applications); and
- Cadastral systems development.

#### **6.4.2 OUTCOME AND RECOMMENDATIONS**

Based on the results of this analysis and the discussions with some member delegates, most countries that responded do not have a National SDI that is currently compatible with the APSDI model. A small number of countries are well advanced in this area. Further as a result of the Taskforce analysis the following outcomes are also identified:

- (a) The economic, social, institutional, legal and technical environment in developing countries is very different from that in developed countries. As such the promotion and diffusion of SDIs in developing countries may be faced with different challenges than those in developed countries. The main limitations are a lack of appreciation of what SDI can and cannot do, lack of resources and trained personnel, inefficient bureaucratic processes, lack of data and lack of infrastructure.
- (b) In developing countries, the long-term political and institutional stability is extremely important for promoting the necessary data collection, building institutes and accomplishing training necessary for the successful development and maintenance of any National and Regional SDI initiatives.
- (c) Every nation in Asia and the Pacific region is unique because of its national context, the national traditional and cultural attitude and the people who participate, develop and use the SDI concept. Therefore, the national situation must always be considered for the success of SDI diffusion.
- (d) The development of the APSDI is found to be much more challenging than the development of a National SDI initiative. This is mainly because a Regional SDI is a multi-participant activities and also because of the voluntary nature of SDIs at this multi-national level.



- (e) The introduction of the Regional SDI concept and sharing of datasets across the region has to upset existing environments, rules and procedures. Change is inevitable for realising the APSDI development and data sharing. With this in mind, managing change requires attention to many implementation issues such as: top political support for the APSDI development; secured long-term funding; well defined and focused pilot project scope; the need to better manage and meet the users' expectations; the importance of cross-national communication to define common language to resolve misunderstandings; and the need to demonstrate clear progress in order to allay political pressures.

Also, within the overall aim of seeking, greater participation in PCGIAP activities and institutional strengthening for those member countries requiring development needs assistance, the following recommendations were proposed:

- i) *Proceed with the Pacific Group institutional strengthening project.*

The workshop concluded that this initiative for the Pacific sub-region should be carried forward because it is in a fairly mature state of preparation. As well it was thought that to incorporate other sub-regions into a similar Asia and Pacific wide project may cause undue delays for the Pacific Group.

- ii) *Scope and seek funds for a Taskforce workshop (similar to March 1999 Suva workshop in the Pacific region) for Russian-speaking - West Asian countries.*

These countries are currently not participating in the PCGIAP and this recommendation proposes scope for a workshop (participants, benefits and arrangements such as translations and interpreting) and using supportive documents to seek funding support for the event.

In addition the workshop proposed immediate action to translate the PCGIAP information into Russian for these countries to increase their awareness of the PCGIAP aims and activities.

- iii) *Send information on the Taskforce and a summary of the PCGIAP, (and re-send questionnaires) to countries that have so far not provided questionnaire response.*

The documents would cover an overview of the PCGIAP, Taskforce achievements and aims and benefits that could result for these countries from their responses to the Taskforce questionnaire and from their participation in PCGIAP activities.

Following workshop deliberations, summaries of responses to questionnaires were prepared in descriptive form per question which can be found in Appendix 6-Attachment 2. Results were also tabulated per sub-region and region and by question (see Appendix 6-Attachment 3).

## **6.5 TECHNICAL QUESTIONNAIRE ON REGIONAL FUNDAMENTAL DATASETS**

In pursuing the objectives of the WG2, and receiving support from the 5<sup>th</sup> meeting of the PCGIAP in Beijing, April 1999, a technical questionnaire (Appendix 7) was designed by the author and was distributed to all 55 countries in the region through the secretariat of the PCGIAP regarding national fundamental datasets, GIS facilities and standardisation initiatives in each of the member countries. This questionnaire was developed in such a way to assist the author to meet the objectives of the research and in parallel to provide WG2 with a better appreciation of the situation existing in the countries of the region with respect to fundamental datasets and the sharing and exchange of geo-referenced data at the national level. This information will help WG2 to better focus and manage the steps required for developing regional fundamental datasets and accurately identifying the proper coverage, scale(s), format and the other important aspect of Asia and the Pacific regional fundamental datasets.

The questionnaire contained five sections. Section A requested information about the existing national datasets including national base map series, hardware and software and institutional arrangements for using and sharing Geographic Information in member nations. Section B asked information about the current use and knowledge about spatial data and data exchange standards in member nations. Section C requested information about the data policy, pricing and copyrighting issues involved with their national datasets. Section D requested information about the potential users of, and expected coverage of spatial data in the Asia-Pacific regional fundamental datasets and the number of personnel active in the field of national datasets. The last section (General),

asked information about anticipated technical and political barriers expected when developing regional fundamental datasets.

### 6.5.1 RESULTS OF THE TECHNICAL QUESTIONNAIRE

This section summarises the key findings and outcomes of the survey on Regional Fundamental datasets. The full analysis of the results of the questionnaire is in Appendix 8. A summary of this report was also submitted and presented at the 15<sup>th</sup> United Nations Regional Cartographic Conference in Asia and the Pacific (UNRCC-AP) and the 6<sup>th</sup> PCGIAP meeting held in Malaysia, April 11-14, 2000.

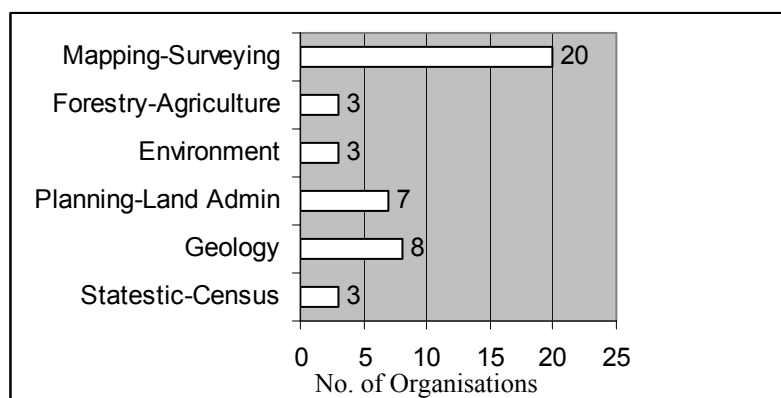
Responses were returned from 18 out of the 55 countries from Asia and the Pacific region (the respond from Indonesia was received after analysis of the questionnaire). All of the organisations who returned the questionnaire were engaged in surveying and mapping. A list of the countries and organisations providing information is given in Table 6.1. All responding organisations are national representatives in the PCGIAP.

**Table 6.1:** List of Respondent Countries

Country	Respondent Organisation	Type
Australia	Australian Surveying & Land Information Group (AUSLIG)	Government
China, People R. of	State Bureau of Surveying and Mapping (SBMS)	Government
Hong Kong, China	Survey and Mapping Office, Land Department (SMO)	Government
Indonesia	National Coordination Agency for Surveys and Mapping	Government
Iran, I.R. of	National Cartographic Center (NCC)	Government
Japan	Geographic Survey Institute (GSI)	Government
Kiribati	Land Management Division	Government
Laos	National Geographic Department	Government
Macau	DIRECCAO DOS SERVICOS DA CARTOGRAFIA E CADASTR (D.S.C.C.)	Government
Malaysia	Department of Survey and Mapping Malaysia	Government
Maldives	Ministry of Construction and Public Works	Government
Mongolia	State Administration of Geodesy & Cartography	Government
Nepal	Survey Department	Government
New Zealand	Land Information New Zealand (LINZ)	Government
Palau, R. of	Bureau of Lands and Surveys	Government
Singapore	Survey Department	Government
Soloman Islands	Survey & Mapping	Government
Tuvalu	Lands and Survey Department	Government

A list of key responsibilities and names of organisations which are the main producers and/or providers of National Datasets (including National base map series/Topographic maps and any other types of Spatial datasets such as: thematic, cadastral, administrative

boundaries, geodetic control points, and state or provincial datasets which are aggregated to a national level) is provided in Table 2, Appendix 8. According to this table (Table 2), all 44 organisations involved in providing and/or producing national datasets are government organisations. Based on the nature of major activity and key responsibilities of producer/provider of national datasets, organisations have been classified as shown in Figure 6.3.



**Figure 6.3:** Type of Organisation/Agency

Resulting from the collection of questionnaires and analysis of the responses, the following outcomes were identified:

- (a) There is more than one organisation in half of the countries which produce/provide national datasets. The number of organisations responsible for producing or providing national dataset ranges from two to seven in these countries with all being Governmental Departments.
- (b) There are large amounts of digital data available at different scales in the region that could be useful for the creation of a regional Fundamental datasets. Four countries have data only in a paper format. The availability of national datasets ranges from small to large scale depending on the size of the countries. The range in scale is from smaller than 1:5,000,000 to larger than 1:2,500. There are also many common layers in different datasets that could be used for a possible regional fundamental dataset.
- (c) Almost all the countries have adopted national standards for the preparation of their datasets. Very few countries have commenced converting their datasets into the ISO/TC211 standards. However most countries have indicated that they plan to adopt the ISO/TC211 standards in the near future.

- (d) In the existing datasets of most countries, the main items of available Metadata are comparable. This similarity should facilitate the development of a common Metadata system for the region. It would be useful to prepare a regional directory concerned with the availability of national datasets using a common metadata system for the region.
- (e) Regarding organisational infrastructure based on availability of the hardware systems, the dominant hardware used are personal computers (88 percent of countries). More than two-thirds use workstations and a minority use mainframes. Large format plotters and digitisers are installed at over 85 percent of countries, two-thirds of countries have large format scanners and a few countries have film writers.
- (f) ARC/INFO and ArcView are the most widely used software and are installed in 65 percent of countries. Other GIS and graphical software includes MapInfo, Microstation and MGE (Intergraph).
- (g) Almost all countries indicated that they are planning to undertake some form of national mapping project within the next five years. The scales of these projects are mostly 1:250,000, 1:100,000 and 1:50,000. The main sources of data collection are aerial photos and satellite imagery.
- (h) The main problems and issues experienced during data exchange between organisations within different countries includes security, cost recovery, copyright, non-standard data formats, metadata and the quality of datasets.
- (i) Only seven countries indicated that they have joint projects along their national borders with other countries. The total number of countries from Asia and the Pacific region that are involved in such joint projects is 17.
- (j) Almost all countries have their own cost recovery or charging policies for digital data which includes useful suggestions which may be used in the preparation of a regional data exchange policy.
- (k) Over 82 percent of countries are exchanging data within their countries. Their organisations typically exchange large volumes (ranging from over 100 MB to 150 GB) of data infrequently, from twice-monthly to once a year. Only three countries indicated that they do not exchange data between organisations.

(l) Storage media (disks, CDs, etc) are used most commonly for both types of data exchange between and within organisations. The second commonly used method is Local Area Networks (LAN). Very little use is made of the World Wide Web (WWW) and Wide Area Networks (WAN), a reflection of the fact that very few organisations are interconnected.

(m) DXF and ASCII files are the most common formats used for the exchange of data. The most important datasets which are desired by different users (over 70 percent) to be in a regional fundamental dataset include geodetic, topography, hydrologic and costlines, transportation, environmental data, place names, statistics data and landuse and forestry data.

In summary, based on the results of the analysis of the technical questionnaire, there are large amounts of digital data with many common layers available at different scales in the region that could be useful for the creation of a regional Fundamental dataset. Moreover, all countries indicated that they are planning to undertake some form of national mapping project within the next five years. Very few countries have commenced converting their datasets into the ISO/TC211 standards. However most countries have indicated that they plan to adopt the ISO/TC211 standards in the near future.

The most anticipated political barriers regarding the establishment of a regional fundamental dataset includes access to datasets for security reasons, lack of resources, national administrative boundaries as a data layer and copyright issues. Regarding technical barriers, the important issues are using different standards, lack of technical expertise, lack of valid information, lack of uniformity in dataset specifications, and differences in geodetic reference frameworks and lack of basic infrastructure in the area of GIS. In this line, the main problems and issues experienced during data exchange between organisations within different countries includes security, cost recovery, copyright, non-standard data formats, metadata and the quality of datasets.

This information shows and confirms the important role that a Regional SDI can play in this situation to facilitate member nations and speed up their cooperation and at the same time minimise these barriers.

## **6.6 ADMINISTRATIVE BOUNDARIES PILOT PROJECT**

Based on the PCGIAP vision and aligned with the case study methodology as illustrated in Figure 6.1 and Figure 1.2 (in chapter 1), a pilot project was needed to facilitate the testing of the hypothesis and objectives of this research. Having this vision and the methodology of this research, the WG2 defined and added an action item into their workplan (Project 2 ‘Develop Fundamental Dataset’, Action Number 8) from that research was to be conducted on an Administrative Boundaries pilot project dataset (what is available, formats and structure,...). Based on this action, which was an important step in the development of a regional fundamental dataset, it was expected that many issues and problems will be encountered (i.e. different scales, different metadata, different projection, etc). This pilot project was a good opportunity for the author to address the research problem, whilst completing the pilot project for PCGIAP-WG2.

The administrative boundaries pilot project was on the agenda at the PCGIAP Executive Board meeting in Melbourne, October 1999, together with three possible project areas which were identified by the author and presented for discussion.

### **Project Area 1:**

Mongolia, China, India, Nepal, Bhutan, Korea (both South and North), Japan and Sri Lanka

### **Project Area 2:**

China, Hong Kong - China, Laos, Thailand, Cambodia, Vietnam, Malaysia

### **Project Area 3:**

Australia, PNG, Solomon Islands, Vanuatu, Fiji, New Caledonia, New Zealand

Each of the above three possible project areas was formed from a set of selected countries (mixed category of countries, based on Figure 6.1) in which there are differing stages of SDI development and awareness. Based on these criteria, the outcomes of the pilot project may be representative for the rest of the region: any of these three project areas had the potential to be considered as a sample of the region. After discussion of the above points Project Area 1 was generally concluded to be the most suitable with regard to the diversity of characteristics of member nations, the size of the pilot project area and the possibility of gaining support and receiving datasets from the involved member nations for purpose of the pilot project.

This is the background providing the justification for development of a regional administrative boundaries pilot project. With this background, the author was asked to plan, conduct and analyse the results of building a pilot project dataset on Administrative Boundaries. Then, drawing upon that analysis, determine what steps need to be taken to amend the policy on sharing fundamental data - if any - and what implications the research has for the collection and integration of other fundamental datasets in the APSDI.

#### **6.6.1 GENERAL DESCRIPTION OF A PILOT PROJECT**

A pilot project can provide the first physical results from a Regional SDI. It is usually the last major milestone prior to corporate and technical commitment (adopted from Department of Geomatics 1998).

A pilot project is part of the effort to promote the initiative within the jurisdiction:

- The results of pilot projects can be demonstrated to decision-makers as evidence of the proposed SDI initiative and its immediate value;
- Pilot projects provide a tangible way of communicating the potential of the system to skeptics within the jurisdiction;
- Pilot projects are useful for verifying estimates of costs and benefits;
- Pilot projects can provide a means of reducing the risks associated with any major project before a final commitment is made;
- Ideally, it will reduce risk in all areas, increase the effectiveness of the major project and improve efficiency in the early stages of the major project;
- Demonstrating the results of the pilot project will allow members of PCGIAP-WG2 to see similar results of the projects and provide early visibility of the project to the WG2 and executive board members.

A pilot project can also result in:

- Well-developed technical, managerial and production procedures; and
- An improved implementation plan.

#### **6.6.2 AIM OF THE ADMINISTRATIVE BOUNDARIES PILOT PROJECT**

From a research point of view, the reason for selecting administrative boundaries as a case study for the purpose of the pilot project was to select a layer from which to gain



greatest attention from all politicians concerned as well as that of the other people interested in the APSDI initiative. It is also the perfect interface between geographic information and a host of other information such as transportation, population, economy and natural phenomenon that can be geographically referenced. Moreover, as noted by Leonard and Luzet (2001) from Europe, a harmonised and commonly agreed upon set of administrative boundaries is a primary necessity for any cross-border GI project and is therefore a keystone for interoperability. With this in mind, the aim of this pilot project was to identify and document - within a sample region - problems and difficulties encountered when integrating administrative boundary data from the pilot project countries. This project is part of the work plan of the PCGIAP-WG2 on Fundamental Data. The key issues for this pilot project were:

- What implications does the research have on the policy for sharing Fundamental Data?
- Was metadata (and its characteristics) supplied with each dataset?
- Does data meet the ISO/TC211 standards?
- What formats were the data supplied in?
- How easy or difficult was it to integrate all the data?
- What problems were encountered?
- Were there restrictions on access and or use of the data?

Similar to this project, the MEGRIN which is now known as the Eurogeographics organization in Europe (see chapter 2 for more detail) also has form a seamless administrative boundaries project of Europe (SABE) as part of an initiative to form European-wide datasets.

SABE is a vector dataset of administrative units in Europe, which was created from administrative boundary data provided by National Mapping Agencies (NMAs) to MEGRIN (Salge 1998a). The low level administrative units are the units which elect representatives to local councils or, for the EU. As an option, a seamless coastline of European database (SCOLE) is available to complement the administrative boundaries, which in some countries do not coincide with the actual coastline. SABE contains the administrative units of Europe at the various administrative levels in each country. The administrative hierarchy of each country is described from the low level administrative unit to the national level.

SABE is supplied as one layer for each country. International boundaries between two countries are identical in both layers. This means that their geometry (coordinates), topology (nodes and arcs) and semantics (attributes) are the same in both layers. Each low level administrative unit consists of one or more closed polygons. Each polygon is identified, by an attribute on its centroid, as the main polygon of the administrative unit or as an enclave in another unit.

**a) Identified Problems**

It was noted by the research that, some of the selected countries in Project Area 1 might have restrictions on making spatial data available for the purpose of the pilot project.

To overcome this problem, PCGIAP-WG2 developed a set of conditions which stated that the outcomes of the pilot project, including any part of the datasets, will not be available or presented in any public domain without prior permission from countries involved in the pilot project.

**b) Expected Outcomes**

Based on the aim and identified problems of the pilot project, the expected outcomes were to document and describe the process of integration of the administrative boundary datasets from the pilot project countries (this document was also expected to identify and analyse the difficulties and problems encountered); a set of recommendations on changes required – if any – to the policy on sharing fundamental data; and a final report on the pilot project for distribution to PCGIAP members and possible submission to the United Nations.

**c) Methodology**

The methodology of this pilot project was to plan, conduct and analyse the results of building a dataset on Administrative Boundaries. Then, drawing upon that analysis, determine what steps need to be taken to amend the policy on sharing fundamental data – if any – and what implications the research has for the collection and integration of other fundamental datasets in the Asia Pacific Spatial Data Infrastructure. The steps of this methodology included:

- 1- Review of documentation about characteristics (digital or analogue, metadata, currency, scale, etc) of data in each of the selected countries;

- 2- Data collection from individual country boundaries involved in pilot project area;
- 3- Develop a Specification and User Guide;
- 4- Data integration based on the Specification in a GIS environment
  - (a) Arrange for digitisation of analogue data (if applicable)
  - (b) Transformation to a common geographic coordinate system
  - (c) Harmonisation of data (transformation to common scale, generalise datasets to prepare same detail data content, identification of areas where national boundaries do not coincide, etc.)

To run this pilot project, it was noted that the lack of successful integration of datasets due to limited quality or availability of data or its metadata documents was beyond the scope of this study. As a result, the methodology was expected to proceed as stated above for all possible dataset integrations.
- 5- Analyse the results of the pilot project and prepare a report for the PCGIAP including recommendation for further actions.

**d) Deliverables**

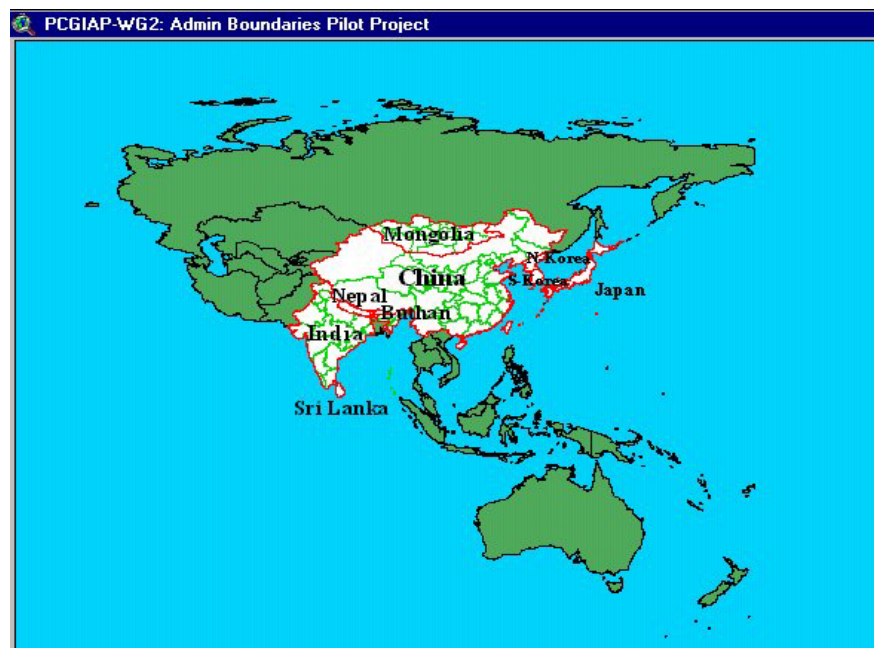
This pilot project study was expected to provide information that was aimed to assist the PCGIAP and its member nations in understanding what challenges may lie ahead in the integration of regional fundamental data. The steps taken during this project included:

- Data collection
  - Determine pilot project countries (UM together with PCGIAP-WG2)
  - Request and gather data (AUSLIG on behalf of PCGIAP-WG2)
- Scoping Statement
  - Draft a scoping statement (AUSLIG and UM)
  - Gather feedback from PCGIAP-WG2 (Chair and AUSLIG)
- Determination of Specifications
  - Draft specifications using Global mapping specification and possibly other examples
  - Gather feedback from PCGIAP-WG2 (Chair and AUSLIG)
- Build pilot project dataset
  - Build dataset with existing (provided) datasets

- The existing datasets were collected from the selected countries of this pilot project and have been provided to the UM by AUSLIG on behalf of PCGIAP-WG2
- The pilot project was executed using the datasets provided by AUSLIG at the beginning of the Pilot project.
- Document the process and outcomes.

### 6.6.3 PILOT PROJECT AREA

As mentioned above, after discussing the three possible pilot project areas, Pilot Area 1 (Figure 6.4) including Mongolia, China, India, Nepal, Bhutan, North and South Korea, Japan and Sri Lanka was generally concluded to be the most suitable for the pilot project to be conducted and was approved by the PCGIAP Executive Board members in their meeting in Melbourne, October 1999.



**Figure 6.4:** Pilot Project Area

]Table 6.2 provides some figures (area and population) about the countries involved in this pilot project.

**Table 6.2:** Areas and Populations of Pilot Project countries

Country	Area (Km <sup>2</sup> )	Population (thousands)
Bhutan	47,000	2,004
China	9,596,961	1,255,698
India	3,287,590	982,223
Japan	377,801	126,281
Korea North	120,538	23,348
Korea South	99,274	46,109
Mongolia	1,566,500	2,579
Nepal	147,181	22,847
Sri Lanka	65,610	18,455

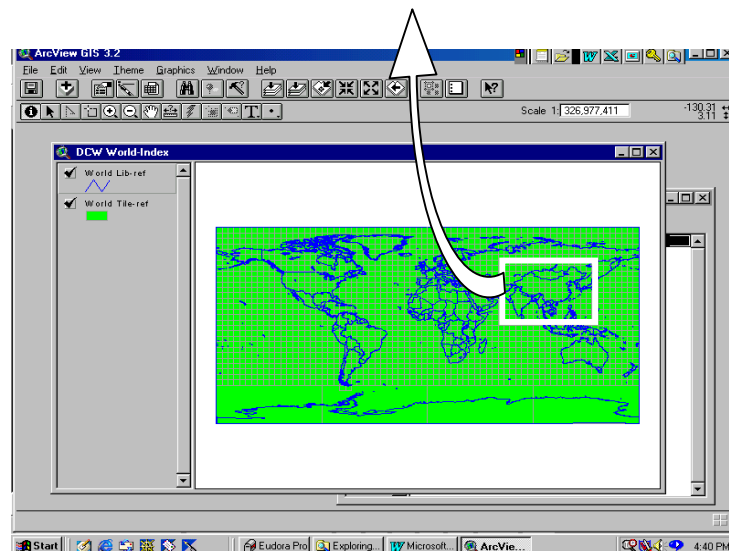
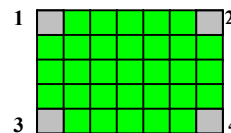
**Notes:**

- The area figures are for land areas only and do not include maritime boundary area claims or other areas of ocean.
- All area figures are from UN Statistics Division ([http://www.un.org/Pubs/CyberSchoolBus/information/e\\_I\\_map.htm](http://www.un.org/Pubs/CyberSchoolBus/information/e_I_map.htm))
- All population figures are from United Nations World Population 1998 (<http://www.undp.org/popin/wdtrends/p98/bp98pas.htm>)

Based on the Digital Chart of the World (DCW) - World Index, the World Tile references of the four corner points of the pilot project area were determined, as shown below (Figure 6.5). Knowing the World Tile reference was helpful when there was a need to use DCW datasets for covering the ‘gap areas’ (areas of no data coverage due to countries failing to provide datasets) within the pilot project.

**DCW WORLD TILE-REFERENCE NUMBERS**

Point 1: SK22  
Point 2: XK12  
Point 3: SG22  
Point 4: WG32



**Figure 6.5:** Pilot Project Area within the DCW

#### **6.6.4 RESULTS OF THE PILOT PROJECT**

This section summarises the key findings and outcomes of the Administrative Boundaries pilot project. The full report of the results of this pilot project is in Appendix 9. This report was submitted and presented at the 7<sup>th</sup> PCGIAP meeting held in Tsukuba, Japan, April 24-27, 2001. The aim of the report and presentation was to inform the PCGIAP about problems and difficulties encountered when integrating administrative boundary data from member countries.

From a research point of view, the main aim of the pilot project was to identify and document, within a sample region, problems and difficulties encountered when integrating administrative boundary data from the pilot project countries, in which to assist the author to meet his research objectives.

Further to the aims and objectives of this pilot project, was also an aim to facilitate the use and integration of regional datasets from various sources. In short, to improve the sharing of data through the provision of metadata and to study how data integration may be achieved.

As was highlighted in the results of the analysis of regional fundamental questionnaires (section 6.5.1), there are large amounts of digital data available at different scales in the region that could be useful for the creation of a regional Fundamental dataset.

Although PCGIAP-WG2 developed a set of conditions to ensure the privacy of the datasets of those countries involved in the pilot project area, four countries (Buthan, India, Mongolia and North Korea) out of the nine involved in the pilot area, still refrained from providing their administrative boundaries datasets to the project. With this in mind, the impetus to guarantee the rights of access and privacy through political and technical means needs to be continued. Indeed, the goal to build the APSDI that contributes to regional economic growth, environmental quality and stability and social progress cannot be fully realised unless open access to regional fundamental datasets is balanced with respect for the national privacy rights of individual member nations.

- (a) In general there was a significant lack of metadata supplied with datasets. This led to difficulties in determining projection system, some of which were impossible to interpret. Moreover, in the cases where datasets were supplied with a metadata file

or document, the metadata did not meet ISO/TC211 standards and was based on individual national standards. But, as was mentioned in the results of the regional fundamental questionnaires section, in the existing datasets of most countries, the main items of available metadata are comparable. This similarity should facilitate the development of a common Metadata System for the region. With this in mind, it is recommended that PCGIAP-WG2 encourage all member nations to create metadata information for all their datasets based on the standards endorsed by the PCGIAP, and at the same time encourage them to make their metadata available to the Asia-Pacific Spatial Data Directory (APSDD) to facilitate its development.

(b) Due to the fact that each dataset was based on different specifications and standards, the datasets were not easy to integrate with each other. There are four main types of problem which may happen when merging datasets from different national sources as reported by Salge (1998a). This is based on the European experience in developing seamless administrative boundaries. These problems are:

- Transformation into a unique geodetic referencing system;
- Transformation into a unique geometric and topological frame;
- Transformation into a unique semantic conceptual model;
- Transformation into a unique temporal frame.

However in this pilot project, in some cases (such as China and Japan) the process of integrating the datasets with others was relatively easy due to preliminary processing of their datasets prior to delivery to the pilot project.

(c) Most national administrative boundaries have discrepancies with other neighbouring boundaries and even with data from the same nation derived from different sources. These discrepancies are mainly due to a combination of different factors such as using different specifications, standards, data format, different units of resolution of original datasets, and etc. As a result, boundaries often do not align with each other. The existent of such discrepancies is also a case which may happen in any similar projects. Because, creating a unique geometric and topologic frame implies a resolution of the discrepancies which appear at the country borders. For example in Europe this problem has been experienced and addressed (Salge 1998).

(d) Data integration and data exchange are two of the most relevant issues in the geospatial industry. The PCGIAP is an initiative intended to create an environment

for the easy and secure access of complete and consistent datasets. One of the potential problems restricting the objectives of the APSDI is the fragmentation of data between national boundary systems.

- (e) The concept and the specification for administrative boundaries (even for expansion of the pilot project) are still evolving. Based on experience derived from this pilot project, users wishing to integrate spatial data from various sources may need to spend over 80% of their time and resources trying to integrate the data in such a way to overcome those four main types of problem which has been mentioned above. With this in mind, it is suggested that PCGIAP-WG2 needs to ensure that appropriate tools would be available for creating, integrating and using the regional fundamental datasets. In this way PCGIAP-WG2 can progress with the draft policy for sharing fundamental data, especially with the Access Conditions and the Sensitivity principles.
- (f) Further to this suggestion, PCGIAP-WG2 can facilitate the development of such appropriate tools by undertaking some further pilot projects, based on the results of the administrative boundaries pilot project. The objective will be to test different approaches or techniques to facilitate the integration of national datasets in both vertical and horizontal levels.
- (g) Opportunities to link data between different administrative boundary systems are limited and they require more graphical and non-graphical processes to facilitate their integration. Agreements are needed which permit some linking of individual member nation records from various sources through detailed protocols to preserve the confidentiality of datasets.
- (h) There are costs associated with managing and integrating regional fundamental datasets. These costs may also limit access. Some regional organisations might have information which is of value to others and may be a source of revenue. This will further restrict access by other regional organisations or individual member nations with limited funds. While effective participation in such a regional fundamental data project requires the encouragement of access, charging for data access may discourage participation from member nations. This is an issue which is also noted by the United Nations in which they addressed it as part of Resolution 5 of the



Thirteenth United Nations Regional Cartographic Conference (UNRCC-AP 1994) in the Resolution on access to information for development.

With this in mind, it is very important that the cost and investment in SDI development is recovered through short-term benefits. Once development costs have been covered, additional costs are minimal. It therefore makes more sense within an open environment such as the Internet to cover costs as a one-time public investment and to allow information access to be free from that point onwards.

- (i) One of the steps towards implementation of the policy for sharing fundamental data is to develop administrative principles and policies that facilitate access to fundamental data under conditions that promote better decision making based on good quality fundamental spatial data. With this in mind, it is recommended PCGIAP-WG2 adopts and uses the Internet as the infrastructure for access and to share regional data fundamental data.
- (j) The goal of regional fundamental datasets and access will not be achieved without developing common standards, specifications and practices in building regional spatial data infrastructures. In this regard, it is recommended that PCGIAP-WG2 should accept the results of this pilot project in its future work plan and use its best endeavours to adopt and implement the Administrative Boundaries Specification, to meet and address the compliance component of the principle of the draft policy for sharing fundamental data. Further, it is recommended PCGIAP-WG2 should expand this specification to cover other fundamental data layers.

## **6.7 OVERALL RESULTS**

With the above introduction and description about different parts of this study, the results of this project were presented officially to the PCGIAP during its annual and Executive Board meetings, in order of their achievement as illustrated in Table 6.3. The reasons for submission and presentation to the PCGIAP were for their information and approval if necessary for the other parts of the research.

**Table 6.3:** Results of the Case Study presented to PCGIAP

<b>Result</b>	<b>Meeting</b>	<b>Date</b>	<b>Location</b>
Analysis of the Taskforce questionnaire	15 <sup>th</sup> UNRCC-AP Conference and the 6 <sup>th</sup> PCGIAP meeting	March, 2000	Kuala Lumpur, Malaysia
Analysis of the Technical questionnaire	15 <sup>th</sup> UNRCC-AP Conference and the 6 <sup>th</sup> PCGIAP meeting	March, 2000	Kuala Lumpur, Malaysia
Technical Specification	Executive Board meeting	November, 2000	Hiroshima, Japan
Report on results of the Pilot project on Admin Bound	7 <sup>th</sup> PCGIAP meeting	April, 2001	Tsukuba, Japan
Technical detail and Demonstration of the pilot project on Admin Bound	7 <sup>th</sup> PCGIAP meeting	April, 2001	Tsukuba, Japan

The presentation of the final results of the project at the 7<sup>th</sup> PCGIAP meeting received a great deal of attention from all members and especially from the Executive Board members. The attention paid by delegates became more and more obvious when difficulties and problems in different national datasets were discussed as well as problems in the process of their integration.

As a result of these presentations, the committee resolved the following resolution to acknowledge the results of this project including its recommendations and to recommend for endorsement of the technical specification proposed in this pilot project (Appendix 10) for the integration of regional administrative boundaries:

The PCGIAP,

*Appreciating* the successful results of the Administrative Boundaries Pilot Project presented at the 7<sup>th</sup> PCGIAP meeting,

*Noting* the report of the pilot project and its recommendations,

*Bearing in mind* the sensitivity of administrative boundaries datasets, if integrated and utilized without proper guidelines,

### *Recommends*

- Formulation of a policy statement for integrating and utilising the administrative boundaries dataset of Asia and the Pacific countries, and
- Endorsement of the draft administrative boundaries specification as a reference document for the development of future specifications of the Regional Fundamental Dataset.

(Resolution 3, 7<sup>th</sup> PCGIAP meeting, April 2001, Tsukuba, Japan)

Also, the Committee recommended this project to be extended to cover the whole Asia and the Pacific region (PCGIAP 2001). This recommendation becomes a part of PCGIAP-WG2 work-plan activities. Moreover, PCGIAP-WG2 recommended, all those countries who did not return their technical questionnaires would be strongly encouraged to send them as soon as possible, and PCGIAP-WG4 (Institutional Strengthening Working Group) made similar recommendations regarding the Taskforce questionnaire.

The importance of these results was also recognised by the UN representative (the chief of UN-Cartographic section) at the 7<sup>th</sup> PCGIAP meeting, when he presented his report at the Open seminar on SDI in Asia and the Pacific region, at the third day of the meeting in Japan (Murakami 2001). Dr Murakami highlighted this project as the first project in the region with this vision and said the UN was looking forward to the results of such research and projects. The main reason being that national and regional administrative boundaries have been identified as high priority issues for the UN-Geographic Information Working Group (UNGIWG) and Global Map. Further, he asked for permission for the distribution of the results of this project (its report and the specification) to all United Nations related spatial data departments.

## **6.8 CHAPTER SUMMARY**

This chapter reports the findings of the case study including the results of the two questionnaires and pilot project on regional administrative boundaries. Based on data presented, evidence is identified in support of the hypothesis. As a result, the questionnaires fulfil the second objective, which was to understand the nature of the needs of member nations, and also provide input and evidence for the third objective of

this research, which is to identify key factors that can facilitate the development of a Regional SDI.

The chapter first provided background information about the case study including both user needs and technical questionnaires and their relationships with the pilot project as part of the research methodology. Then, it continued by reviewing the source of data for the pilot project and defining the strategy for running the pilot project. Aims and designs of both questionnaires were explained and their key findings and outcomes were also presented.

As a result of the analysis of the first questionnaire (Taskforce questionnaire), a classification of Asia and the Pacific nations was identified and presented. According to this classification, two broad groups of countries were considered: developed and developing countries. The category of developing countries was then broken into another three sub-groups: first countries in transition from developing to developed status; secondly countries at an early stage of economic development and awareness; and lastly the Oceania/Pacific Island nations. Further, the main points emerging from the analysis of this questionnaire survey were:

- Countries that are either not participating in the PCGIAP or participating infrequently would benefit from closer involvement by attending meetings and joining in working group activities;
- Countries that provided a response to the questionnaire have varying SDI development needs, however the majority of the 33 countries (number of respondent countries) would be in the category of requiring development assistance within the aims of the Taskforce group. Further, the main limitations identified in this survey are a lack of appreciation of what SDI can and cannot do, lack of resources and trained personnel, inefficient bureaucratic processes, lack of data and lack of appropriate infrastructures.

As part of the results and outcomes of the second questionnaire - technical questionnaire on regional Fundamental Datasets - this research shows that there are large amounts of digital data with many common data layers available at different scales in the region that could be useful for the creation and facilitation of a Regional SDI. Further, it was noted that almost all countries indicated that they are planning to undertake some form

of national mapping project within the next five years. This information confirmed the important role that a Regional SDI can play in this situation to facilitate member nations and speed up their cooperation. However, the most anticipated political barriers regarding the establishment of a regional fundamental dataset include access to datasets for security reasons, lack of resources, national administrative boundaries as a data layer and copyright issues. Regarding technical barriers, the important issues are using different standards, lack of technical expertise, lack of valid information, lack of uniformity in dataset specifications, differences in geodetic reference frameworks and lack of basic infrastructure in the area of GIS. In this regard, the main problems and issues experienced during data exchange between organisations within different countries include security, cost recovery, copyright, non-standard data formats, metadata and the quality of datasets.

Based on the results of both questionnaire surveys, the pilot project on administrative boundaries was designed and implemented within nine countries of the region. The main aim of the pilot project was to identify and document, within a sample region, problems and difficulties encountered when integrating administrative boundary data from the pilot project countries.

Further to the aims and objectives of this pilot project, was also an aim to facilitate the use and integration of regional datasets from various sources. In short, to improve the sharing of data through the provision of metadata and to study how data integration may be achieved. The final results of the pilot project were presented to the PCGIAP member nations at the 7<sup>th</sup> PCGIAP meeting in April 2001, in Tsukuba, Japan. The presentation received a great deal of attention from all members and especially from the Executive Board members. As a result of these presentations, the committee endorsed a resolution to acknowledge the results of the pilot project including its recommendations and to recommend for endorsement of the technical specification proposed in this pilot project for the integration of regional administrative boundaries.

The importance of the results of this project were also recognised by the United Nations - representative (the chief of UN-Cartographic section) at the 7<sup>th</sup> PCGIAP meeting.

# **CHAPTER 7**

## **KEY FACTORS IN THE FUTURE DEVELOPMENT OF REGIONAL SDI**

### **7.1 INTRODUCTION**

Following the discussion and analysis done of chapters 4 and 6 on Asia and the Pacific region, regarding Regional SDI activities, the pilot project and its related questionnaire surveys, this chapter discusses and presents the key factors influencing the diffusion of a Regional SDI and discusses future directions of SDI development. The chapter starts by providing a background about the importance of identifying key factors especially within the defined social system and follows with a review of other research studies in this respect. Then the chapter presents major classes of factors influencing the development of a Regional SDI and proceeds to discussions on the future directions of SDI development. The transition between the understanding of SDIs from product-based to process-based approaches is investigated, with a review of the positions taken by current SDI initiatives throughout the world. A model of how these approaches provide a framework to facilitate the mandates of the relevant jurisdictions is proposed and factors contributing to the success of such positions in the future are discussed.

The chapter concludes by presenting four recommendations in order to overcome the current problem of low participation of nations in the APSDI development. These recommendations are based on the possible future directions for SDIs and the identified classes of factors.

### **7.2 INFLUENCING FACTORS FOR REGIONAL SDI DIFFUSION**

#### **7.2.1 OVERVIEW**

The challenge of designing, building, implementing and maintaining a Regional SDI lies in the structured arrangement of a substantial number of different disciplines and

the examination of a large number of factors and issues. It is essential that SDI practitioners understand the significance of human and community issues as much as technical issues, which determine the success of SDI developments. However, it is a complex task fraught with difficulties in sustaining a culture of sharing, a shared language, a shared sense of purpose and reliable financing.

For example, Asia and the Pacific region has complex social and political environments, typified by competing and often conflicting priorities and motivations. Every case in this region is unique because of its national context, language and characteristics (such as size, population, political systems, varied infrastructures and skills), the national traditional and cultural attitude and the people who participate, develop and use SDIs.

With this in mind, in order to develop a functioning Regional SDI efficiently, the Regional SDI coordinating agency must manage such diversity to get more support in which to meet their objectives. The management of such diversity can be facilitated by identifying critical social factors and processes in the acquisition, implementation and utilisation of a technology. It is expected that decision-making responses of individuals, nations, groups and regional organisations may be predicted and therefore also may be accommodated or redirected through prescriptive strategies.

By identifying key human and technical factors within classes of potential users, diffusion studies also have the potential for directing the design strategy and efforts of SDI coordinating agencies to those jurisdictional characteristics and improvements most valued by target users. The next section addresses the factors and issues identified or noted by other research projects in SDI and related fields of study such as GIS diffusion.

### **7.2.2 OVERVIEW OF PREVIOUS RESEARCH ON SUCCESS FACTORS IN DIFFUSION**

The underpinning technology for SDI is GIS. Therefore, like any GIS project, it should also be understood by all spatial data stakeholders that community issues will determine the long term success of an SDI project. SDI, therefore, can no longer be regarded, or taught, primarily as a technical matter. Developing a successful SDI initiative depends at least as much upon issues such as political support within the community, clarifying the business objectives which the SDI is expected to facilitate, securing sufficient

project funding and enlisting the cooperation of all members of the community, as upon technical issues relating to spatial data quality, standards, software, hardware and networking. Therefore, developing a successful SDI within a jurisdictional level must be seen as a socio-technical, rather than a purely technical, exercise.

Obviously, the communities concerned are expecting to reap benefits from their investment in SDIs in terms of improved corporate performances. Human nature, however, gives prominence to success and tends to be rather less forthcoming about failure. One cause of frustration and delay in SDI initiatives is the lack of participation which in turn causes other issues like lack of support and the absence of appropriate data.

In the mainstream Information Systems industry it has long been recognised that systems fail as much for human as for technical reasons and this reality is increasingly being recognised within the GIS community. Based on Campbell and Masser (1995), 27.2% of the significant problems that they had experienced were organisationally based, mentioning most frequently poor GIS management structures, staff limitations and lack of support from senior staff. If the success rate of SDI initiatives is to be improved it is clear that attention needs to be paid to understanding the community within which SDI is used.

SDI is an initiative that has developed from information systems and technology. Campbell and Masser (1995) believe that the technological imperative leads us to believe that the adoption of new technology is inevitable and the sooner we adopt the new products the greater our advantage. In accord with this, like any new technology, any community adopting SDI sooner, increase their advantages.

To realise the advantages of an SDI and to speed up its development, at least six key factors should be considered (Rajabifard *et al.* 1999, Rajabifard and Williamson 2001). These factors are:

- awareness of the value of spatial information and SDIs;
- cooperation between the various stakeholders (partnerships);
- involvement of the politicians concerned;



- knowledge about the type, location, quality and ownership of spatial datasets (knowledge based society);
- accessibility of data; and
- the successful widespread use of data.

All stakeholders, including politicians and technical people, should be aware of the potential and advantages of spatial information and SDIs. The organisation responsible for an SDI initiative must help to raise this awareness. The development of any SDI is a matter of its related jurisdictional cooperation and partnerships. There must be willingness for cooperation between various stakeholders to facilitate data sharing which is crucial to the success of SDIs. The involvement of those politicians concerned with the SDI development is essential. The politicians' support provides legitimacy and encourages the necessary financial investment for the SDI development. Knowledge about the type of data, its location and quality is also required. This will lead the community toward a knowledge based society. Also, spatial data needs to be equitably accessible to all parties and the wider community, and widespread use of these data need to be facilitated by appropriate infrastructure such as suitable intellectual property laws and proper human resource development.

There is considerable documented experience in designing different levels of SDIs. As a result there are a number of key issues and strategies to be considered within the design process:

- The development of a strategic vision and associated implementation strategy;
- The recognition that SDI is not an end in itself; and
- The key institutional strategy is to have all coordinating processes administered within one government department.

In a similar line, Masser (2001) highlighted four issues that are likely to need special consideration by those involved in an SDI development. In order of priority, these are the nature of the machinery for coordination, the need to develop metadata services, the importance of capacity building initiatives and the need to promote data integration.

In addition to the above factors and issues, there are also a number of factors that have been identified or pointed out by other researchers in GIS diffusion, which are also relevant to this research (Onsrud and Pinto 1991, Onsrud and Pinto 1993, Budic 1993,

Budic and Godschalk 1996, Budic and Pinto 1999a). For example, Onsrud and Pinto (1993) conducted a large scale questionnaire survey that covered 256 local governments in six different counties/regions, to identify the factors that best predict adoption/utilisation success. Eleven groups of factors are found to account for 62 percent of the total variance of adoption/utilisation success. Four groups of factors, namely utility, ease of use, history of failure and cost are found to be significant predictors, with utility being the single most important group.

In a similar line, Budic (1993) studied GIS diffusion in local governments in four South-Eastern states in the USA. Budic finds two characteristics of GIS that significantly affect GIS adoption by individual people: perceived relative advantage and exposure to GIS technology. In addition, Budic and Godschalk (1996) examined the unexplored process of GIS diffusion inside local governments in terms of the impact of human factors, internal organisational context, external organisational environment and GIS management activities using a multiple-case study of four agencies. Their research focused on the following eight human factors that have been considered as significant in other research on diffusion of computerised information systems and GIS technology:

- Perceived relative advantage of the innovation,
- Personal values and beliefs about computerised technology,
- Computer experience,
- Perceived complexity of innovation,
- Exposure to the innovation,
- Computer/GIS-related anxiety,
- Attitude toward work-related change, and
- Communication behaviour (networking).

They found that GIS diffusion is a very complex process and concluded that perceived relative advantage, previous computer experience, exposure to the technology and networking are the most significant determinants of people willingness to use new technology, while organisational and GIS management factors strongly influence GIS diffusion. Their research findings have important implications for devising strategies for effective incorporation of GIS and other information system technologies in public organisations.

In summary, a range of factors that cover the structure, the norms and culture of social systems in GIS diffusion are studied together. Identified by individual or groups of

researchers as important in successful GIS implementation including the three cited above, four different mixes of factors are identified:

- Organisational factors (Croswell 1989);
- Perceived GIS characteristics and organisational factors (Onsrud and Pinto 1993);
- Technical and economic factors in addition to organisational and personal factors (Ventura et al. As quoted in Ferrari and Onsrud 1995); and
- The external environment of the organisation and management (Budic 1993) in addition to the organisational and personal factors.

The above examples are taken from the North American context. Concurrently with their North American counterparts, European researchers are also examining different types of factors/problems that are affecting GIS diffusion. For example, Masser and Craglia (1996) compare GIS diffusion in five European countries. They used similar approaches for these studies based on the methodology developed in the Department of Town and Regional Planning at the Sheffield University in Britain. As a result of their studies data-oriented, technical and organisational factors are identified. Data-oriented factors concern availability, cost, compatibility and quality of data. The technical factors are primarily about lack of hardware and software compatibility and hardware reliability. The organisational factors are generally similar to those identified in America. They include lack of skilled staff, motivation and awareness, poor coordination and bureaucratic inertia.

In addition, researchers have also started looking into issues of sharing of spatial data and information. Many factors/strategies affecting spatial data sharing are found to be common to those of general GIS implementation (Craig 1995, Dueker and Vrana 1995, Obermeyer 1995, Budic and Pinto 1999a). Good examples include organisational structure and independence/autonomy, corporate culture, political support/environment, organisation inertia/resistance to change, different requirements of participants and roles of champions. Similarly, Kevany (1995 as cited by Chan 1998) identifies and defines nine categories of 30 factors that affect spatial information sharing. The nine categories comprise sharing classes, project environment, need for shared data, opportunity to share data, willingness to share data, incentive to share data, impediments to sharing, technical capability for sharing and resources for sharing. Wehn de Montalvo (2000) also identified and used three classes of factors for the study in the willingness of

organisations to share spatial data. These classes of factors are attitude, social pressure and perceived behavioural control. Treating sharing as an inter-organisation relation issue, Azad and Wiggins (1995) identify six reasons for sharing, namely, necessity, asymmetry, reciprocity, efficiency, stability and legitimacy. They also identify three types of sharing and three stages of sharing.

Research findings of GIS diffusion described above cover factors that not only concern the organisation or a community itself, but the environment created by the larger social system in which the organisation and/or community is located.

### **7.2.3 KEY FACTORS INFLUENCING ASIA-PACIFIC SDI DEVELOPMENT**

There are many issues and challenges faced by SDI development initiatives throughout the world (Onsrud 1998, Masser 1998a, Mohamed 1999), including the compatibility of the visions and expectations for an SDI and the development model selected, all of which justify the need to identify influencing factors and to improve understanding about the alternative approaches that may be adopted whilst at the same time learning from current development experiences.

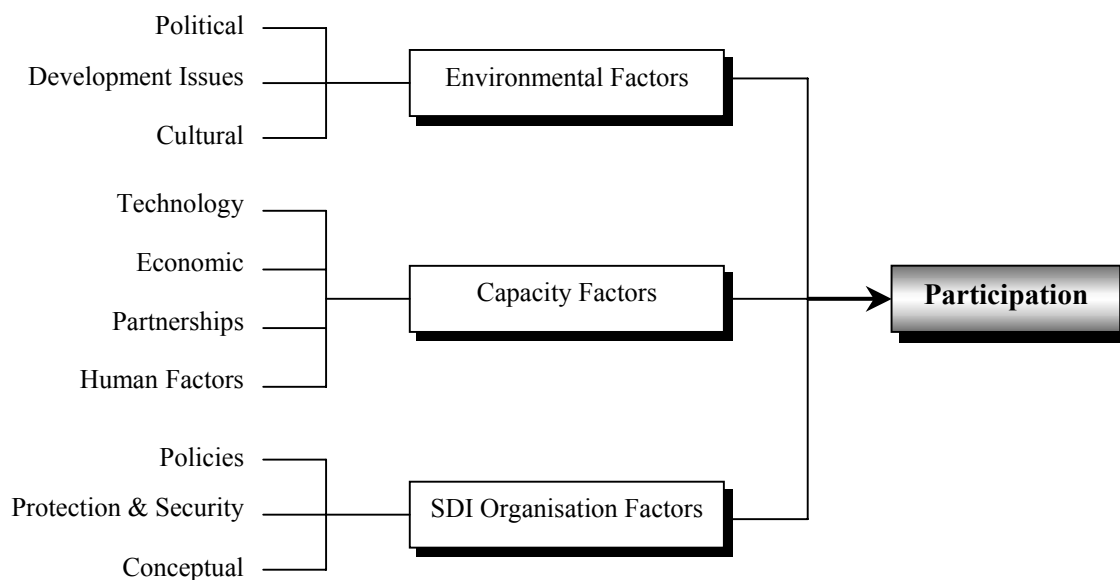
With this in mind, as was mentioned in chapter 1, one of the objectives of this research was to identify the key factors that facilitate the development of a Regional SDI, in order to support the hypothesis of this thesis:

*The support of member nations for a Regional SDI can be improved by better matching the conceptual model of the Regional SDI with their needs.*

Therefore, this research focused on the factors influencing diffusion of a Regional SDI innovation toward individual member nations, that is, their decisions to adopt or reject the innovation and, as a result of that, to accept or reject their support and participation in the development and implementation of that Regional SDI. Better knowledge about SDI diffusion and relevant factors that contribute to successful development and implementation will enable the design of more effective strategies for sharing regional datasets through a Regional SDI.

Having said that, this research first has identified a long list of factors, which are influencing, or contributing to the development of an SDI initiative in general and a

Regional SDI in particular. The presentation of that long list of factors was not in the form that could help the practitioners and users to facilitate the design and development of an SDI initiative. Therefore, after many discussions with researchers in this field and based on the lessons learnt from the methodologies used by other researchers, this list has been classified into three major classes, which are influencing, or contributing to the development of the Asia-Pacific Regional SDI initiative. These classes of factors are: Environmental Factors, Capacity Factors and SDI Organisation Factors as illustrated in Figure 7.1. These three classes of factors have been identified based on the discussion on the current situation in Asia and the Pacific region (chapter 4), the results of the analysis of two survey questionnaires and pilot project on administrative boundaries (chapter 6), the framework suggested and developed in chapter 5 (section 5.9), and also lessons learned from other researchers.

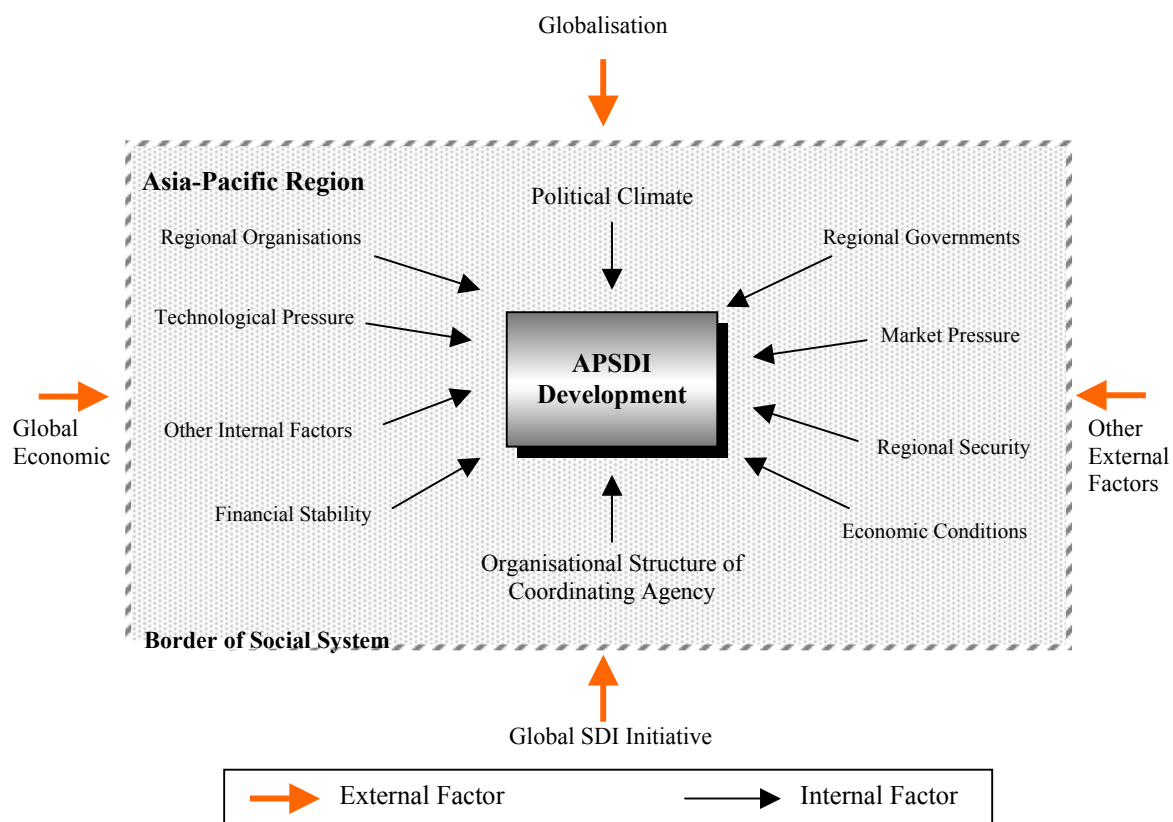


**Figure 7.1:** Factors influencing the development of a Regional SDI

According to the above figure (Figure 7.1), the three classes of factors together effect the participation rate. In other words, by considering these three classes of factors in the design and implementation of a Regional SDI, it can be expected to increase the rate of involvement and participation of member nations.

### a) Environmental Factors

The environment is the overall structure within which the social system operates and is characterised by internal and external factors. Therefore, the different characteristics of social systems, or communities, adopting the SDI concept can be attributed to a number of environmental factors, including the different cultures of the communities, political factors and development issues. The external factors as illustrated in Figure 7.2, are those factors outside the border of social system which affect, or could potentially affect, the performance of an organisation. These factors impinge more on management levels. The internal factors are those factors inside the border (Figure 7.2) and affect both management and member levels. Therefore, determining an appropriate social border for study and analysis of a social system is very important (understanding the social system is the first step. It determines how we define implementation success and the drivers of implementation success).



**Figure 7.2:** Asia-Pacific Social System and some of its Internal and External Factors

Some examples of external factors are Globalisation (global market, global economics, other global initiatives); the GSDI initiative; and the global environment. In terms of

internal factors, examples include the political climate; political structure and procedures; relationships with regional organisations; technological pressure; financial stability of each member nation; organisational structure of the coordinating agency (this is one of the most important factors); regional security; market pressure; and the degree of culture of data sharing.

It is important to note that, these internal and external factors may be applicable anywhere in the world, however in a general sense the difference between these factors in a specific jurisdiction like the Asia-Pacific region or other regions is in their attributes and the context of each factor within that specific jurisdiction. These attributes and contexts are based on the characteristics and structure of the jurisdiction which make that jurisdiction unique compared with other jurisdictions.

In terms of effectiveness of factors, the effects of cultural factors on Regional SDI development can be extremely high. The social dynamics of national relations can cause enormous effects on cooperation and costs within the business environment and poor decision-making. By examining the social dynamics of cultural difference within jurisdictions, it would be possible to understand why a high proportion of capabilities of member nations is hidden or not functioning. Regional SDI coordinating agencies must therefore assess the impact of cultural factors in SDI development. If the risk of these factors is seen to be too high, then the strategy for development can be redesigned. This can be done through human resource policy, selection of a conceptual model, training and language schemes.

Moreover, the cultural factors should no longer be treated as intangible. They can be analysed and they can be incorporated into the study of the social system of a jurisdiction in which an SDI is supposed to be developed. These are factors of enormous significance in determining the level of support and expectation of individual members within a specific jurisdiction. Those who want to increase the level of support should therefore consider these factors carefully. Thus, any SDI coordinating agency must consider cultural factors to gain significant progress in their activities through concerted policies.

## **b) Capacity Factors**

Capacity building as defined by Georgiadou (2001), may refer to improvements in the ability of institutions and (government and non-government) organisations to carry out their functions and achieve desired results over time. It may also refer to the provision of foundation data, metadata standards, clearinghouse functionalities and a facilitating environment for decentralising GIS application in manageable application domains within the SDI concept. Therefore, based on this definition, capacity building for an SDI in a broad sense may refer to improvements in the ability of all involved parties to perform appropriate tasks within the broad set of principles of that particular SDI initiative.

Capacity building can be undertaken in various ways. But the important issue which need to be considered is to conduct both institutional as well as individual level capacity building. In this regard, the importance of training in creating a successful environment for SDI diffusion needs to be realised. Training should be of the largest possible breadth and depth. It is not simply a matter of learning a particular concept. It goes much further than that, to a whole new way of thinking about sharing and exchanging spatial data assets and about optimum solutions. So this is an essential and important issues to be considered for the success of an SDI diffusion.

With this in mind, Capacity Factors therefore are those factors that cover technology, economic factors, partnerships and human factors. Based on the areas covered by this class of factors, one can conclude that this class of factors encompasses technological capacity, human capacity and financial capacity. Some examples of Capacity Factors are: the level of awareness of values of SDIs; the state of infrastructure and communications; technology pressures; the economic and financial stability of each member nation (including the ability to cover participation expenses); the necessity for long-term investment plans; regional market pressures (the state of regional markets and proximity to other markets); the availability of resources (lack of funding can be a stimulus for building partnerships, however, there should be a stable source of funding); and the continued building of business processes.

In terms of awareness, good state education and awareness of benefits of GI and SDI (particularly for politicians and management) is a major factor in determining the level



of chance in obtaining support and being successful in an SDI development. Countries at a higher degree of economic development have better scope for effective political and management training and thereby – for reaping the economic rewards it brings. Countries with a sound comprehensive and technical education therefore can actively participate in the SDI development and encourage support at corporate level. Or in terms of economic and financial factors, economic situation and stability of each member nation for example can impact on their support and cooperation with other members with regards to their level of involvement in Regional SDI activities.

### **c) SDI Organisation Factors**

These are factors related to the way that an SDI is defined, designed and implemented. This mainly includes all SDI core components, including technical and institutional issues such as access policies, access networks, technical standards and the SDI conceptual model. Some examples of SDI Organisation Factors are: the suitability and degree of complexity of the SDI conceptual model; the availability of spatial data and metadata; the integration and inter-flow of datasets from different parties (this has important implications for the ownership and control of information); access networks; and multiple trusted data sources.

## **7.3 FUTURE DIRECTIONS FOR SDI DEVELOPMENT**

### **7.3.1 BACKGROUND**

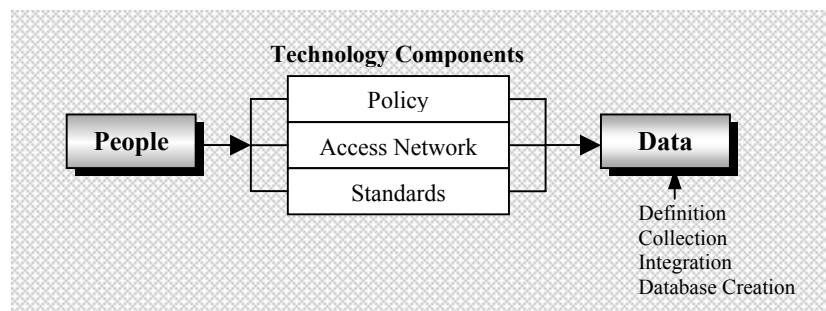
As discussed in chapter 2 and chapter 3, much has been done to describe and understand the components and interactions of different aspects of SDIs and their integration into the transactions of the spatial data community. However, there is still a need for descriptions to actually represent the discrepancies between the role and deliverables of an SDI and thus contribute to a simpler, but dynamic, understanding of the complexity of the SDI concept. To this end, it has been suggested, that the roles of SDI have been pursued through two different approaches: product-based and process-based models, which contribute to the evolution, uptake and utilisation of the SDI concept in different ways.

However, the deliverables expected from SDI initiatives have frequently had more to do with aligning the access networks, policies and standards for particular stakeholders or databases, than establishing *conduits* or long-term process-based spatial data-people

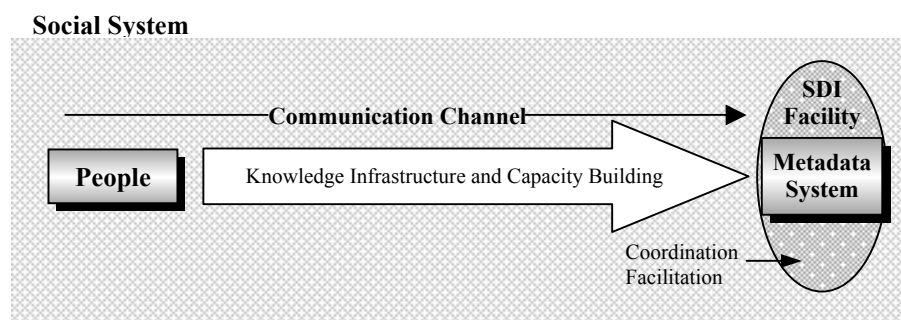
networks. The partnership strategies employed in facilitating such networks have been successful within several government departments (Jacoby *et al.* 2001). Rajabifard *et al.* (2001) propose the future of SDI lies in addressing the balance between the competing foci in SDI development toward an emphasis on process-based facilitation for participant initiatives for spatial data sharing. Whilst ongoing *content* development (a product-based approach), is essential to complement process-based facilitation, the differing roles of each in the development of SDIs is becoming more important for longer-termed commitments to, and investments in SDIs.

### 7.3.2 THE PRODUCT AND PROCESS-BASED MODELS

Based on the strategies, aims, objectives and status of individual SDI initiatives in different political/administrative levels (chapter 2), both product-based and process-based models can be identified in contemporary SDI development, as illustrated in Figure 7.3. The existence of these two models, was also mentioned by Masser (2000), where he discussed the implications for access within National SDI initiatives.



**A) Product-Based Model**



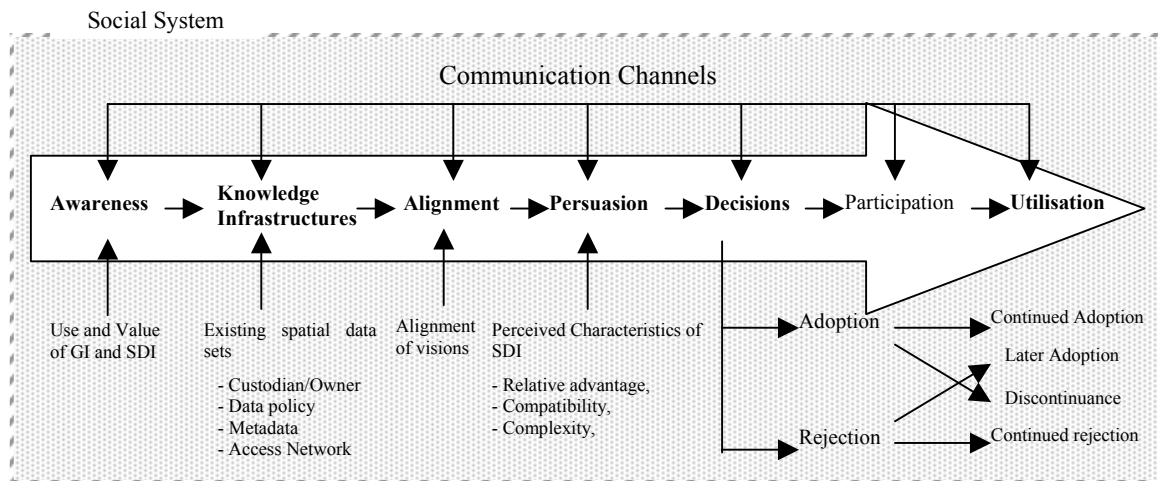
**B) Process-Based Model**

**Figure 7.3:** Product and Process based models for SDI development

The product-based model, outlined in Figure 7.3A, represents the main aim of an SDI initiative being to link existing and potential databases of the respective political/administrative levels of the community. Chan *et al.* (2001) provides a detailed description of the production aspect of SDIs in terms of spatial data, value-added services and end-users, describing the chain of spatial data flow in the environment of multiple ‘production lines’.

The process-based model, Figure 7.3B, is the second approach possible for SDI development. This model presents the main aim of an SDI initiative as defining a framework to facilitate the management of information assets. In other words, the objectives behind the design of an SDI, by any coordinating agency, are to provide better communication channels for the community for sharing and using data assets, instead of aiming toward the linkage of available databases. In return, this can also facilitate the concept of partnerships (chapter 3, section 3.7).

The process-based model emphasises the communication channel of knowledge infrastructure and capacity building, which is illustrated in detail in Figure 7.4. According to this figure, an SDI initiative can proceed by following certain steps towards the creation of an infrastructure in which to facilitate all parties of the spatial data community in the cooperation and exchange of their datasets. This facilitation can be supported by creating a clearinghouse system, metadata directory system or other forms of collecting and storing information about datasets and databases within that community. This is the prerequisite for data discovery and access. In this context, harmonised and quality metadata or clearinghouse systems are therefore essential for the facilitation tools that users are expecting. By creating such systems the coordinating agency is able to increase the knowledge infrastructure for that community by which to enable them to better identify appropriate datasets and communication links with custodial agencies.



**Figure 7.4:** Process-based model for SDI development (based on Rogers' Innovation-Decision Process 1993)

In order to take full advantage of this approach, it is important to understand the social system of the community or jurisdiction in which this approach is designed to be executed. The social system as defined in chapter 5, is a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The importance of this condition is that the characteristics of an innovation, like an SDI, as perceived by the members of a social system, determine its rate of adoption. The social system definition then becomes particularly influential when an innovation is developed and implemented within different communities, due to different characteristics of each community. The characteristics of the social system strongly influence the approach taken with the development of an SDI initiative. The understanding of the social system can help with the selection of an appropriate strategy for SDI development.

The different characteristics of social systems, or communities, adopting the SDI concept can be attributed to a number of variables, including the different cultures of the communities. However, the objectives behind cooperation toward SDI development are still to take advantage of common interests toward achieving certain goals. These characteristics can be seen as very similar to the organisational objectives of people working together with common interests toward achieving organisational goals. Although SDI stakeholders do not necessarily conform to the formal structure of an organisation, the motivating concepts behind cooperation toward SDI development apply at global and regional levels, as much as to individual countries, states and corporations in an SDI hierarchy, despite the more voluntary nature of the cooperation than in a formal organisational structure.

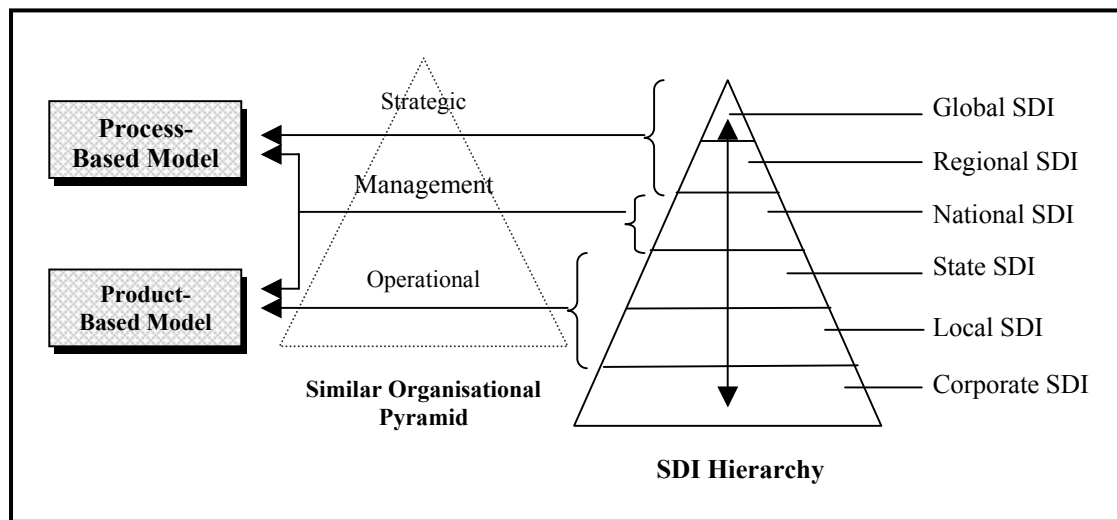
Therefore, taking an organisational approach can enhance understanding of the role of the social system in approaching individual SDI development strategies. The development model adopted for SDI initiatives influence the roles individual SDIs play within an SDI hierarchy as well as in the broader context of the spatial data community. Linking the development models adopted, to the roles each SDI will eventually play in an SDI hierarchy, to achieve defined organisational (or super-organisational) objectives, presents an opportunity to demonstrate the complexity and flexibility as well as the dynamic nature of the concept of SDIs. A framework is described below proposing how the relationships between SDI hierarchy, organisational structure and different models of SDI development could enable the SDI concept to meet the mandates of the relevant jurisdictions.

### **7.3.3 RELATIONSHIPS BETWEEN SDI HIERARCHY AND DIFFERENT MODELS OF SDI DEVELOPMENT**

According to Petch and Reeve (1999), most organisations, regardless of their particular spheres of activity, develop broadly similar organisational structures with three different tiers constituting operational, management and executive roles. This structure is often represented as an organisational pyramid.

The base of the organisational structure is the operational level where production processes take place. The middle organisational tier is composed of managers, researchers and administrators whose tasks include monitoring the performance of the operational level, researching the external environment of the organisation and preparing policy options for the highest organisational tier. This highest organisational tier consists of decision-makers that determine the strategic direction of the organisation. All three organisational tiers are applicable to every SDI hierarchy level. However, by characterising each SDI level by the dominant organisational structure, this research aims to simplify the understanding of the relationship between development models for SDI hierarchy levels.

The organisational pyramid model has found its way into textbooks in a wide range of subjects from sociology, geography, economics and business to management (Petch and Reeve 1999). Its relevance here is that each layer of the organisational structure has distinct information requirements and hence demands support from a specific SDI level. It is thus possible to classify different levels of an SDI hierarchy (which is made up of inter-connected SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels), according to the roles played within different political/administrative levels and their similarities to the organisational structure, as illustrated in Figure 7.5.



**Figure 7.5:** Relationships between SDI Hierarchy and different models of SDI development

According to the above figure (Figure 7.5) and based on the nature of SDIs, any multi-national SDI (regional or global), can be considered similar to the strategic tier of an organisational structure. An SDI at a national level has resemblance to both managerial and strategic tiers, depending on the political system of the nation. If the nation is a federated system of states/provinces, then more advantage can be taken from adopting a process-based model to develop a National SDI. Non-federated nations can select between SDI development models to optimise advantage.

The local and state levels of an SDI hierarchy are similar to the operational tier of an organisational structure. Both these levels of SDIs are producing data and are thus contributing to higher levels of the SDI hierarchy. However, state level SDIs can play

more important roles in a federated system of government, where due to the power and responsibilities of states, state-level SDIs can emulate management or operational organisational tiers, or both, for the entire state. Both management and operational tiers take product-based models due to their key roles in data development. Only the strategic tier and nations with federated systems are advised here to adopt the process-based model of SDI development. The main reason multinational and federated nations can capitalise on using a Process-based model is because of the voluntary nature of SDI participation in these levels of an SDI hierarchy.

#### **7.3.4 ASSESSMENT OF CURRENT SDI INITIATIVES**

The criteria used to investigate the development models of SDIs assist in understanding the roles the SDI will play in an organisational sense as well as within the spatial data community. The main criteria for discussing the development of any SDI initiative includes the motivations for the development, expected outcomes, management of the development, development participants, the measures of progress, the primary political/administrative function of the development, as well as the time-frame commitment of development. As a broad-brush assessment of the approach taken by SDI initiatives, these criteria provide a framework against which any initiative can be defined as product or process-based. Whilst there is no exact formula for belonging to one or the other model of development, the alignment of criteria towards achieving product-based or process-based objectives is generally quite specific. As suggested by Rajabifard *et al.* (2001), approaches within each of the criteria might include the following examples:

<i>Motivations for the development:</i>	integrating existing data with the aim to develop a common fundamental database within a spatial data community, or establishing the links between people and data to facilitate exchange and sharing within a spatial data community
<i>Expected outcomes:</i>	an SDI database/warehouse, data-exchange agreement, or an active directory linking data and people
<i>Management of the development:</i>	implementation or coordination
<i>Development participants:</i>	participatory, representative, compulsory or voluntary

<i>Measures of progress:</i>	punctuated deliverable, or ongoing establishment and maintenance of a framework or conduit for spatial data for a community
<i>Political/administrative function:</i>	intra-jurisdictional, inter-jurisdictional, inter- and intra-jurisdictional
<i>Time-frame commitment:</i>	project-oriented, short-term and long-term planning.

There are currently many SDI initiatives established and operating for different jurisdictional levels, which have pursued different development models. The following table (Table 7.1) illustrates the status of some of these current SDI initiatives, and has been prepared mainly from baseline information provided by Onsrud (1998) on the nature and characteristics of SDIs. These initiatives have been classified as product-based or process-based against the discussed criteria. In other words, based on these two SDI development models, any SDI initiative can be classified by checking and evaluating the strategies, aims, objectives and status of their development against the discussed criteria. This is the methodology which has been used in preparation of Table 7.1. For example, in the case of Colombia, according to the information provided by the Colombian government in response to Onsrud's survey on National SDI initiatives (<http://www.spatial.maine.edu/~onsrud/gsd/columbia.html>), the goal for Colombian SDI development is to build *a national geographic database* which comprises the following eight basic themes: ground control points; transportation-hydrography; cadastre; relief; vegetation and land use; administrative; political areas; and geosciences. Therefore, based on this statement, this National SDI initiative is a product-based model as it aims to construct a national geographic database.

Table 7.1 illustrates the predominance of a product-based approach to SDI development by current SDI initiatives. Communities adopting primarily process-based SDI development are mostly located in Europe, including France, Northern Ireland and the United Kingdom, and also Sweden and the Netherlands which are taking composite models with differing emphases on the balance between product-based and process-based initiatives within their SDI development strategies.



**Table 7.1:** Current SDI initiatives displaying product-based or process-based models principally (√) or partially (~)

SDI Community	Product-Based Model	Process-Based Model	SDI Community	Product-Based Model	Process-Based Model
Australia	√		Kiribati	√	
Canada	√	~	Macau	√	
Colombia	√		Malaysia	√	
Finland	√		The Netherlands	√	~
France	~	√	Northern Ireland	~	√
Germany	√		South Africa	√	
Greece	√		Sweden	√	~
Hungary	√		UK	~	√
India	√		USA	√	
Indonesia	√		ANZLIC	√	
I.R of Iran	√		Asia-Pacific (APSDI)	√	
Japan	√		Europe (EGII)		√

Until now most initiatives have taken a product-based development approach possibly due to a lack of alternative options and awareness of the use and advantages of alternative models characterising the development-coordinating SDI community. One example is the APSDI development. As discussed in chapter 4, the PCGIAP approach to SDI development reflects a product rather than process-based model.

European nations in particular have a greater frequency of taking composite product-process models to SDI development compared with nations in any other region. These demonstrate National SDI development initiatives taking advantage of the combined benefits of operating at both managerial and operational levels, to complement the more strategic focus of regional European SDI development (Figure 7.5). SDI development initiatives taking composite product-process models are able to balance the advantages drawn from both, enabling the SDI initiatives to be more versatile. An initiative predominantly adopting a process-based approach may fast-track development by establishing working-groups addressing particular content issues or responsible for the establishment of specific SDI components, which adopt a product-based approach.

Some SDI development initiatives have in recent times begun to manifest characteristics of both having made an initial or partial commitment to addressing the essential balance between the models, or being in a transitional stage - developing a more process-based approach having had product-based origins. Reference to such an adaptation of current SDI development directions is being made to the FGDC's prospective SDI strategies.

An FGDC change in direction, as part of the ongoing process of refining SDI development, can be interpreted in terms of the FGDC aligning themselves more with a strategic organisational approach to better achieve the objectives desired for the level of SDI in which they predominantly operate.

As discussed in chapter 2, following more than six years coordination and implementation of the United States National SDI by the FGDC and efforts from other committees, such as the Mapping Science Committee (MSC), the development of the US National SDI is still challenged by lack of support from some member states and is faced with many implementation difficulties (Budic *et al.* 2001, Reichardt and Moeller 2000). Inability to persuade different states to align themselves to form the requisite components of a National SDI for the USA is just one example of the persistent difficulties. Another is the different stages of development achieved by the different states.

Therefore as a result of some of the difficulties discussed, at the end of 1999 the FGDC started to develop a new GeoData Organisational initiative for the geospatial data community (chapter 2, section 2.3.4). This new strategy appears to show that the FGDC is moving from a product-based to a process-based model of SDI development in order to neutralise difficulties arising from existing models.

Also as discussed in chapter 2, Australia, like the USA have started a transition from a product to a more process-oriented SDI development to address some of the challenges faced, particularly at a national level, under the influence of a federated political system. Whilst product-based models to dataset assembly and sharing were the focus of SDI development from 1991-1996 (ANZLIC 1996) a transition toward process-based development has been initiated through a clearinghouse initiative - the focus of an ANZLIC workshop in March 2000 (ANZLIC 2000).

The difficulties faced by the USA and Australia in the development of a National SDI which precipitated their change in strategies are not unique and suggest a trend for other SDI initiatives throughout the world which face the same challenges to achieving their future development and implementation phases. These challenges occur more when the political structure of a nation is a federated system as well as at the multinational level, which in both cases rely on voluntary participation. By selecting an appropriate model

for SDI development, depending on the jurisdictional level of the SDI communities, jurisdictions may be better able to address and overcome some of the difficulties currently faced by SDI development.

As suggested by Groot and McLaughlin (2000), any SDI initiative that follows the top-down approach from the political level must make stakeholders sensitive to the longer-term benefits of an SDI and it must involve them in the development of standards.

### **7.3.5 RELATIONSHIPS AND ROLES OF METADATA AND CLEARINGHOUSES IN AN SDI PROCESS-BASED MODEL**

As discussed in section 7.3.2, the selection of a process-based model can be facilitated by creating clearinghouse or metadata systems. This is important, as finding appropriate spatial data these days is often a painful task (Chan and Lee 1999). Even when users are lucky enough to find a candidate dataset, they might not understand its quality and content. Possibly, further analysis on the data might produce unreliable products and misleading results if there is no further effort to study its useability. These frustrations are caused by the lack of a mechanism to share data as highlighted by Chan and Lee (1999), and the use of metadata could help to a certain extent. Spatial metadata provides information about stored data such as its content, its quality, how it was derived and how to access it. However, in addition to the availability of spatial metadata, it is recognised that SDI users at different sites also need to:

- Access metadata within a data-sharing network,
- Browse and view the metadata,
- Understand the dataset such as data quality, usage and coordinate system used and so on by reading the metadata content,
- Determine data fitness for SDI, GIS and other applications, and
- Determine the workflow for performing spatial analysis with appropriate datasets.

In addition, standardisation of the descriptive items of metadata can provide a common language for exchanging metadata among spatial data user communities. According to the US president Executive Order (Executive Order 1994), the major uses of spatial metadata are to:

- Maintain an organisation's internal investment in spatial data,

- Provide information about an organisation's data catalogues, clearinghouses and brokerages, and
- Provide information needed to process and interpret data to be received through a transfer from an external source.

### **7.3.6 SPATIAL METADATA MANAGEMENT SERVICE AND METADATA SYSTEM**

Metadata management is an important issue for ensuring that spatial metadata can be exploited in the community (Phillips *et al.* 1999). In this regard, there are a series of spatial metadata management services to handle this issue. These services can be defined as suggested by Chan and Lee (1999), as a series of operating tools for providing functionality in three aspects: metadata creation, robust metadata store and its distribution mechanism.

Spatial metadata is being recognised as another essential component for producing complete spatial data. To enable exploitation of spatial metadata, as suggested by Chan and Lee (1999), this requires a Metadata Management System and a Metadata Information System to deliver the services accordingly, while both are built based on the same metadata standard. The purpose of a Metadata Management System is to provide efficient and convenient creation, storage and retrieval of metadata for SDI datasets.

A Metadata Information System is a system for collecting, processing, storing, retrieving and distributing spatial metadata within a community and between communities in an inter-networked environment. In this case, within the environment, users can search for information efficiently. This is not a new function since similar mechanisms are available on the Internet. However, there are many limitations for searching information on the Internet.

To search for spatial metadata, users expect to get precise and meaningful query results. This is a critical requirement that cannot be supported by the current search mechanisms of the Internet (Chan and Lee 1999). In addition, to keep the metadata delivery in a manageable, fully utilised and standardised manner, a data clearinghouse concept can be applied to build a centralised metadata storage or to connect to an established Metadata Information System dedicated to metadata exchange. Therefore, spatial metadata resides

on data clearinghouses. A data clearinghouse is a data central point and it should provide capability to allow users to submit a query, search metadata and browse information. Advanced applications such as dataset selection, data fitness tests, geo-processing workflow management, online purchasing and so on could be provided. In the following sections, the technology for developing a metadata management system will be presented.

Based on current developments of spatial metadata management services, further development needs to be carried out. Present developments have yielded to end requirements and frameworks for users to better understand and discover spatial resources. The effort of the FGDC (USGS 1997) and other organisations (see Chan and Lee 1999) in developing metadata standards and making these available on the Internet recognises the importance of generating metadata becomes is higher today than it has been previously. Nevertheless, it is limited in metadata sharing and management. Therefore, there are two other aspects of dealing with metadata which need development as suggested by Chan and Lee (1999). These two aspects are metadata integration and management of spatial processing workflow. Metadata integration is an important issue for metadata maintenance in the future. Thinking about the current situation, complex and cumbersome manual updates are essential for maintaining metadata. On the other hand, the workflow management of spatial processing is another aspect related to the use of spatial metadata. Workflow is the operational aspect of a business process (Mohan 1998).

Therefore, to enable future development of spatial metadata, context information is an essential component of the metadata document. This will allow data processing and interpretation on the document's contents. Once the metadata is ready, mechanisms for sharing the data should be defined. The current standard for producing and formatting information content is the HyperText Markup Language (HTML) and for delivery the HyperText Transfer Protocol (HTTP). This information publishing suite is working on the Internet, in which the HTML defining how information is rendered on the client machine for presentation purposes (Majid 2001) and HTTP governs the mechanism for serving client requests and standardises the implementation of the web server.

HTML has several limitations as noted by Chan and Lee (1999) which consequently limit its capability for exploiting information content. Some of these limitations are:

- Limited set of mark up tags solely for presentation use, which leads to a problem on extensibility;
- HTML does not provide context information for the document and there is no means for properly cataloguing the information content;
- HTML can not provide capability for precise information searching, which is expected to be a basic service provided by the Metadata Information System.

### **7.3.7 SPATIAL DATA CLEARINGHOUSE**

A Spatial Data Clearinghouse is an environment that can facilitate access to data, products and services. It incorporates (ANZLIC 2000):

- Discovery, transfer and access facilities (it connects users to data holders and information services to enable users to assess ‘Fitness for Use’, not just technology);
- Legal arrangements including supporting custodians’ ability to control access to their data;
- Coordination and management functions (promotes use of information, provides organisational processes and reduces duplication);
- The spatial information commercial market place in which data is value-added and integrated to produce products, services and solutions.

The main concept for producing a spatial data clearinghouse is that when users are looking for spatial data, it is desirable to have a single source for accessing all the available resources without further searching. A spatial data clearinghouse is a concept to provide this capability, which is an agent like a hub, that serves as a central point for sharing data among data producers and users (Phillips 1998). In addition, a data clearinghouse provides a mechanism for controlling not only the completeness of shared data, but also the quality of its metadata, since all the metadata document or data items distributed via a data clearinghouse are required to strictly conform to particular standards. The Clearinghouse exists between data custodians and end users. It should include multi-national data and products formed by joining national datasets to produce extended regional coverage. Therefore, making links between current clearinghouse

initiatives in member nations is essential in order to facilitate the creation of the regional clearinghouse.

A spatial data clearinghouse provides an information network, which contains a number of nodes and is running on the Internet in the form of a peer networking model. Each node is physically a metadata information server and is available to be accessed by users, while a list of node information is also available in the clearinghouse. Therefore, by making a single connection and query to the clearinghouse, results would be returned from peer neighbours in the list too. Hence, users are no longer required to switch between different servers. In fact, a data clearinghouse can be considered as a strategy to facilitate communication channels within user community for building an SDI and also enabling users to search for metadata from multiple resources at a time. According to the FGDC as reported by Chan and Lee (1999), a data clearinghouse is a decentralised system of information servers located on the Internet, which contain field-level descriptions of available digital spatial data. Therefore, the assumptions of a clearinghouse can be that it:

- Is a framework not an entity;
- Has a set of policies, protocols and standards;
- Informs and educates;
- Delivers;
- Improves in response to demand; and it
- Can support a range of data policies including price and access network.

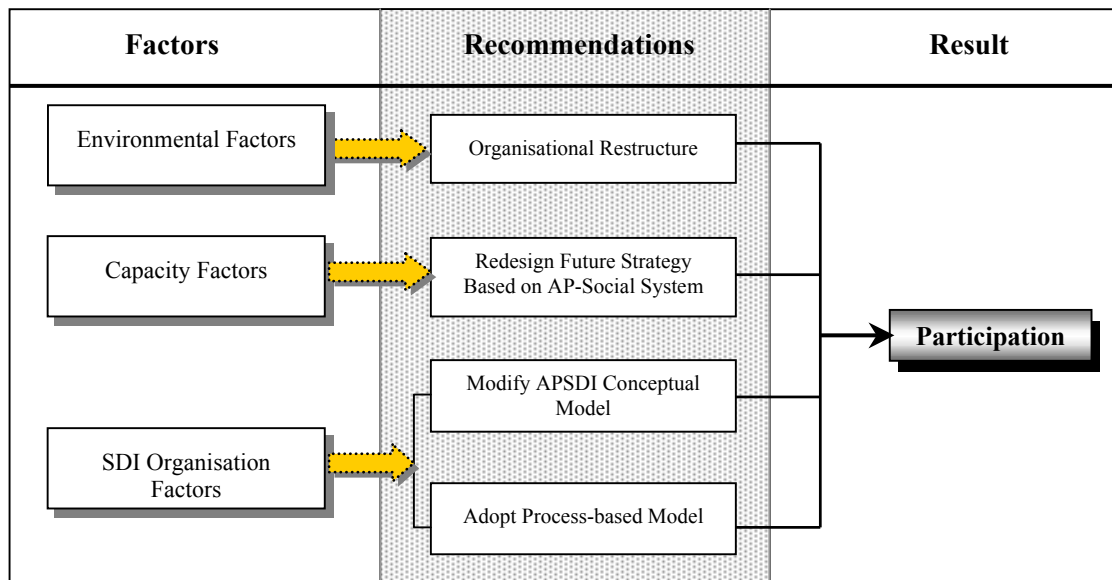
But, it must be considered that, a clearinghouse for a region like Asia and the Pacific, is not only a summation of national clearinghouses. It needs consistent standards and policies to ‘glue’ them together. For doing this, the PCGIAP, as the APSDI coordinating committee, is in the best position to manage the ‘glue’ using the best people from all member nations. In this regard, the regional private sectors and organisations can be involved in building such a clearinghouse and play a big or small role depending on data custodian and national policies. However, to be able to link or combine the individual national clearinghouse initiatives to facilitate the creation of a regional clearinghouse, there is need to draw political attention of member nations as well as increasing their willingness for participation.

## 7.4 RECOMMENDATIONS

There are four major recommendations that can be derived from a consideration of the key factors important to the success of an SDI development and the proposed future directions, which relate directly to the APSDI development. In light of the findings from chapter 4 and chapter 6, these recommendations as illustrated in Figure 7.6, are proposed as central to the PCGIAP achieving an increased rate of participation from nations for the APSDI development.

The adoption and implementation of these recommendations can assist the PCGIAP in such a way that they overcome the problem of low participation and speed up the progress in the development of the APSDI initiative.

According to the Figure 7.6, these recommendations are organisational restructure of the PCGIAP; redesign future strategy based on the study and understanding of the Asia-Pacific social system; modify the current APSDI conceptual model; and adoption and utilisation of a process-based model instead of the current product-based model. Each recommendation will be discussed and presented in more detail in the next sections.



**Figure 7.6:** Four major recommendations to the PCGIAP to increase participation rate

### 7.4.1 ORGANISATIONAL RESTRUCTURE

The first recommendation is to revise the current structure and organisation of the PCGIAP as the coordinating committee for the design and development of the Asia-



Pacific Regional SDI. As discussed in chapter 4, one of the reasons why the PCGIAP can not receive full support from all member nations is because of its organisational structure. This Committee is currently comprised of 55 nations in which member nations are represented on the Committee by directorates of national survey and mapping organisations and equivalent national agencies, which mainly are providers or producers of national spatial datasets and not necessarily the user of such national and regional datasets. However, one of the main promising advantages of SDIs is to facilitate sharing and access to common and required spatial datasets by users. Therefore, it is essential to involve those potential users of regional spatial datasets, in development and implementation of the Regional SDI. By involving such regional users, the PCGIAP can identify and include the user needs in the design and implementation of the APSDI. In this regard, as noted in chapter 4 and also discussed and highlighted in this chapter, the involvement of politicians' concerns and regional organisations are essential in the success of a Regional SDI development. This is one of the Environmental Factors.

The other problem is that the level of political position and responsibilities of each PCGIAP member are different from the position and responsibilities of other members. In some nations the mapping and spatial data activities are the responsibility of a civil organisation, but in other member nations the mapping and spatial data activities are the responsibility of a military organisation. In addition, the relationships between each PCGIAP member with other organisations in their respective countries are also different. Therefore, to overcome these problems the PCGIAP should restructure its organisation in such a way that can also invite and involve other interested and related organisations within the region and even within the each member nation as well as other regional users. As part of this restructuring, the PCGIAP should evaluate and modify the responsibilities and membership on the Executive Board and Working Groups.

#### **7.4.2 REDESIGN FUTURE STRATEGY BASED ON ASIA-PACIFIC SOCIAL SYSTEM**

The second recommendation is to redesign the future strategy based on the Asia-Pacific social system. As it was noted in chapter 1, one of the obstacles of gaining support from certain countries and regional organisations to develop an SDI is the lack of understanding of the complexity of the interacting social, economic and political issues. Therefore, in order to develop an appropriate and functioning Regional SDI and receive

support from different parties, and also to speed up the process of such development, it is important to understand the social system of the community or jurisdiction. The social system as defined in chapter 5, is a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The importance of this condition is that the characteristics of an innovation, like a Regional SDI, as perceived by the members of a social system (Asia and the Pacific region), determine its rate of adoption.

Moreover, the characteristics of the social system strongly influence the approach taken to the development of an SDI initiative. The understanding of the social system can help with the selection of an appropriate strategy for SDI development. With this in mind, it is recommended that the PCGIAP improve its understanding about the complexity of the interacting social, economic and political issues by taking a comprehensive case study research in that regards in the region. This case study should be carried out by a group of experts including people from different disciplines (such as academic sectors and regional organisations as well as member delegates).

#### **7.4.3 MODIFY APSDI CONCEPTUAL MODEL**

The third recommendation is to modify the current APSDI conceptual model. As was mentioned in the research problem, one major obstacle in gaining support is defining the SDI and its related conceptual model. It was argued that the current SDI conceptual model adopted by the PCGIAP is incompatible with the perceived needs of the member nations. Further, chapter 2 suggested an SDI comprises not only the four core components identified by the PCGIAP as institutional framework, technical standards, fundamental datasets and access networks (chapter 4, section 4.7.3), but also an important additional component, namely, the human resource-people. This component includes the spatial data users and suppliers and any value-adding agents in between, who interact to drive the development of the SDI. Therefore, it is essential that SDI practitioners understand the significance of human and community issues as much as technical issues, as they determine the success of SDI developments.

The absence of this important component would cause the problem that the SDI coordinating agency (like the PCGIAP) would just concentrate on the four core components and develop their strategies to build the APSDI in such a way that ignores the interests and potential contributions of other stakeholders such as the non-

participating members and agencies. To avoid this problem, therefore, the current APSDI model and the strategy to its development need to be modified. For this modification the fifth component – human resources, needs to be defined and presented clearly within the current APSDI conceptual model.

Regarding definition and presentation of this human resources component within the current APSDI conceptual model, as was described in chapter 4, the PCGIAP needs first to accept and add this component then describe its definition as suggested in chapter 4, for example. Additionally, the relationship with other components should be described. Regarding the relationships, the interaction between this human resources component with the other four components of an SDI is a direct interaction and the existence of this component is to support and to facilitate the development and implementation of the other components. This direct relationship is in such a way that any strategy and plan for development and implementation of any other component will directly effect on this human resource component and therefore requires this component to be revisited and structured in order to support and facilitate the implementation of other strategies and plans for other components.

For the purpose of its implementation, the PCGIAP should assign a group of members to study and work on this component from different angles and by interacting with other groups working on the other components. This group must evaluate the current situation with respect to the existence requirement of infrastructures and awareness of SDIs, and then, based on this evaluation provide the most possible and suitable solutions for the implementation and utilization of SDI initiatives.

#### **7.4.4 ADOPTING SDI PROCESS-BASED MODEL**

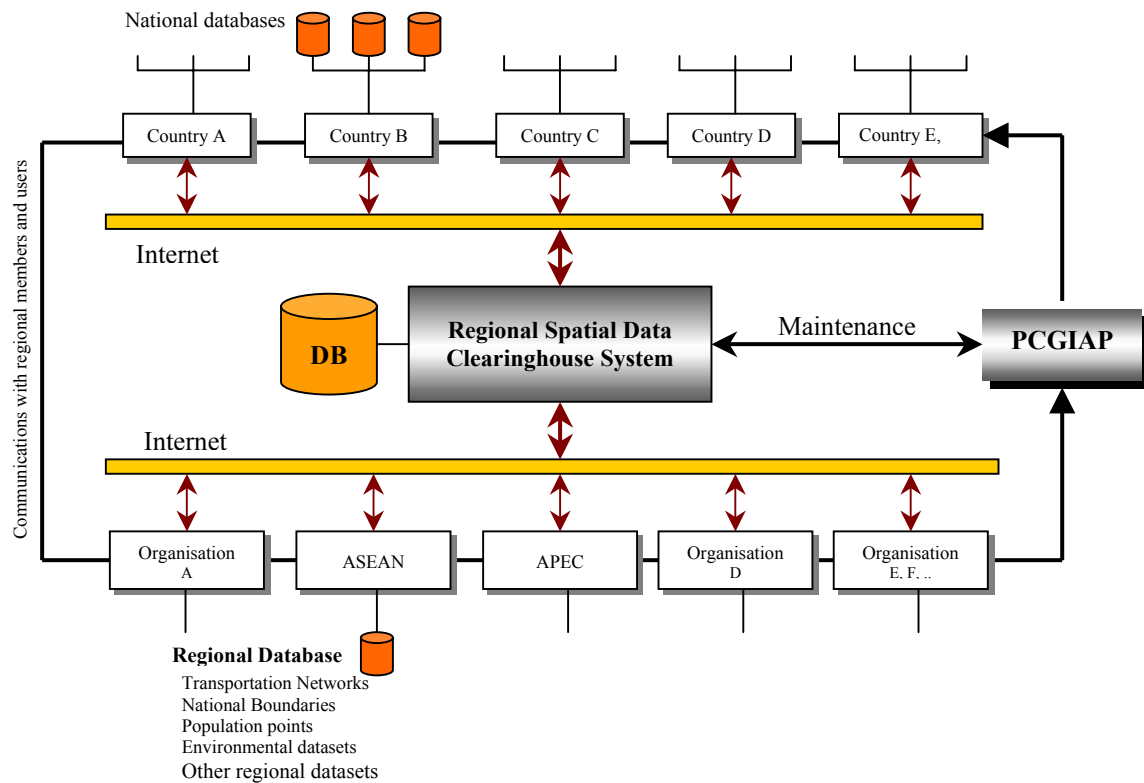
The last recommendation is the adoption of an SDI process-based model instead of the current strategy for the APSDI development. Based on the current APSDI model by the PCGIAP, their strategies for its development (PCGIAP 1998b), show that this committee have predominantly adopted a product-based approach to SDI development. However, considering the nature and required conditions for SDI development as discussed in chapter 2, and the more voluntary nature of the cooperation at a multi-national level like in Asia and the Pacific region, and following the suggestion in section 7.3.3, the strategy and the SDI model adopted by the PCGIAP is not an adequate

approach. Therefore, selecting and using a process-based model instead of the current one for SDI development would be a better approach to overcome some of the challenges facing SDI initiatives persisting with a product-based approach, especially in this region.

With this in mind, the PCGIAP should recognise the value in taking a facilitation role for SDI development rather than that of implementation of a specific data product by itself. Based on the initial aims for the APSDI development, the difficulties of coordinating many individual efforts toward SDI development, including the various stages achieved by this committee, and awareness of the value and vision of SDI development have made the objective of the APSDI development difficult to achieve.

Therefore, it is highly recommended that by adopting a process-based model, the PCGIAP can develop a spatial data clearinghouse system to facilitate a regional communication channel for data sharing and to contribute to the regional knowledge infrastructure instead of collation and integration of regional datasets which seems to be very difficult, if not an impossible and challenging task as was shown in the pilot project on administrative boundaries. In addition, by improving the current conceptual model by adding one more component (people) and defining a proper border for its social system (as suggested in chapter 5), the PCGIAP can define its future strategy by better understanding the complexity of the interacting social, economic and political issues within that border.

To this end, Figure 7.7 illustrates a proposed framework for a regional communication network through a regional spatial data clearinghouse. It shows how the regional data clearinghouse might be designed to link the current member nations, regional organisations and regional databases and also it gives an idea of the clearinghouse concept to facilitate its development.



**Figure 7.7:** Regional communication Network

According to this figure, any member nation and regional organization can be linked to the regional communication network via the Internet in such a way as to share their national and regional datasets respectively. The clearinghouse system of the region needs to be created using the metadata information of the existing datasets (both national and regional) and be available to all the users. This clearinghouse system should be maintained by the PCGIAP and would be updated regularly by receiving the latest information from the members. When a user connects to the system in search for information, they would be provided with either the relevant contact details of the custodian or a direct connection to the datasets (via the custodian's website).

## 7.5 CHAPTER SUMMARY

This chapter discusses and presents the key factors influencing the diffusion of a Regional SDI, as an outcome of this research. The chapter first discussed the importance of identifying such factors followed by a review of the other research conducted in this respect and factors listed. Then the chapter presents and discusses three major classes of factors namely Environmental Factors, Capacity Factors and SDI Organisation Factors, and then argued that these three classes of factors are influencing

the development of a Regional SDI and together they can effect the participation rate of member nations.

Based on the strategies, aims, objectives and status of individual SDI initiatives in different levels of an SDI Hierarchy (see chapter 3), this chapter introduced two models as a new vision on SDI development, namely a product-based and process-based model. An SDI initiative is considered to be a product-based model if the main aim of the initiative is to link existing and future databases of the respective political and administrative levels of the community. However, if the main aim of an SDI initiative is to define a framework to facilitate the management of spatial information assets, the initiative is considered to be a process-based model. Further, it is suggested that a process-based approach needs to be developed within a defined or acknowledged social system. Both models have value, but contribute to the evolution and uptake/utilisation of the SDI concept in different ways. They provide different frameworks for dealing with intra-jurisdictional mandates for the objectives of spatial data access and sharing. But in some circumstances, it is a combined approach that can offer most potential for developing effective SDIs.

Then the chapter assessed and analysed current SDI initiatives using the proposed models for SDI development. According to the results of this analysis, current SDI initiatives predominately adopt product-based models of SDI development. This is possibly due to a lack of awareness of alternative options and the advantages of each of the two models for SDI development. The chapter argued that appropriately adopting either the product-based or process-based models for SDI development will provide a framework in which to meet the mandates of the relevant SDI jurisdictions.

The chapter then presented the relationships between SDI hierarchy and different SDI development models by demonstrating similarities between the objectives of SDI development and a model of organisational structure. According to this relationship, any SDI initiative belonging to the higher levels of SDI hierarchy (especially multi-national SDIs) can benefit more by using a process-based model of SDI development. A process-based model may be better able to overcome some of the challenges facing SDI initiatives that are currently following a product-based approach, especially in the voluntary domains of SDI initiatives at higher levels.

In conclusion, the chapter presented a list of four major recommendations to facilitate the development of the APSDI initiative. It is argued that the adoption and implementation of these recommendations can assist the PCGIAP in such a way that they overcome the problem of low participation and speed up their progress in the development of the APSDI initiative.

# CHAPTER 8

## CONCLUSION AND RECOMMENDATIONS

### 8.1 THE RESEARCH

Despite considerable interest and activities, the development of an effective and comprehensive Asia-Pacific Regional Spatial Data Infrastructure has been hampered by a lack of support from member nations. As a result this initiative still remains very much an innovative concept. Based on this situation, the main aim of this research was to address the minimisation of this problem and design an improved conceptual model for Regional SDI. It was proposed that the minimisation of this problem could be achieved through increasing the level of awareness about the nature and value of SDIs; improving the SDI conceptual model to better meet the needs of nations; and by identifying key factors that facilitate development through better understanding the complexity of the interaction between social, economic and political issues. Another purpose of this research was to take another step toward gaining a better understanding of key factors necessary to support successful adoption of an SDI innovation at a regional (multi-national) level.

To achieve the aim of this research, chapter 1 provided a background of the importance of SDIs and diffusion research. The research problem was then described and the hypothesis of research articulated as follows:

*The involvement of member nations in a Regional SDI can be improved by increasing awareness, identifying user needs and by developing a new conceptual model of the Regional SDI.*

To test the hypothesis, three objectives are identified for the thesis:

- To identify and describe the nature and components of SDIs.
- To investigate the needs of the member nations in the context of a Regional SDI.
- To identify the key factors that facilitate the development of a Regional SDI.



This research adopted a case study approach. For this purpose, Asia and the Pacific region was selected for study. In this context, the research strategy was designed to meet the objectives of the research, which were made up of a number of activities. These steps can be broadly grouped into literature review; exposure to SDI development, diffusion activities and research worldwide; data collection and data analysis; model generation; and pilot project for model validation. A section on the structure of the thesis sums up the chapter and provides pointers to the various chapters that follow.

To take up the challenge identified in chapter 1, chapter 2 reviewed the concept and definitions of SDI in the literature with the view of identifying the precise nature and concept of SDIs. Based on those reviews, it is noted that SDI is understood and described differently by stakeholders from different disciplines and different political and administrative levels. It is argued that while those definitions provide a useful base for the understanding of SDI, individually on their own they are inadequate for SDI development in the future. Further, current SDI definitions are individually insufficient to describe the dynamic and multi-dimensional nature of SDI. In other words, despite the international interest and activities towards SDI development, SDI remains very much an innovation, even among practitioners. There are still doubts regarding the nature and identities of SDI, particularly in connection with how it evolves over time to meet user needs.

With this in mind, chapter 2 and chapter 3 discussed the concept and nature of SDIs in detail in order to facilitate their development and progressive uptake and utilisation by different communities (diffusion). These two chapters together meet the first objective of the research. It is proposed that an SDI comprises not only the four basic components of institutional framework, technical standards, fundamental datasets and access networks, but also an important additional component, namely, people (human resources). Chapter 2 concluded that SDIs are a much-needed tool to better facilitate data sharing as well as jurisdictional cooperation and partnerships. However, an understanding of key SDI principles, such as the SDI hierarchy and the dynamic nature of SDIs, are also essential.

Based on the nature and concept of SDIs, chapter 3 introduced a model of SDI hierarchy. According to this model, an SDI hierarchy is made up of inter-connected

SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels. Each SDI, at the local level or above, is primarily formed by the integration of spatial datasets originally developed for use in corporations operating at that level and below. The hierarchy provides two viewpoints of SDI structure. The first view is an umbrella view (top down), in which the SDI at a higher level, say the global level, encompasses all the components of SDIs at levels below. This suggests that, ideally at a global level, the necessary institutional framework, technical standards, access network and people are in place to support sharing of fundamental spatial data sets kept at lower levels, such as the regional and national levels. The second view is the building block view (bottom up), in which any level of SDI, say the state level, serves as the building block supporting the provision of spatial data needed by SDIs at higher levels in the hierarchy, such as the national or regional levels.

The concept, properties and reasons for using a hierarchical structure was then discussed and found suitable to apply to the concept of an SDIs' development. Hierarchical Spatial Reasoning (HSR) provides an expandable framework to demonstrate the concept of SDI and represent the complexities of the different levels of SDI based on hierarchical principles. The existence of hierarchical capability for SDIs will enable utilisation of the advantages of this concept.

Chapter 4 set the scene, providing the political and historical context of Asia and the Pacific region and regional activities in which Regional SDI diffusion progresses. It then discussed the nature and concept of regional cooperation, by reviewing a number of regional organisations. These reviews have helped to build the current understanding about the importance of an infrastructure to facilitate regional cooperation.

According to these reviews, all the regional organisations need to access regional spatial data to identify regional spatial features and their characteristics to make informed decisions and to implement resulting regional initiatives. However, chapter 4 argued that in most cases all efforts by these organisations face similar difficulties in accessing such spatial data. Then chapter 4 listed some of the more contentious issues and highlighted the conservative definitions of security which pertain to accessing spatial data, as the main difficulty and suggested that this attitude needs to be expanded to include non-military concepts such as economic, social and environmental security.

Based on this criticism, chapter 4 then discussed and introduced the concept and nature of Regional SDIs with an emphasis on current Regional SDI initiatives in Asia and the Pacific region. It was argued that although the PCGIAP has achieved some steps toward the development of the APSDI which are important and provide a valuable contribution, there are additional issues involved, which need to be discussed and resolved before moving forward. These issues are the low rate of participation in PCGIAP activities, the organisational structure of the PCGIAP and the APSDI conceptual model.

Current rates of participation in PCGIAP activities show that after many years of effort the APSDI initiative still does not receive support from all member nations and regional organisations. The maximum number of countries who have participated in the PCGIAP meetings is 25 out of 55 member nations, which is less than half of the members. This shows that despite all the interest and activities by the PCGIAP, the development of this Regional SDI initiative remains very much an innovative concept among members of the community. Some reasons for the limited support from certain nations, regional organisations and other relevant institutions were identified, including:

- the lack of awareness of the value of SDIs;
- defining the SDI;
- the incompatibility of the current conceptual and organisational model with the perceived needs of the member nations; and
- the complexity of different regional issues such as diverse political, cultural and economic positions.

The limited number of participants has been highlighted as an important issue, which has been suggested to be considered, discussed and resolved by the PCGIAP, before moving on from any important principle policy, such as the policy on sharing fundamental data. One of the reasons why the PCGIAP can not receive full support from all member nations can be traced back to the PCGIAP organisational structure. The PCGIAP Committee is comprised of 55 nations. Member nations are represented on the Committee by directorates of national survey and mapping organisations and equivalent national agencies. This structure causes problems from two different perspectives.

The first problem is the members are mainly providers or producers of national spatial datasets and not necessarily the users of such datasets. One of the main promising advantages of SDIs is to facilitate sharing and access to common and required spatial datasets by users. Therefore, it is essential to involve those potential users of regional spatial datasets in the development and implementation of the Regional SDI. The second problem relates to the organisational and political position and responsibilities of each national surveying and mapping organisation which differ among member nations. In some nations the mapping and spatial data activities are the responsibility of a civilian organisation, but in others the mapping and spatial data activities are the responsibility of a military organisation. Therefore, different members have different levels of mandate and power of decision-making within their jurisdiction, which makes it difficult to expect that each member follows and implements decisions made by the PCGIAP in a certain period.

To improve the rate of participation, the research proposed that the organisational structure of the PCGIAP, the current APSDI model and the strategy to its development need to be modified and restructured. In terms of restructuring, the PCGIAP should invite and involve other interested parties such as regional organisations (potential users), related regional research institutes and other academic and educational sectors.

Chapter 5 related diffusion theory and mainly GIS diffusion research back to its grounding disciplines, namely, innovation research and socio-technical systems research in the disciplines of organisational behaviour and information systems. In the process the chapter provided the necessary theoretical background in support of the applicability of this theory as a framework for the context and aim of this research. This is achieved by providing an overview of the four elements of the diffusion paradigm of innovation research, namely the innovation, the communication channel, time and the social system. The overview is supplemented by experience of researchers in socio-technical systems.

Through the scope of current GIS diffusion research and adopting that into SDI research, certain areas are identified as requiring more in depth study. However, it can be concluded that the elements of the diffusion paradigm are also applicable to SDI diffusion. Based on Rogers' definition of diffusion (for example see 1983), SDI

diffusion can be defined as the process by which an innovation of SDI is communicated through certain channels over time among the members of a social system. This definition also supports the theoretical framework of this research.

Chapter 6 reported the findings of the case study including the results of two questionnaires and a pilot project on regional administrative boundaries (Appendices 6, 8 and 9). Based on the data presented, evidence is identified in support of the hypothesis. As a result, the questionnaires fulfil the second objective of the research, which was to investigate the needs of the member nations, and also provide input and evidence for the third objective, which is to identify key factors that can facilitate the development of a Regional SDI. As a result of the analysis of the first questionnaire - 'Taskforce questionnaire' (Appendix 6) -, a classification of Asia and the Pacific nations was identified and presented. According to this classification, two broad groups of countries are considered: developed and developing countries. The category of developing countries is then broken into another three sub-groups: first countries in transition from developing to developed status; secondly countries at an early stage of economic development and awareness; and lastly the Oceania/Pacific Island nations.

As part of the results and outcomes of the second questionnaire - Technical questionnaire on regional Fundamental Datasets (Appendix 8) - this research showed that there are large quantities of digital data with many common data layers available at different scales in the region that could be useful for the creation and facilitation of the Regional SDI. Further, it was noted that almost all countries indicated that they are planning to undertake some form of national mapping project within the next five years. This information confirmed the important role that a Regional SDI can play in this situation to facilitate member nations and speed up their cooperation. However, the most anticipated political barriers regarding the establishment of a regional fundamental dataset include access to datasets for security reasons, lack of resources, national administrative boundaries as a data layer and copyright issues. Regarding technical barriers, the important issues are use of different standards, lack of technical expertise, lack of valid information, lack of uniformity in dataset specifications and differences in geodetic reference frameworks and lack of basic infrastructure in the area of GIS.

Based on the results of both questionnaire surveys, a pilot project on administrative boundaries was designed and implemented with nine countries of the region. The main aim of the pilot project was to identify and document, within a sample region, the problems and difficulties encountered when integrating administrative boundary data from the pilot project countries, in which to assist the author to meet his research objectives. Further to the aims and objectives of this pilot project, was also an aim to facilitate the use and integration of regional datasets from various sources. In short, to improve the sharing of data through the provision of metadata and to study how data integration may be achieved (see Appendix 9 for detail).

The final results of the pilot project were presented to the PCGIAP member nations at the 7th PCGIAP meeting in April 2001, in Tsukuba, Japan. The presentation received a great deal of attention from all members and especially from the Executive Board members. As a result of these presentations, the committee formed a resolution to acknowledge the results of the pilot project including its recommendations and to recommend for endorsement the technical specification proposed in this pilot project for the integration of regional administrative boundaries (Appendix 10). The importance of the results of this project were also recognised by the United Nations representative at the 7th PCGIAP meeting.

Chapter 7 presented and discussed the key factors influencing the diffusion of a Regional SDI and proceeds to discussions on the future directions of an SDI development. The chapter first discussed the importance of identifying such factors followed by a review of complementary research. Chapter 7 then presented and discussed three major classes of factors as an outcome of this research, namely Environmental Factors, Capacity Factors and SDI Organisation Factors. The chapter argued that these three classes of factors are influencing the development of a Regional SDI and together they can effect the participation rate. The results of these factors fulfil the last objective of this thesis.

This chapter then introduced two models - based on the strategies, aims, objectives and status of individual SDI initiatives in different levels of an SDI hierarchy, as a new vision on SDI development, namely a product-based and process-based model. An SDI initiative is considered to be a product-based model if the main aim of the initiative is to

link existing and future databases of the respective political and administrative levels of the community. However, if the main aim of an SDI initiative is to define a framework to facilitate the management of spatial information assets, the initiative is considered to be a process-based model. Further, it is suggested that a process-based approach needs to be developed within a defined or acknowledged social system. Both models have value, but contribute to the evolution and uptake/utilisation of the SDI concept in different ways. They provide different frameworks for dealing with intra-jurisdictional mandates for the objectives of spatial data access and sharing. But in some circumstances, it is a combined approach that can offer most potential for developing effective SDIs.

With this in mind, current SDI initiatives were assessed and analysed using the proposed models for SDI development. According to the results of this analysis, a predominance of product-based models of SDI development have been adopted by current SDI initiatives. This results possibly from a lack of awareness of alternative options and advantages of each of the two approaches for SDI development. Appropriately adopting either the product-based or process-based models for SDI development will provide a framework to facilitate the mandates of the relevant SDI jurisdictions.

Chapter 7 also presented and discussed the relationships between SDI hierarchy and different SDI development models by demonstrating similarities between the objectives of SDI development and a model of organisational structure. According to this relationship, any SDI initiative belonging to the higher levels of SDI hierarchy (especially multi-national SDIs) can benefit more by using a process-based model of SDI development. A process-based model may be better able to overcome some of the challenges facing SDI initiatives that are currently following a product-based approach, especially in the voluntary domains of SDI initiatives at higher levels.

In concluding, the chapter presented four major recommendations together with a framework for a regional communication network through a regional spatial data clearinghouse, as a means to facilitate the development of the APSDI initiative. It is argued that the adoption and implementation of these recommendations can assist the PCGIAP in such a way that they overcome the problem of low participation and speed

up their progress in the development of the APSDI initiative. These recommendations are restructuring of the PCGIAP's organisational model as proposed; redesign of future strategies based on the study and understanding of the Asia-Pacific social system; modifying the current APSDI conceptual model; and adoption and utilisation of a process-based model instead of the current product-based model.

In addition to the above conclusions, there were many other conclusions arising from this research. These are arranged into the following three sections which detail conclusions and recommendations for SDI development in general, conclusions and recommendations for the Asia-Pacific SDI specifically, and future directions for research.

## **8.2 CONCLUSIONS AND RECOMMENDATIONS FOR SDI DEVELOPMENT**

### ***Role and Awareness***

- a) SDI is a promising infrastructure that can assist people in the decision-making process. As a result, SDI may affect many organisations, groups and programs whose support may be critical to its successful adoption and implementation. Building support among those groups and individuals is as important as any other aspect of the development process.

However, the fundamentals of an SDI are much more than that of a single combination of spatial data (suppliers), value-added services and end-users as follows:

- Spatial data, value-added services and end-users do not result in an efficient and integrated SDI. An SDI involves other important issues such as policies, interoperability and access networks.
- Moreover, spatial data users increasingly recognise the importance of spatial metadata.
- By building an interconnected network that connects multiple servers, a data clearinghouse can be an entry point for accessing this network. This mechanism enables users to query and discover data from multiple databases at any one time, by using their metadata information.



- b) The predicted benefits of SDI initiatives are yet to be realised in most jurisdictions. In fact the development of SDI initiatives are at early stages even in countries which have taken leadership in SDI development.

Therefore, widespread adoption of SDIs have value beyond simple efficiency and facilitation as follows:

- They have value in increasing the awareness and spatial literacy of society and thus facilitating more effective data sharing and decision-making.
  - They may directly affect the underlying politics of the jurisdiction and the willingness of individuals, departments, jurisdictions and decision-makers to support common spatial data activities.
  - While every SDI initiative will address jurisdiction-specific needs and priorities, there are many lessons and experiences of a technical, administrative and even institutional nature which can be usefully shared with others.
- c) Since the success of an SDI is based to a large extent on cooperation, networking and access to information, the inherent organisational culture impedes the establishment of an efficient SDI.
- d) Different stages of an SDI development are affected by a different set of success factors.
- e) Capacity building is one of the most important issues in the success of SDIs. It can be undertaken in various ways as follows:
- Both institutional as well as individual level capacity building needs to be considered.
  - The importance of training in creating a successful environment for SDI diffusion needs to be realised.
  - In this regard, research and educational institutions can play an important role and their actions are important for SDI diffusion.
  - Capacity building is not simply a matter of learning a concept. It goes much further than that to a whole new way of thinking about sharing and exchanging spatial data assets.

- f) This research suggested that in a similar to the research on GIS diffusion, the identity of an SDI changes in the course of its diffusion in a jurisdictional level. Therefore, it is important to be able to track the changing identity of SDIs.

#### ***Understanding operational aspect***

- a) The process of SDI development is critical to ensuring its adoption and the effective utilisation in a specific jurisdictional level. It is this process which determines whether the potential of the SDI is realised as seen below:
- The potential development of an SDI will be influenced more by the acceptance and utilisation of SDIs by the user community. It is the needs of the user community that will drive SDI development in the future.
  - SDI is an evolving field being led by practitioners who are learning as they go along. Thus, the definitions of SDI will also evolve.
  - There is often a misunderstanding of the respective roles of SDI process and SDI business process. In general, a country cannot produce SDI benefits without an investment in the underlying infrastructure. This requires a recognition that SDI does not return significant benefits in itself; it is only the SDI business applications, which build on the infrastructure, which return benefits.
- b) The development of an SDI will rely heavily upon opportunities provided by the socio-political stability and the legal context of a jurisdiction as well as other important institutional arrangements that might become instrumental while implementing such an initiative.
- c) One of the most challenging tasks for researchers and practitioners of SDIs lies in gaining a better understanding of the processes by which a jurisdiction adopts and diffuses SDIs innovations.

#### ***Organisational affects***

- a) Development of SDIs can affect a jurisdiction's physical, financial and human resources. Therefore, adoption of an SDI may effect the organisational structures and business strategies of those involved as follows:

- For most jurisdictions there must be a change in thinking, abilities and understanding of the value of SDIs, in combination with other technological advancement, in order to take full advantage of SDI initiatives.
  - However, the SDI technologies are still evolving and changing in their concept, meaning and development. These changes may also alter the way SDIs are utilised and perceived.
  - Changing the concept and nature of SDIs in the next few years will be governed by developments in information and communications technologies; by various national and multi-national relationships; various international and industrial policies and standardisation agreements; and by the expansion of data sharing and the provision of associated infrastructures.
- b) One of the major weaknesses in developing SDIs throughout the world is that they focus mainly on developing fundamental datasets, not creating the best communication channel processes. In other words, most current SDI initiatives are using a product-based model instead of taking the advantages of a process-based model.
- c) In terms of effectiveness of factors, the effects of culture on SDI diffusion can be extremely high. The social dynamics of national relations can have an enormous effect on cooperation and costs. Therefore, culture should no longer be treated as an intangible. It can be analysed and it can be incorporated into the study of the social system of a jurisdiction in which an SDI is being developed.

### ***Technological uptake***

- a) Technological advancements, such as GPS and remote sensing for data collection, and the Internet for data dissemination and access, are likely to have a major impact on the spatial data industry as follows:
- These advancements significantly change the nature of the products and services uptake by nations and the way data users access and manipulate information.
  - Conversely, they offer new opportunities to develop regional databases, establish e-government portals and streamline information maintenance supply chains.

- SDI innovation has been underpinned by the phenomenon of the Internet and related telecommunications and network technology. It is the Internet that allows communities to share and leverage spatial data resources and facilitates the diffusion of distributed usage and consumption by the user community.
- b) Diffusion of an SDI is affected by the nature of SDIs, its development model and strategy, the organisational structure of its coordinating agency and the interplay of all three, as follows:
- For countries just starting to develop an SDI initiative, the taking-off effects within the overall diffusion process are of greatest interest.
  - A particular problem is low availability of resources and support.
  - Political support is one of the keys to making SDI development a success particularly in the early stages of speeding up SDI diffusion.

### **8.3 CONCLUSION AND RECOMMENDATION FOR THE ASIA-PACIFIC SDI**

#### ***Role and Awareness***

- a) The region of Asia and the Pacific is complex both in terms of its social and political environments, typified by competing and often conflicting priorities and motivations. Every nation in this region is an unique case because of its national context, the national traditional and cultural attitude and the people who participate, develop and use the SDI concept. Therefore, the regional situation formed by the collaboration of individual nations, must always be considered for the success of a Regional SDI diffusion.
- b) Despite all interest and activities by the PCGIAP, Asia and the Pacific nations still need to realise the value of SDIs and the importance of participation and data sharing.
- c) Based on the national reports from PCGIAP member nations on spatial data activities and SDI initiatives, the development of a Regional SDI is much more challenging than the development of a National SDI initiative within a nation. This is mainly because of the voluntary nature of cooperation at a multi-national level.
- d) The success of short-term strategies like conducting pilot projects, can help establish the value of SDIs in developing countries. With this in mind, it is very important

that the cost and investment in SDI development is recovered through short-term benefits.

- e) To encourage support for the APSDI development, potential benefactors of this initiative must be allowed the opportunity to address those issues affecting regional support in a manner that will educate, inform and resolve any conflicts that may discourage support. In regard to education, good state education and awareness of the value of GI and SDI (particularly for politicians and decision-makers) is a major factor in determining the level of support and therefore being successful with the APSDI initiative.
- f) The introduction of a Regional SDI initiative and sharing of regional datasets across national boundaries will be affected by the existing rules and procedures and requires inevitable change for realising the value of SDIs and data sharing.
  - Managing change requires attention to many implementation issues, such as:
    - top political support for SDI development;
    - secured long-term funding for the SDI development;
    - well defined and focused pilot project scope;
    - the need to manage the users and their expectations about the need to demonstrate clear progress in order to counter negative political pressures.
  - The willingness and the commitment of politicians and decision-makers to put the APSDI initiative high on the political agenda, are indispensable conditions.
- g) The PCGIAP should be well positioned to assist in determining mechanisms for sharing country experiences in the development of National SDIs. Such a sharing of experiences is important and should be further encouraged as it enables late starters to build on the positive experiences of the early starters while avoiding costly mistakes that others could not escape.
- h) The economic, social, legal, institutional and technical environment in developing countries is very different from that in developed countries. As such the promotion and diffusion of an SDI in developing countries is faced with different challenges than those in developed countries. The main limitations are a lack of appreciation of

what SDI can and cannot do, lack of resources, lack of data and lack of appropriate infrastructures.

***Understanding operational aspect***

- a) This research shows that countries with a strong tradition of mapping and surveying suggest that the reservoir of expertise and data would facilitate the introduction of SDI. However, in developing countries, the long-term political and institutional stability in regard to long-term support, promulgating the necessary data collection, building institutes and accomplishing training necessary for the successful development and implementation of the Regional SDI initiative.
- b) On the basis of this research, even though numerous technical problems have been encountered, it has also been realised that the most critical problems are not technical in nature. Rather it was found that political and cultural issues are the most critical problems to be overcome. On the political front there has been a lack of real interest. Beyond the few words of appreciation at the official meetings of the PCGIAP by senior politicians, nothing serious has been done to support the Regional SDI initiative.
- c) Due to the voluntary nature of activities at multinational levels, the PCGIAP should change its strategy from a product-based approach to process-based approach. This model can be facilitated by development of a regional spatial data clearinghouse. Another means of facilitation is through demonstration and improvement of technology, such as the Internet to the extent that it is useful for sharing and exchanging spatial data sets. In this regard, cost/benefit analysis and demonstration of the main interrelated application areas such as administrative boundaries, are key actions to be considered in planning and driving the SDI diffusion process.
- d) The limitations of the past in Asia and the Pacific region were well recognised when the PCGIAP was established and mechanisms to effect change were incorporated into its objectives. However, the PCGIAP may increase its success by ongoing maintenance of communication channels and promotion of data sharing that can support the constitutional framework, regional security in terms of non-military issues and regional emergency service responses. In other words, the mission of the coordinating agency of a Regional SDI initiative must be to guide and promote

regional governments' collective interests in the acquisition, management and sharing of regional fundamental datasets. The PCGIAP is facilitating the provision of sharing databases for common regional interests such as environmental and emergency needs, the integration of fundamental datasets, the maximisation of investment in data and the provision of high quality and up to date data.

### ***Organisational affects***

- a) Based on the organisational structure of the PCGIAP, members come from different backgrounds and cultures, and may not talk the same language as other members. They are also likely to have different levels of knowledge of the technology as well as the SDI concept – a factor which can inhibit discussion and decision-making because the less well-in-formed contributors feel unqualified to challenge other, firmly held and forcefully expressed opinions.
- b) The organisational structure of the SDI coordinating agency is one of the most important internal factors affecting the development and implementation of an SDI at a regional level. This is also a case for the other jurisdictional levels. For example at a national level, the organisational structure of SDI coordinating agencies are important.

### ***Technological uptake***

- a) Although technical issues do play a significant role in the success of a Regional SDI development, financial and environmental factors are just as critical and may have longer impact on this kind of initiative.
- b) Regarding APSDI, it is anticipated that collective efficiencies will be obtained that will provide long-term benefits, however its success has yet to be assured but gains are starting to be made. These are:
  - Member nations need an understanding that regional data will be collected and prepared once only and shared with other member nations. Then, a common format, content and accuracy standards need to be established for all fundamental datasets. Common metadata standards and a spatial data clearinghouse also need to be established to facilitate data sharing.

- Having a clearinghouse system - a common set of data access policies need to be developed as regional governments move to adopt principles for the provision of regional information.
  - Greater emphasis needs to be given to the maintenance of the metadata and clearinghouse system in such a way that all members of the region can use it with confidence.
- c) The PCGIAP must try to find the right balance between long-term and short-term objectives. In particular it must look for quick winners that produce visible results which demonstrate the potential benefits of the SDI initiative and help to build political support for the strategy as a whole. In this regards, one of the problems faced by Asia and the Pacific regional users is the lack of information about spatial data sources that might be relevant to regional users. With this in mind, the development of metadata services should be given a high priority in the implementation of APSDI. This is a very practical strategy because metadata services can be developed relatively quickly and at a relatively low cost.
- d) The establishment of a Regional SDI requires a strong institutional focus, because the responsibility of its development can not be fragmented throughout regional governments. Periodic examination of the Regional SDI institutional framework is therefore essential. In this regard, the participation of national governments is seen as particularly critical to the success of a Regional SDI initiative. Also, the development and success of such an initiative requires new relationships and partnerships among different member nations and regional organisations.
- e) Involvement of potential users proved to be essential in gaining progress in SDI development. It should also be noted that a region is more than just national mapping organisations. Other components, such as regional organisations, political structures and procedures of the individual nations are also important.

In conclusion, the adoption of the proposed improved APSDI conceptual model, restructuring the organisation of the PCGIAP and redesigning the strategy of the APSDI development, can be expected to lead to an increase in the rate of participation of



members and as a result a decrease in the amount of duplicative maintenance activity that is occurring on spatial data activities across Asia and the Pacific region.

#### **8.4 FUTURE DIRECTIONS OF RESEARCH**

It is anticipated that this research will provide some useful insights into the political and technological context surrounding any decision to adopt an SDI in general and a Regional SDI in particular. But further research is needed for a more systematic approach to the study of SDI diffusion including:

- Research efforts should be expanded to include other possible pilot projects, multiple-case studies of development and implementation, as well studies of adoption and non-adoption of SDIs at a national level by member nations.

This research has only carried out a pilot project on one of the common data layers (administrative boundaries), however research needs to be expanded to include other possible cases, for example, regional transportation layers, or regional environmental layers which target different regional users. In this regard, one of the important projects would be a pilot project on the integration of the results of different Working Groups which are related to each other. For example, on one side, WG1 (Geodesy) has implemented a regional precise geodesy network and also defined a regional geodesy datum, on the other side, WG2 (Fundamental Data) which is working on the development of regional fundamental datasets has developed and approved a policy on sharing fundamental data, and has also developed guidelines on custodianship. Therefore, the implementation of this policy and a test of the suitability of this policy via integrating different datasets using the results from WG1 still remain.

Moreover, this research investigated the relationships between and within different level of SDIs (through an SDI hierarchy approach) in order to clarify their nature. However, conducting multiple-case studies on adoption and utilisation of National SDIs by member nations would also help understanding and values of SDIs and help to identify issues and barriers to adoption of the concept in this region.

- Research on criteria that can be used to measure the value and the development progress of SDIs in general and Regional SDIs in particular is needed. In

addition to evaluating impacts on communities and institutions, impacts on society need to be critically evaluated.

As was discussed and highlighted in this research, the development of an SDI initiative is a long-term process and requires long-term support and investment. Therefore, to guarantee such long-term support from politicians and decision-makers, as well as their willingness to provide a secure resource, research efforts must be expanded to identify criteria as well as the mechanisms to measure and monitor the progress of SDI initiatives. This research identified and addressed a list of success factors. Therefore, the next step would be to define the mechanisms to measure this success and to monitor the progress.

- As was explained in chapter 7, in terms of effectiveness of factors, the effects of cultural factors on Regional SDI development can be extremely high. The social dynamics of national relations can cause enormous effects on cooperation and costs within the business environment and poor decision-making. Therefore, by examining the social dynamics of cultural difference within jurisdictions, it would be possible to understand why a high proportion of capabilities of member nations is hidden or not functioning. With this in mind, greater emphasis on both institutional and cultural issues is needed in future research given the extent to which they influence SDI diffusion. In the process, special attention needs to be given to the comparative evaluation of national and multi-national experiences; and further emphasis is needed on the mechanisms that have been or might be used to overcome these institutional and cultural barriers at the national, regional and global levels need to be more critically examined. In this regard, as was discussed in chapter 2, SDI is solely about cooperation and facilitation, therefore to guarantee such cooperation, especially at the multi-national level, this area of research needs to be carried out.

In contrast a wide range of technical, organisational and data related problems have been experienced in this research. Furthermore, the nature of the factors influencing the results of the process of Regional SDI development have been introduced but will require more detailed investigation.

So while this research may have shed some new light on the area of SDI development, much additional work needs to be done in order to respond to the following areas regarding the potential impact of SDIs. For example:

- Identifying the main features of the SDI diffusion process

In the area of GIS there have been many research studies which have identified and addressed different aspects of GIS diffusion. But, like GIS, the SDI environment also needs to be examined with respect to the different aspects of diffusion in order to address those specific features in such a way as to facilitate the use of this theory for better development and use of this type of innovation.

- The way that regional and national cultural factors affect the diffusion process  
This research addressed the importance of cultural factors and identified success factors. However to gain a better picture of the way that regional and national cultural factors affect the diffusion process, further study is required.

- The mechanisms that might be used at different jurisdictional levels to facilitate SDI diffusion

There are different approaches which have been used by different researchers and communities in the field of GIS diffusion, therefore like the GIS environment, research needs to be carried out to identify and propose different possible mechanisms and approaches that might be used at different jurisdictional levels to facilitate SDI diffusion.

In terms of technological advancement, further research efforts need to be expanded on the impact of current and future development of Information Communication Technologies (ICT) such as wireless and mobile-based mapping techniques on SDI developments.

In particular, due to the importance of cultural factors and social dynamics in regional cooperation, it would be useful to undertake research regarding the nature of particular business cultures and national differences within a region, which can then contribute to our knowledge about the region and the way that they can be managed. Moreover, understanding the social dynamic of cultural differences can enable us to understand how cultural differences can assist in managing and overcoming cultural problems. Understanding cultural difference can facilitate ways to categorise different aspects of the social system into different levels.

## **8.5 CONCLUDING REMARKS**

The development of a Regional SDI is much more challenging than the development of a National SDI initiative within a nation. This is mainly because of the voluntary nature of cooperation at a multi-national level and the difficulties of participation in a Regional SDI initiative. As a result, the development of an effective and comprehensive Asia-Pacific Regional SDI has been hampered by a lack of support from member nations. As a result, this initiative still remains very much an innovative concept. Based on this situation, the main aim of this research was to explore strategies to promote support for a Regional SDI.

To achieve this aim, the research strategy was designed in such a way to meet the hypothesis and objectives of the research. As a result, three classes of success factors and four major recommendations, together with a framework for a regional communication network, were suggested. It was argued that the adoption and implementation of these recommendations would assist the PCGIAP in such a way that it can overcome the problem of low participation and speed up in the development of the APSDI initiative. The key recommendations are restructuring of the PCGIAP's organisational model; redesign of future strategies based on the study and understanding of Asia and the Pacific social system; modifying current APSDI conceptual model; and adoption and utilisation of a process-based model instead of the current product-based model.

Although this research focused on the development of a Regional SDI initiative in Asia and the Pacific region, the results and lessons learned in this research – especially the key factors influencing the diffusion of a Regional SDI - can also be used and applied in other regions and potentially other jurisdictional levels.

## REFERENCES AND SELECTED BIBLIOGRAPHY

- Abel, D. J. (1996). The national spatial data infrastructure and the research community, Paper Presented at The National Spatial Data Infrastructure Summit, Canberra, 27 September 1996.
- AGI Standards Committee (1991). GIS Dictionary, Association for Geographic Information.
- Alford, J. (1993). Towards a new public management model: beyond “managerialism” and its critics, *Australian Journal of Public Administration* 52(2): 135-148.
- Annitto, R. N. and B. L. Patterson (1995). A new paradigm for GIS data communications, *URISA Journal* 7(1): 64-67.
- ANZLIC (1996). National spatial data infrastructure for Australia and New Zealand, ANZLIC Discussion Paper, Commonwealth of Australia, <http://www.anzlic.org.au/anzdiscu.htm>, (Accessed November 1998).
- ANZLIC (1998). Spatial data infrastructure for Australia and New Zealand, <http://www.anzlic.org.au/anzdiscu.htm>, (Accessed November 1998).
- ANZLIC (2000). Outcomes of the ANZLIC Clearinghouse Workshop, 3-4 May 2000, Adelaide, <http://www.anzlic.org.au/news/workshop/outcomes.htm>, (Accessed November 1998).
- Arnaud, A. M., Vasconcelos, L.T. and Geirinhas, J. D. (1996). Portugal: GIS diffusion and the modernisation of local government, *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, I. Masser, H. Campbell and M. Craglia. London, UK; Bristol, PA, Taylor & Francis: 111-124.
- AUSLIG (1999). Australian Spatial Data Infrastructure Partnerships Program, Commonwealth of Australia, Homepage of AUSLIG, <http://www.auslig.gov.au>, (Accessed December 1999).
- Azad, B. (1993). Theory and measurement in GIS implementation research: critique and proposals. Paper presented at the 3<sup>rd</sup> Annual Conference on Computers in Urban Planning and Urban Management, Atlanta, Georgia.
- Azad, B. and Wiggins, L. (1993). Institutional issues in the transfer of GIS technology to organizations: the people gone missing, Paper presented at the First Sharjah Conference on Geographic Information Systems and Applications, Sharjah, United Arab Emirates, February 8-10, 1993.
- Azad, B. and Wiggins, L. L. (1995). Dynamics of inter-organizational geographic data sharing: a conceptual framework for research. *Sharing Geographic Information*, H. J. Onsrud and G. Rushton, New Brunswick, NJ, Center for Urban Policy Research: 22-43.
- Bamberger, W. J. (1995). Sharing geographic information among local government agencies in the San Diego region, *Sharing Geographic Information*, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 119-137.
- Barr, T. (1996). The information and communication revolution: whose revolution? *Proceedings of WALIS '96 Forum*, Perth, WALIS.
- Barr, R. (1998). I had a dream.... *GIS Europe*: 16-17.
- Bassolet, A. (2000). An Overview of SDI Activity in Africa, 4<sup>th</sup> Global Spatial Data Infrastructures Conferences, 13-15 March 2000, Cape Town, South Africa.
- Bathurst Declaration (1999). UN-FIG Bathurst Declaration on Land Administration for Sustainable Development, <http://www.sli.unimelb.edu.au/UNConf99/proceedings.htm>, (Accessed January 2000).

- Benwell, G. L. (1993). Culture, change, incorporation and geographical information systems. Human Factors in Geographical Information Systems. D. Medyckyj-Scott and H. M. Hearnshaw. London, Belhaven Press: 223-232.
- Berends, J. and Kok, I. B. C. (1997). GI distribution in Europe: EUROGI sets priorities for legal research, Geomatics Info Magazine, Lemmer, the Netherlands, GITC bv. 11: 29-31.
- Borrero, S. (2000). Formation of the Permanent Committee on SDI for the Americas-PCIDEA, Proceedings of the 15<sup>th</sup> UNRCC-AP, Kuala Lumpur, Malaysia.
- Borrero, S. (2001). Permanent Committee on Spatial Data Infrastructure for the Americas PCIDEA, a Status Report presented at the Open Seminar on SDI in Asia and the Pacific, 26 April 2001, 7<sup>th</sup> PCGIAP meeting, Tsukuba, Japan.
- Bradbury, R. (1996). The national spatial data infrastructure: a reality check on the Mappa Mundi, Paper Presented at The National Spatial Data Infrastructure Summit, Canberra, 27 September 1996.
- Brand, M. (1998). Global spatial data infrastructure: policy & organisational issues, Selected Conference Papers of the 3<sup>rd</sup> Global Spatial Data Infrastructure Conference, 17-19 November 1998, Canberra, Australia.
- Brodman, J. (1987). Key Management Factors Determining the Use of Microcomputers in Decision- Making in the Governments of Developing Countries, Chapter 7, In S. R. Ruth and C. K. Mann, eds., Microcomputers in Public Policy: Applications for Developing Countries, Oulder: Westview for the AAAS.
- Buchanan, D. A. (1993). The organisational politics of technological change, Human Factors in Geographical Information Systems, D. Medyckyj-Scott and H. M. Hearnshaw. London, Belhaven Press: 211-222.
- Budic, Z. D. (1993). Human and Institutional Factors in GIS Implementation by Local Governments, The University of North Carolina at Chapel Hill.
- Budic, Z. D. (1994). Effectiveness of Geographic Information Systems in local planning, Journal of the American Planning Association 60(2): 244-262.
- Budic, Z. D. (1995). Mechanisms for coordinating development and use of GIS databases: a research framework, Proceedings of URISA '95, San Antonio, Texas, URISA.
- Budic, Z. D. and Godschalk, D. R. (1996). Human Factors in Adoption of Geographic Information Systems: A local Government Case Study, Public Administrative Review, November/December 56(6): 554-567.
- Budic, Z. D. and Pinto, J.K. (1999a). Interorganisational GIS: Issues and prospects, The Annals of Regional Science (Springer-Verlag).
- Budic, Z. D. and Pinto, J.K. (1999b). Understanding interorganizational GIS activities: a conceptual framework, URISA Journal 11(1): 11 pp.
- Budic, Z. N. (2000). Commentary: Highlights of Institutional and Organisational Issues, Monitoring Land Supply with Geographic Information Systems: Theory, Practice, and Parcel-Based Approaches, A. V. a. H. Moudon, M. New York, John Wiley & Sons. 1.
- Budic, Z. N. and Pinto, J.K. (2000). Information sharing in an interorganizational GIS environment, Environment and Planning and Design 27: 455-474.
- Budic, Z. D., Feeny, M.E., Rajabifard, A., and Williamson, I.P. (2001). Are SDIs Serving the Needs of Local Planning?, Case Studies of Victoria, Australia and Illinois, USA, Computers in Urban Planning and Urban Management Conference, 18-21 July 2001, Hawaii.

- Bundock, L. (1996). Factors that influence the success of a GIS implementation, Proceedings of the 24<sup>th</sup> Annual International Conference and Technical Exhibition of the Australasian Urban and Regional Information Systems Association AURISA '96, 25-29 November 1996, Hobart.
- Burrough, P. A. and Jones, K. (1993). Assessing cultural and institutional issues, Diffusion and Use of Geographic Information Technologies, I. Masser and H. J. Onsrud, Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 209-212.
- Byamugisha, F. and Zakout, W. (2000). World Bank Support for Land-Related Projects in Developing Countries Experiences and Implications for International Cooperation, Paper presented at the 15<sup>th</sup> UN Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP), 11-14 April 2000, Kuala Lumpur, Malaysia.
- Campbell, H. J. (1992). Organisational issues and the implementation of GIS in Massachusetts and Vermont: some lessons for the United Kingdom, Environment and Planning B: Planning and Design 19: 85-95.
- Campbell, H. (1992). Organisational issues in the implementation of GIS in Massachusetts and Vermont: some lessons for the UK, Environment and Planning B: Planning and Design 19: 85-95.
- Campbell, H. J. (1993). GIS implementation in British local government, Diffusion and Use of Geographic Information Technologies, I. Masser and H. J. Onsrud, Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 117-146.
- Campbell, H., Masser, I., Poxon, J. and Sharp, E. (1994). Monitoring the Take-up of GIS in British Local Government, Luton, Local Government Management Board.
- Campbell, H. and Masser, I. (1995). GIS and Organizations, London, UK; Bristol, PA, Taylor & Francis.
- Campbell, H. (1996). Theoretical perspectives on the diffusion of GIS technologies, GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe, I. Masser, H. Campbell and M. Craglia. London, UK; Bristol, PA, Taylor & Francis: 23-45.
- Car, A. and Frank, A. (1994). General principles of hierarchical spatial reasoning – the case of wayfinding, Proceedings of the Sixth International Symposium on Spatial Data Handling, Edinburgh, Taylor & Francis Ltd.
- Car, A. (1997). Hierarchical Spatial Reasoning: Theoretical Consideration and its Application to Modeling Wayfinding, PhD thesis, Department of Geoinformation, Technical University Vienna
- Cartwright, T. J. (1993). Geographic Information Technology as Appropriate Technology for Development, in Diffusion and use of Geographic Information Technologies, Edited by Ian Masser and Harlan J. Onsrud, NATO ASI Series, Series D: Behavioural and Social Sciences – Vol. 70, published by Kluwer Academic Publishers, the Netherlands.
- Chan, E. H. and Lee, Y. (1999). Geospatial Metadata and its Management, Proceedings of the International Symposium on Spatial Data Quality'99, Hong Kong.
- Chan, T. O. and Williamson, I. P. (1995). Justification of GIS as an infrastructure investment - some observations regarding GIS management in Victoria, AURISA '95, 20-24 November 1995, Melbourne, AURISA '95.
- Chan, T.O. and Williamson, I.P. (1996). A model of the decision process for GIS adoption and diffusion in a government environment, Proceedings, URISA 1996, 26 July - 1 August 1996, Salt Lake City, USA, pp. 247-260.

- Chan, T. O. (1998). The Dynamics of Diffusion of Corporate GIS. Department of Geomatics, Melbourne, The University of Melbourne: 220.
- Chan, T. O. and Williamson, I. P. (1999a). Long term management of a corporate GIS, *International Journal of Geographical Information Science*: accepted for publication.
- Chan, T. O. and Williamson, I. P. (1999b). Spatial data infrastructure management: lessons from corporate GIS development, Presented at AURISA '99, 22-26 November 1999, Blue Mountains, NSW, AURISA '99.
- Chan T O and Williamson I.P. (2000). Long term management of a corporate GIS, *International Journal of Geographical Information Science*, 3(14): 283-303
- Chan, T. O., Feeney, M., Rajabifard, A., and Williamson (2001). The Dynamic Nature of Spatial Data Infrastructures: A Method of Descriptive Classification, *Geomatica* 55(1): 451-462.
- Clarke, D. (2000). The Global SDI and Emerging Nations - Challenges and Opportunities for Global Cooperation, 15<sup>th</sup> UNRCC Conference and 6<sup>th</sup> PCGIAP meeting, 11-14 April 2000, Kuala Lumpur, Malaysia, United Nations.
- Coffey, W.J. (1981). *Geography: Towards a General Spatial Systems Approach*, London, New York: Methuen Co.
- Coleman, J., Menzel, H., and Katz, E. (1966). *Medical Innovation: A Diffusion Study*, Bobbs-Merrill, New York.
- Coleman, D. J. and McLaughlin, J.D. (1998). Defining Global Geospatial Data Infrastructure (GGDI): components, stakeholders and interfaces, *Geomatica* 52(2): 129-144.
- Coopers and Lybrand (1996). Economic aspects of the collection, dissemination and integration of government's geospatial information, Ordnance Survey, <http://www.ordsvy.govt.uk/literatu/external/geospat/index.html#Introduction>, (Accessed April 2001).
- Craglia, M. and I. Masser (1996). Introduction. GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe. I. Masser, H. Campbell and M. Craglia. London, Bristol, PA., Taylor & Francis: 1-6.
- Craig, W. (1995). Why We Can't Share Data: Institutional Inertia, *Sharing Geographic Information*, eds. Harlan J. Onsrud, and Gerard Rushton, 107-118, New Brunswick, NJ: Center for Urban Policy Research.
- Croswell, P. L. (1989). Facing reality in GIS implementation: lessons learned and obstacles overcome. In *Proceedings of the URISA '89*, Boston, Massachusetts: 15-28.
- Croswell, P. L. (1991). "Obstacles to GIS implementation and guidelines to increase the opportunities for success." *Journal of URISA* 3(1): 43-57.
- CSDC (2001). Commonwealth Spatial Data Committee Homepage, [http://www.csdc.gov.au/csdc\\_sd.htm](http://www.csdc.gov.au/csdc_sd.htm), (Accessed May 2001).
- Dangermond, J. (1999). The Future Favors GIS. AURISA '99, 22-26 November 1999, Blue Mountains, NSW, Australia,
- Davies, C. (1993). Sources of useful information, *Human Factors in Geographical Information Systems*. D. Medyckyj-Scott and H. M. Hearnshaw, London, Belhaven Press: 244-251.
- Department of Natural Resources (1999). Home page of Queensland Spatial Information Infrastructure Strategy, Queensland Spatial Information Infrastructure Council, <http://www.qsiis.qld.gov.au/>, (Accessed December 1999).
- Divis, D. A. (2000). GeoData Alliance- Gets Chaorganized, (a paper reprinted from Geospatial Solutions, November 2000, an Advanstar publication, USA, GeoData Alliance Web-site, <http://www.geoall.net/>, (Accessed August 2001).



- Dueker, K. J. and Vrana, R. (1995). Systems integration: a reason and a means for data sharing, *Sharing Geographic Information*, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 149-171.
- Dunford, R. W. (1992). *Organisational Behaviour: An Organisational Analysis Perspective*, Sydney, Addison-Wesley.
- Eagleson, S., Escobar, F., and Williamson, I.P. (1999). Spatial Hierarchical Reasoning Applied to Administrative Boundary Design Using GIS, *Proceeding of the Australian National Surveying Congress*, Perth, Australia.
- Eagleson S, Escobar F, and Williamson I.P. (2000). Hierarchical Spatial Reasoning Applied to Automated Design of Administrative Boundaries, *Proceeding of the URISA 2000 Conference*, 19 - 23 August 2000, Orlando, USA.
- Eason, K. D. (1993). Gaining user and organisational acceptance for advanced information systems, *Diffusion and Use of Geographic Information Technologies*, I. Masser and H. J. Onsrud. Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 27-44.
- Effenberg, W. W. and Williamson, I.P. (1996). Data flows, standards and incremental cadastral update, *Proceedings of the 8<sup>th</sup> Annual Colloquium of the Spatial Information Research Centre*, Dunedin, New Zealand, 9-11 July, Spatial Information Research Centre, University of Otago.
- EUROGI (1998). Homepage of The European Umbrella Organisation for Geographic Information, <http://www.eurogi.org>, (Accessed November 1998).
- EUROGI (1999a). Developing a Vision for the EGII-Geographic Information Infrastructure: a report of the meeting of experts, 7-9 December 1998 at DG XIII/E Luxembourg, [http://www.eurogi.org/forum/egii\\_1298.html](http://www.eurogi.org/forum/egii_1298.html), (Accessed May 1999).
- EUROGI (1999b). On-line proceedings of the 1996, 1997, 1998 Global Spatial Data Infrastructures Conferences, <http://www.eurogi.org/gsdi/>, (Accessed September 1999).
- EUROGI (2000a). Towards a strategy for geographic information in Europe, A consultation paper prepared by the European Umbrella Organisation for Geographic Information, Version 1.0, released on 5 October 2000, <http://www.eurogi.org/geoinfo/eurogiprojects/strategy.pdf>, (Accessed May 2001).
- EUROGI (2000b). EUROpean umbrella Organisation for Geographic Information, A brochure published by EUROGI, The Netherlands.
- European Commission (1995). GI2000-Towards a European Geographic Information Infrastructure (EGII)-A discussion document for consultation with the European GI community. European Commission, <http://tempus1.utc.sk/gis/txts/gi2000xz.htm>, (Accessed December 1999).
- Evans, J. and Ferreira, J. J. (1995). Sharing spatial information in an imperfect world: interaction between technical and organizational issues, *Sharing Geographic Information*. H. J. Onsrud and G. Rushton, New Brunswick, NJ, Center for Urban Policy Research: 448-460.
- Executive Order (1994). Coordinating geographic data acquisition and access: the National Spatial Data Infrastructure, Executive Order of the White House, Office of the Press Secretary, USA.
- Ezizbalike, C., Selebalo, Q. C., Faiz, S., and Zhou, S. Z. (2000). Spatial Data Infrastructures: Is Africa Ready? The 4<sup>th</sup> Global Spatial Data Infrastructure, 13-15 March 2000, Cape Town, South Africa.
- Feeney, M. and Williamson, I.P. (2000). Researching Frameworks for Evolving Spatial Data Infrastructures, *Proceedings of SIRC 2000, The 12th Annual Colloquium of the Spatial Information Research Centre*, University of Otago, Dunedin, New Zealand, 10-13 December 2000. p 93-105.

- Feeney, M.E., Rajabifard, A., and Williamson, I.P.(2001). Spatial Data Infrastructure Frameworks to Support Decision-Making for Sustainable Development, Proceedings of the 5<sup>th</sup> Global Spatial Data Infrastructure Conference, 21-25 May, Cartagena de Indias, Colombia.
- Ferrari, R. and H. J. Onsrud (1995). Understanding Guidance on GIS Implementation: A Comprehensive Literature Review, National Center for Geographic Information and Analysis.
- FGDC (1991). A National Geographic Information Resource The Spatial Foundation of the Information-Based Society First Annual Report to the Director Office of Management and Budget, Federal Geographic Data Committee, Washington, D.C.
- FGDC (1993). The National Spatial Data Infrastructure A Technical Perspective A Summary of Discussion, A Federal Geographic Data Committee Sponsored Meeting, Charleston, South Carolina, February 18-21, Federal Geographic Data Committee, Washington, D.C.
- FGDC (1994). The National Geospatial Data Clearinghouse, A Report on Federal Agency Activities Within the First Six Months of Executive Order 12906, Federal Geographic Data Committee, Washington, D.C.
- FGDC (1994). The 1994 Plan for the National Spatial Data Infrastructure, Federal Geographic Data Committee, Washington, D.C.
- FGDC (1995). Development of a National Digital Geospatial Data Framework, Federal Geographic Data Committee, Washington, D.C.
- FGDC (1995). Guidelines to Encourage Cooperation in Development of the National Spatial Data Infrastructure (version 3.0), Federal Geographic Data Committee, Washington, D.C.
- FGDC (1997). A Strategy for the NSDI, Federal Geographic Data Committee, Washington DC.
- FGDC (2000). Improving Federal Agency Geospatial Data Coordination, Report prepared by the Design Study Team Commissioned by the Federal Geographic Data Committee, May 11, 2000, Washington DC.
- Fox, J.M. (1991). Spatial Information for Resource Management in Asia: a review of institutional issues, *International Journal on Geographic Information Systems*, 5(1).
- Frank, S. (1994). The national spatial data infrastructure: designing navigational strategies, *URISA Journal* 6(1): 37-55.
- Frank, A. U. and Timpf, S. (1994). Multiple Representations for cartographic objects in a multi-scale tree - an intelligent graphical zoom, *Computers and Graphics Special Issue on Modelling and Visualisation of Spatial Data in GIS*.
- Frank, S. M., Goodchild, M. F. Onsrud, H. J. Pinto, J. K. (1995). A survey on user requirements for framework GIS data, *Proceedings of URISA '95*, San Antonio, Texas, URISA.
- Frank, A. U. and Kuhn, W. Eds. (1995). *Spatial Information Theory: A Theoretical Basis for GIS*, *Lecture Notes in Computer Science*, Verlag, Springer.
- Fukasaku, K. (1995). *Regional Cooperation and Integration in Asia*, Organisation for Economic Cooperation and Development, France.
- Gattiker, U. E. (1990). *Technology Management in Organizations* (Newbury Park: Sage Publications).
- GDA (2001). GeoData Alliance Homepage, <http://www.geoall.net/>, (Accessed August 2001).
- Georgiadou, Y. (2001). Capacity Building Aspects for a Geospatial Data Infrastructure (GDI). *Proceedings of 5<sup>th</sup> Global Spatial Data Infrastructure Conference*, 21-25 May, Cartagena de Indias Colombia.
- GI2000 (1995). *Towards a European Geographic Information Infrastructure (EGII)*, A document of GI-2000 homepage, <http://www.echo.lu/gi/en/gi2000/egii.html>, (Accessed January 1999).

- GI2000 (1996). Towards a European Policy Framework for Geographic Information, A working document of GI 2000 homepage, <http://www.echo.lu/gi/en/gi2000/gi2000dd.html>, (Accessed January 1999).
- GI2000 (1998). GI in the Fifth RTD Framework Program (1998-2002) - EGII, <http://www.echo.lu/gi/en/fp5/gi5fpegii.html>, (Accessed December 1998).
- GI2000 (1999). Cross program action line: New GI Society- Background document, received 21/Setember/1999 through GI-2000 discussion list.
- Goodchild, M. F. (1995). Sharing imperfect data, *Sharing Geographic Information*. H. J. Onsrud and G. Rushton, New Brunswick, NJ, Center for Urban Policy Research: 413-425.
- Goodchild, M. F. (1995). Future directions for geographic information science, *Geographic Information Sciences* 1(1): 1-8.
- Goodman, P. S., Sproull, L. S. and Associates, Eds. (1990). *Technology And Organization*, San Francisco, Oxford, Jossey-Bass Publishers.
- Goodman, P. S. (1993). Implementation of new information technology, In *Diffusion and Use of Geographic Information Technologies*, edited by I. Masser, and H. J. Onsrud. (Dordrecht/Boston/London: Kluwer Academic Publishers), 45-58.
- Gore, A. (1998). The Digital Earth: understanding our planet in the 21st century, *The Australian Surveyor* 43(2): 89-91.
- Groot, R. and McLaughlin, J. (2000). *Geospatial Data Infrastructure: concepts, cases and good practice*, Oxford University Press, New York, 286 p.
- Groot, R. (2001). Economic Issues in the Evolution of National Geospatial Data Infrastructure, 7<sup>th</sup> United Nations Regional Cartographic Conference for the Americas, 22-26 January, New York, USA.
- GSDI (1997). Global Spatial Data Infrastructure Conference findings and resolutions, Chapel Hill, North Carolina, 21 October 1997, EUROGI.
- GSDI (1998). Recommendations and Resolutions of the 3<sup>rd</sup> Global Spatial Data Infrastructure Conference, 17-19 November, Canberra, Australia.
- Hearnshaw, H. M. and Medyckyj-Scott, D. (1993). The way forward for human factors in GIS, *Human Factos in Geographical Information Systems*, D. Medyckyj-Scott and H. M. Hearnshaw. London, Belhaven Press: 235-243.
- Hoffmann, F. (1999). GI definition, A message sent to GI-2000 discussion list, Received May 1999.
- Holland, W. S. (1994). Copyright, licensing and cost recovery for geographic and land information system data: a legal, economic and policy analysis, *Proceedings of the Conference on Law and Information Policy for Spatial Databases*, Tempe, Arizona, National Center for Geographic Information and Analysis, University of Maine.
- Holland, P. (1998a). Roles of the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) and the United Nations Regional Cartographic Conference for Asia and the Pacific, Paper presented at the Special Working Group Meeting of the United Nations Regional Cartographic Conferences, Aguascalientes, 25-27 March 1998, Mexico.
- Holland, P. (1998b). GIS infrastructure for Asia and the Pacific, *AURISA News*: 1 & 7.
- Hollan, P. (1999). The strategic Imperative of a Global Spatial Data Infrastructure, *Proceedings of Cambridge Conference*, 19-23 July 1999, UK.
- Holland, P. (2001). Global Perspective of NGDI, Paper presented at the Workshop on NGDI – Towards a Road Map for India held on 5-6 February 2001 in New Delhi, India, <http://www.gisdevelopment.net/application/gii/global/giigp0001pf.htm>, (Accessed May 2001).

- Jacoby, S. (1997). Spatial data infrastructure - GDV's perspective, Slide presentation to the final year Geomatics students of the University of Melbourne.
- Jacoby, S, Smith, J, Ting, L and Williamson, I.P. (2001) Developing a Common Spatial Data Infrastructure between State and Local Government An Australian case study, Forthcoming publication in International Journal of Geographic Information Systems.
- Kelley, P.C. (1993). A National Spatial Information Infrastructure, Proceedings of the 1993 Conference of the Australian Urban and Regional Information Systems Association (AURISA), Adelaide, South Australia, Australia.
- Kevany, M. J. (1995). A proposed structure for observing data sharing, In Sharing Geographic Information, edited by H. J. Onsrud, and G. Rushton. (New Brunswick, NJ: Center for Urban Policy Research), 76-100.
- King, J. L. (1995). Problems in public access policy for GIS databases: an economic perspective, Sharing Geographic Information, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 255-276.
- Koestler, A. (1968). Das Gespenst in der Maschine (The Gohst in the Machine), Wien-Munchen-Zurich: Verlag Fritz Molden.
- Kok, B. (1998). Achieving effective cooperation through commercialisation based on a fund of accumulated knowledge and experience, Invited Presentation during the 3<sup>rd</sup> Global Spatial Data Infrastructure Conference, 17-19 November 1998, Canberra, Australia.
- Labonte, J., Corey, M. and Evangelatos, T. (1998). Canadian Geospatial Data Infrastructure (CGDI) - geospatial information for the knowledge economy, Geomatica 1998, Canadian Geoconnections, <http://cgdi.gc.ca/english/publications/index.html>, (Accessed February 2001).
- Land Victoria (1997). Victoria's Geospatial Information Strategic Plan 1997-2000, Melbourne, Department of Natural Resources and Environment: 23pp.
- Land Victoria (1999). Home page of G.I. Connections, <http://www.giconnections.vic.gov.au/>, (Accessed December 1999).
- Lemmens, M. J. P. M. (2001). An European Perspective on Geo-Information Infrastructure (GII) Issues. GIS Development.net. 1.
- Leonard, J. and Luzet, C. (2001). EuroGeographics: the metamorphosis of CERCO/MEGRIN, Proceedings of 5<sup>th</sup> Global Spatial Data Infrastructure Conference, 21-25 May, Cartagena de Indias, Colombia, <http://codazzi4.igac.gov.co/gsdi5/index.html>, (Accessed August 2001).
- Longhorn, R. A. (1998). Strategic initiatives for the global spatial data infrastructure (GSDI), Selected Conference Papers of the 3<sup>rd</sup> Global Spatial Data Infrastructure Conference, 17-19 November 1998, Canberra, Australia.
- Longhorn, R. A. (2000). Regional Geographic Information Policy: Fact or Fiction - the case in Europe and lessons for GSDI, The 4<sup>th</sup> Global Spatial Data Infrastructure Conference, 13-15 March 2000, Cape Town, South Africa.
- Luftman, J. N., Ed. (1996). Competing in the information age: strategic alignment in practice (New York: Oxford University Press).
- Majid, S.I. (2001). A Multi-Purpose Cadastre Prototype On The Web, MSC Thesis, Department of Geomatics, The University of Melbourne.
- Mapping Science Committee (1993). Toward A Coordinated Spatial Data Infrastructure For The Nation, National Academy Press, Washington DC.
- Mapping Science Committee (1995). A Data Foundation for the National Spatial Data Infrastructure, National Academy Press, Washington DC.

- Mapping Science Committee (1997). The Future of Spatial Data and Society, National Academy Press, Washington DC.
- Markus, M. L. and D. Robey (1988). Information technology and organizational change: causal structure in theory and research, *Management Science* 34(5, May): 583-598.
- Masser, I. and Onsrud, H. J. (1993). Diffusion and use of geographic information technologies: an introduction, *Diffusion and Use of Geographic Information Technologies*, I. Masser and H. J. Onsrud, Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 1-8.
- Masser, I. (1993). The diffusion of GIS in British Local Government. *Diffusion and Use of Geographic Information Technologies*, I. Masser and H. J. Onsrud, Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 99-116.
- Masser, I. and Campbell, H. (1994). Information sharing and the implementation of GIS: some key issues, *Innovations in GIS*, M. F. Worboys. London, Taylor & Francis Ltd: 217-227.
- Masser, I. and Craglia, M. (1995). The diffusion of GIS in local government in Europe, *Proceedings of the 23<sup>rd</sup> Annual International Conference and Technical Exhibition of the Australasian Urban and Regional Information Systems Association AURISA '95*, 20-24 November 1995, Melbourne.
- Masser, I. and Campbell, H. (1995). Information sharing: the effects of GIS on British local government, *Sharing Geographic Information*, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 203-249.
- Masser, I., Campbell, H. and Craglia, M. Eds. (1996). *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, GISDATA III, London, Bristol, PA., Taylor & Francis.
- Masser, I. and Campbell, H. (1996). Great Britain: the dynamics of GIS diffusion, *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, I. Masser, H. Campbell and M. Craglia. London, Bristol, PA., Taylor & Francis: 49-66.
- Masser, I. and Craglia, M. (1996). A comparative evaluation of GIS diffusion in local government in nine European countries, *GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe*, I. Masser, H. Campbell and M. Craglia, London, Bristol, PA., Taylor & Francis: 211-233.
- Masser, I. (1996). A comparative evaluation of national geographic information strategies, *Proceedings of AGI 96 Conference*, Birmingham, UK, 24-26 September, AGI.
- Masser, I. (1998a). The first generation of national geographic information strategies, *Selected Conference Papers of the 3<sup>rd</sup> Global Spatial Data Infrastructure Conference*, 17-19 November 1998, Canberra, Australia.
- Masser, I. (1998b). *Governments and Geographic Information*, London, UK; Bristol, PA, Taylor & Francis.
- Masser, I. (2000). What is a spatial data infrastructure? *Proceedings, 4<sup>th</sup> Global Spatial Data Infrastructures Conference*, 13-15 March 2000, Cape Town.  
<http://www.gsdi.org/docs/capetown/masser/masser.ppt> , (Accessed April 2001).
- Masser, I. (2001). Reflections on the Indian National Geospatial Data Infrastructure, *GIS Development.net, Application, Geographic Information Infrastructure*,  
<http://www.gisdevelopment.net/application/gii/global/giigp0009.htm>, (Accessed June 2001).
- McKee L. (1996). Building the GSDI-discussion paper, *Proceedings of the 1996 Conference on Emerging Global Spatial Data Infrastructure*, September 1996, Königswinter,

- Bundesrepublik, Deutschland (Germany), European Umbrella Organization for Geographical Information (EUROGI): 19 pages.
- McLaughlin J.D. and Nichols S.E. (1992). Building a national spatial data infrastructure, Computing Canada 6<sup>th</sup> January: 24.
- McLennan, B. (1996). Creation and maintenance of spatial data infrastructure by the private sector, Paper Presented at The National Spatial Data Infrastructure Summit, Canberra, 27 September 1996.
- Medyckyj-Scott, D. and Hearnshaw, H. M. Eds. (1993). Human Factors in Geographical Information Systems, London, Belhaven Press.
- MEGRIN (1998). Meeting the demand for pan-European digital mapping, *Geoinformatics*, **1**: 18-21.
- Mesarovic, M.D., Macko, D., and Takahara, Y. (1970). Theory of hierarchical, multilevel, systems, Mathematics in science and engineering, ed. Bellmann, Richard. New York: Academic Press.
- Miellet, P. (1996). France: a historical perspective on GIS diffusion, GIS Diffusion: The Adoption and Use of Geographical Information Systems in Local Government in Europe, I. Masser, H. Campbell and M. Craglia, London, UK; Bristol, PA, Taylor & Francis: 163-182.
- Millner, J., Hale, M., Brown, N., Kealy, A., Smith, J., and Williamson, I.P. (2001). The Influence of Emerging Location-Based Technologies and Electronic Commerce Business Models on Victoria's Geodetic Strategy, Proceedings of International Symposium on Satellite Navigation Technology and Application, Canberra.
- Mohamed, A.M. (1999). PCGIAP and the Asia Pacific Spatial Data Infrastructure (APSDI), Proceedings, Cambridge Conference, 19-23 July 1999, Ordnance Survey, Cambridge.
- Mohan, C. (1998). Workflow Management in the Internet Age, Advances in Databases and Information Systems, Second East European Symposium, ADBIS'98, Eds. W. Litwin, T. Morzy, and G. Vossen., Poznan, Poland.
- Mohr, L. (1978). Process theory and variance theory in innovation research, The Diffusion of Innovations: An Assessment. L. Mohr and M. Radnor, Evanston, Illinois, Center for Interdisciplinary Study of Science and Technology, Northwestern University: 315-342.
- Mooney, J. D. and Grant, D. M. (1997). The Australian Spatial Data Infrastructure, Framework of the World. D. Rhind, Cambridge, GeoInformation International: 187-201.
- Moore, G. C. (1993). Implications from MIS research for the study of GIS diffusion: some initial evidence, Diffusion and Use of Geographic Information Technologies, I. Masser and H. J. Onsrud. Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 77-94.
- Nairn, A. and Irwin, B. (1997). The Australian Spatial Data Infrastructure: Its current status and future directions, Cartography Journal of the Mapping Sciences Institute, Australia, 26(1), June 1997.
- Nairn, A. and Holland, P. (2001). The NGDI of Australia - Achievements and Challenges from a Federal Perspective, Paper presented at the Workshop on NGDI – Towards a Road Map for India” held on 5-6 February 2001 in New Delhi, India, <http://www.gisdevelopment.net/application/gii/global/giigp0003.htm>, (Accessed May 2001).
- Nanson, B. and Rhind, D. (1998). Establishing the UK National Geospatial Data Framework, <http://www.ngdf.org.uk/whitepapers/ngdfcan.html>, (Accessed February 1999).
- NAPA (1998). Geographic Information for the 21st Century - Building a Strategy for the Nation. Washington, DC, National Academy of Public Administration.
- NCGIA (1995). National Center for Geographic Information and Analysis, I-16 bibliography on law and policy, National Center for Geographic Information and Analysis.

- Neal, M. (1998). *The Culture Factor: Cross-National Management and the Foreign Venture*, London, Macmillan Press.
- Nord, W. R. and Tucker, S., Eds. (1987). *Implementing Routine and Radical Innovations* (Boston: D. C.: Heath.).
- NSIF (2000). *Spatial Data Infrastructure in Africa: A synopsis of the SDI Africa survey questionnaires received*, The 4<sup>th</sup> Global Spatial Data Infrastructure, CapeTown, South Africa.
- Obermeyer, N. J. (1995). Reducing inter-organizational conflict to facilitate sharing geographic information, *Sharing Geographic Information*, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 138-148.
- Onsrud, H. J., Obermeyer, N. J. and Calkins, H. W., Eds. (1989). *Use and Value of Geographic Information: Initiative 4 Specialist Meeting Summary Report*, Technical Report No. 89-6, NCGIA.
- Onsrud, H. J. and Pinto, J. K. (1991). Diffusion of geographic information innovations, *International Journal Geographical Information Systems* 5(4): 447-467.
- Onsrud, H. J. and Rushton, G., Eds. (1992). *Initiative 9: Report for the Specialist Meeting: Institutions Sharing Geographic Information*, NCGIA Technical Report No. 92-5.
- Onsrud, H. J. and Pinto, J. K. (1993). Evaluating correlates of GIS adoption success and the decision process of GIS acquisition, *URISA Journal* 5(1): 18-39.
- Onsrud, H. J. and Masser, I. (1993). Extending the research agenda, *Diffusion and Use of Geographic Information Technologies*, I. Masser and H. J. Onsrud, Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 339-343.
- Onsrud, H. J. and Reis, R. I. (1994). Law and information policy for spatial databases, *Proceedings of the Conference on Law and Information Policy for Spatial Databases*, Tempe, Arizona, National Center for Geographic Information and Analysis, University of Maine.
- Onsrud, H. J. (1994). Privacy and Land Information Systems, *FIG XX International Congress*, Melbourne, 5-12 March 1994, FIG.
- Onsrud, H. J. and Reis, R. L. (1995). Law and information policy for spatial databases: a research agenda, *Jurimetrics Journal* 35: 377-393.
- Onsrud, H. J., Ed. (1995). *Proceedings of the Conference on Law and Information Policy for Spatial Databases*, Tempe, Arizona. Orono, ME, National Center for Geographic Information and Analysis, University of Maine.
- Onsrud, H. J. and Rushton, G., Eds. (1995). *Sharing Geographic Information*, New Brunswick, NJ, Center for Urban Policy Research.
- Onsrud, H.J. (1998). Survey of national and regional spatial data infrastructure activities around the globe, *Selected Conference Papers of the 3<sup>rd</sup> Global Spatial Data Infrastructure Conference*, 17-19 November 1998, Canberra, ANZLIG.
- Onsrud, H. J. (2000). Survey of National and Regional Spatial Data Infrastructure Activities around the Globe, *4<sup>th</sup> Global Spatial Data Infrastructures Conferences*, 13-15 March 2000, Cape Town, South Africa.
- Parent, P. (1999). The application of metadata, *GIS User*: 28-30.
- Parker, J. (1996). Surveying and mapping for the NSDI: national, state and territory base dataset, Paper Presented at The National Spatial Data Infrastructure Summit, Canberra, 27 September 1996.
- Pattee, H. H. (1973). *Hierarchy Theory – The Challenge of Complex Systems*, New York: Braziller.
- PCGIAP (1995). *An Interim Report of formation of Permanent Committee On GIS Infrastructure for Asia and the Pacific*, Kuala Lumpur, Malaysia.

- PCGIAP (1996). Report of the 2<sup>nd</sup> Permanent Committee on GIS Infrastructure for Asia and the Pacific meeting, 29 September-4 October, Sydney, Australia, Permanent Committee home page, <http://www.gsi.go.jp/PCGIAP/>, (Accessed May 1999).
- PCGIAP (1997a). Report of the 3<sup>th</sup> Permanent Committee on GIS Infrastructure for Asia and the Pacific meeting, 1-2 February, Bangkok, Thailand, Permanent Committee home page, <http://www.gsi.go.jp/PCGIAP/>, (Accessed May 1999).
- PCGIAP (1997b). Resolutions Adopted by the 14<sup>th</sup> UNRCC-AP Conference, 3-7 February 1997, Bangkok 1997.
- PCGIAP (1998a). Report of the 4<sup>th</sup> Permanent Committee on GIS Infrastructure for Asia and the Pacific meeting, 28 February-4 March, Tehran, Iran, Permanent Committee home page, <http://www.gsi.go.jp/PCGIAP/>, (Accessed May 1999).
- PCGIAP (1998b). A Spatial Data Infrastructure for the Asia and the Pacific Region, (PCGIAP Publication No. 1, Canberra).
- PCGIAP (1999a). Report of the 5<sup>th</sup> Permanent Committee on GIS Infrastructure for Asia and the Pacific meeting, 19-22 April, Beijing, China, Permanent Committee home page, <http://www.gsi.go.jp/PCGIAP/>, (Accessed September 2001).
- PCGIAP (1999b). Statutes of the Permanent Committee on GIS Infrastructure for Asia and the Pacific, Permanent Committee home page, [http://www.gsi.go.jp/PCGIAP/pcstat\\_c.htm](http://www.gsi.go.jp/PCGIAP/pcstat_c.htm), (Accessed September 1999).
- PCGIAP (2000). Report of the 6<sup>th</sup> Permanent Committee on GIS Infrastructure for Asia and the Pacific meeting, 11-15 April, Kuala Lumpur, Malaysia, Permanent Committee home page, <http://www.gsi.go.jp/PCGIAP/>, (Accessed September 2001).
- PCGIAP (2001). Report of the 7<sup>th</sup> Permanent Committee on GIS Infrastructure for Asia and the Pacific meeting, 23-28 April, Tsukuba, Japan, Permanent Committee home page, <http://www.gsi.go.jp/PCGIAP/>, (Accessed September 2001).
- PCGIAP-WG2 (2000). Status Report on WG2 (Regional Fundamental Datasets) Activities, Report presented at the 15<sup>th</sup> UNRCC-AP Conference and the 6<sup>th</sup> PCGIAP meeting, 11-14 April, Kuala Lumpur, Malaysia.
- Petchenik, B. B. (1991). New directions for national mapping, *URISA Journal* 3(1): 77-79.
- Petch, J. and Reeve, D. (1999). *GIS Organisations and People, a socio-technical approach*, Taylor & Francis, UK.
- Petersen, B. (1994). Issues concerning access to electronic records. Proceedings of the Conference on Law and Information Policy for Spatial Databases, Tempe, Arizona, National Center for Geographic Information and Analysis, University of Maine.
- Phillips, A. (1998). A Metadata Management System for Web Based SDIs, MSc Thesis, Department of Geomatics, The University of Melbourne.
- Phillips, A., Williamson, I.P. and Ezigbalike, I.C. (1999). Spatial Data Infrastructure Concepts, *The Australian Surveyor*, Vol. 44, No. 1, 20-28.
- Pinto, J. K. and Onsrud, H. J. (1993). Correlating adoption factors and adopter characteristics with successful use of geographic information systems, *Diffusion and Use of Geographic Information Technologies*, I. Masser and H. J. Onsrud, Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 165-194.
- Pinto, J. K. and Azad, B. (1994). The role of organisational politics in GIS implementation, *URISA Journal* 6(2): 35-61.



- Pinto, J. K. and Onsrud, H. J. (1995). Sharing geographic information across organizational boundaries: a research framework, *Sharing Geographic Information*, H. J. Onsrud and G. Rushton, New Brunswick, NJ, Center for Urban Policy Research: 44-64.
- Polley, I., Williamson, I.P. and Effenberg, W. (1997). Suitability of Internet technologies for access, transmission and updating of digital cadastral databases on the www, *Proceedings (CD-ROM) of the AURISA '97 Conference*, 19-21 November 1997, Christchurch, New Zealand, AURISA '97.
- Price Waterhouse (1995). *Australian Land & Geographic Data Infrastructure Benefits Study*, Australia New Zealand Land Information Council.
- PSMA (1996). Report of the PSMA/ICSM Workshop on Digital Cadastral Data Bases held in Melbourne, 5-7 August, Canberra, Public Sector Mapping Agencies.
- PSMA (2000). Web-site of The Public Sector Mapping Agencies, , <http://www.pdma.com.au/>, (Accessed November 2000).
- Rajabifard, A. (1995). GIS Standardisation Aspects, UN-ESCAP Expert Group Meeting on GIS Standardisation, Kuala Lumpur, Malaysia.
- Rajabifard, A. and Noori Bushehri, S. (1996). Evaluation of Iranian GIS in Compare with GIS of Asia-Pacific Contries, 3<sup>rd</sup> National GIS Conference, Tehran, Iran.
- Rajabifard, A. (1997). GIS Standardisation Aspects in the context of GIS Infrastructure for Asia and the Pacific, 14<sup>th</sup> United Nation Regional Cartographic Conference for Asia and the Pacific UNRCC-AP, 3-7 February 1997, Bangkok, Thailand.
- Rajabifard, A., and Noori Bushehri, S. (1997). Development of National Spatial Data Infrastructure in Islamic Republic of Iran, Global Mapping Forum, Gifu, Japan.
- Rajabifard, A. and Williamson, I. P. (1999). Status report of research on: Asia-Pacific Regional Spatial Data Infrastructure (APSDI), 5<sup>th</sup> Meeting of the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), Beijing, China.
- Rajabifard, A. Chan, T. O., and Williamson, I. P. (1999). The Nature of Regional Spatial Data Infrastructure, *Proceedings of the AURISA 99*, 22-26 November 1999, Blue Mountains, NSW, Australia.
- Rajabifard, A. and Williamson, I.P. (2000). Report on Analysis on Regional Fundamental Datasets Questionnaire, Presented at and Published by the 15<sup>th</sup> UNRCC-AP (UN-Regional Cartographic Conference for the Asia and the Pacific), 11-14 April 2000, Kuala Lumpur, Malaysia.
- Rajabifard, A. Escobar, F. and Williamson, I.P. (2000a). Hierarchical Spatial Reasoning Applied to Spatial Data Infrastructures, *Cartography Journal* 29(2), Australia.
- Rajabifard, A. Williamson, I.P., Holland, P., and Johnstone, G. (2000b). From Local to Global SDI initiatives: a pyramid building blocks, *Proceedings of the 4<sup>th</sup> Global Spatial Data Infrastructures Conferences*, 13-15 March 2000, Cape Town, South Africa.
- Rajabifard, A. (2001). SDI Hierarchy – From Local to Global SDI initiatives, *Proceedings of Open Seminar on SDI in Asia and the Pacific Region*, 7<sup>th</sup> meeting of the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), April 26, 2001, Tsukuba, Japan, [http://www.gsi.go.jp/PCGIAP/tsukuba/seminar/seminar/paper\\_sdi.pdf](http://www.gsi.go.jp/PCGIAP/tsukuba/seminar/seminar/paper_sdi.pdf).
- Rajabifard, A. and Williamson, I.P. (2001). Spatial Data Infrastructures: Concept, SDI Hierarchy and Future directions, *Proceedings of GEOMATICS'80 Conference*, 29 April-2 May 2001, Tehran, Iran.

- Rajabifard, A., Feeney, M., and Williamson I.P. (2002). Future Directions for the Development of Spatial Data Infrastructure, Forthcoming publication, Journal of the International Institute for Aerospace Survey and Earth Sciences (JAG), ITC, The Netherlands.
- Reichardt, M. E. and Moeller, J. (2000). SDI Challenges for a New Millennium- NSDI at a Crossroads: Lessons Learned and Next Steps. 4<sup>th</sup> Global Spatial Data Infrastructures Conferences, 13-15 March 2000, Cape Town, South Africa.
- Rhind, D. (1994). Spatial databases and information policy: a British perspective, Proceedings of the Conference on Law and Information Policy for Spatial Databases, Tempe, Arizona, National Center for Geographic Information and Analysis, University of Maine.
- Rhind, D. W. (1996). Economic, legal, and public policy issues influencing the creation, accessibility, and use of GIS databases, Transactions in GIS 1(1): 3-12.
- Rhind, D. (2001). Lessons Learned from local, National and Global Spatial data Infrastructures, Workshop on NGDI - Towards a Road Map for India” held on 5-6 February 2001 in New Delhi, India, <http://www.gisdevelopment.net/application/gii/global/giigp0006.htm>, (Accessed May 2001).
- Robertson, W. A. and Garratt, K. J. (1996). The role of the United Nations in spatial data infrastructure, Paper Presented at The second Meeting of The Permanent Committee on GIS Infrastructure for Asia and the Pacific, Sydney, 29 September – 3 October 1996.
- Rocheleau, B. (1995). Computers and horizontal information sharing in the public sector, Sharing Geographic Information, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 207-229.
- Rogers, E. M. (1962). Diffusion of Innovations, New York, The Free Press.
- Rogers, E. M. (1971). Diffusion of Innovations, New York, The Free Press.
- Rogers, E. M. and F. F. Shoemaker (1971). Communication of Innovations: A Cross-Cultural Approach, New York, The Free Press.
- Rogers, E. M. and Agarwala-Rogers, R. (1976). Communication in Organizations, New York, Free Press.
- Rogers, E. M. and Kincaid, D. L. (1981). Communication Networks: Towards a New Paradigm for Research, New York, Free Press.
- Rogers, E. M. (1983). Diffusion of Innovations, New York, The Free Press.
- Rogers, E. M. (1993). The diffusion of innovation model, Diffusion and Use of Geographic Information Technologies, I. Masser and H. J. Onsrud. Dordrecht/Boston/London, Kluwer Academic Publishers. 70: 9-24.
- Rogers, E. M. (1995). Diffusion of Innovations, New York, The Free Press.
- Rogers, P. J. and Hough, G. (1995). Improving the effectiveness of evaluations: making the link to organizational theory, Evaluation and Program Planning 18(4): 321-332.
- Rosegger, G. (1986). The Economics of Production and Innovation, Oxford, Pergamon.
- Salge, F. (1998). Presentation in the panel discussion on global spatial data infrastructure initiatives, The 3<sup>rd</sup> Global Spatial Data Infrastructure Conference, 117-19 November 1998, Canberra, Australia.
- Salge, F. (1998a). From an understating of European GI economic activity to the reality of a European data set, Chapter two in European Geographic Information Infrastructures: opportunities and pitfalls, Edited by Peter Burrough and Ian Masser, Taylor & Francis, London, UK.

- Schumacher, E. (1973). *Small is Beautiful: a Study of Economics as if People Mattered*, London: Blond and Briggs.
- Scott, W. R. (1990). Technology and structure: an organizational-level perspective, In *Technology And Organization*, edited by P. S. Goodman, and L. S. a. A. Sproull. (San Francisco, Oxford: Jossey-Bass Publishers), 109-143.
- SDI Cookbook (2000). *Developing Spatial Data Infrastructures: The SDI Cookbook*, Version 1.0, Prepared and released by the GSDI-Technical Working Group, <http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf>, (Accessed July 2001).
- Simon, H. A. (1973). The Organisation of Complex Systems, In *Hierarchy Theory*, Pattee H. (Eds.), pp. 1-27, New York: Braziller.
- Simon, H.A. (1981). *The Sciences of the Artificial*, Cambridge, MA: MIT Press.
- Simpson, S. (1996). Managing risks in the global information infrastructure: corporate information – confidential asset or lever aged resource? *Proceedings of WALIS '96 Forum*, Perth, WALIS.
- Smith, J., Kealy, A., and Williamson, I.P. (2001). Adapting Spatial Data Infrastructures to Support Location Based Wireless Applications, *Upcoming AURISA 2001 Conference*, 29<sup>th</sup> Annual Conference of AURISA, 19-23, Melbourne.
- Somers, R. (1989). Organizational change for successful GIS implementation, *Proceedings of URISA '89*, Boston, Massachusetts, URISA.
- Spence, W. R. (1994). *Innovation: The Communication of Change in Ideas, Practices and Products*. London, Glasgow, Weinheim, New York, Tokyo, Melbourne, Madras, Chapman & Hall.
- Stage, D. (1995). A multi-agency management structure to facilitate the sharing of geographic data in Florida, *Sharing Geographic Information*, H. J. Onsrud and G. Rushton, New Brunswick, NJ, Center for Urban Policy Research: 426-447.
- Starkey, K. and A. McKinlay (1996). *Organisational Innovation: Competitive Strategy and the Management of Change in Four Major Companies*, Aldershot, Hants.; Brookfield, Vermont, Avebury, Gower Publishing Company.
- Suter, K. (1992). *Global Change, Armageddon and the New World Order*, Albatross Books, Australia.
- Steudler, D., Williamson, I. P. Kaufmann, J. and Grant, D.M. (1997). Benchmarking cadastral systems, *The Australian Surveyor* 42(3): 87-106.
- Tang, M. (1995). *Asian Economic Cooperation: Opportunities and Challenges*, Organisation for Economic Cooperation and Development, Paris.
- Therborn, G. (1994). Sociology as a discipline of disagreements and as a paradigm of competing explanations: culture, structure, and the variability of actors and situation, In *Agency And Structure: Reorienting Social Theory*, Ed. by P. Sztompka. (Yverdon, Switzerland; Langhorne, Pa.: Gordon and Breach), 283-306.
- Thompson, B. (1999). *Victorian Geospatial Information Strategy 2000-2003 (Draft )*, Melbourne, Geospatial Information, Land Victoria, Department of Natural Resources and Environment: 19 pages.
- Thompson, M. (1995). The Evolution of a National Spatial Data Infrastructure, *Proceedings of AURISA/SIRC'95, the 7<sup>th</sup> Colloquium of Spatial Information Research Centre*, University of Otago, in association with AURISA, 26-28 April.
- Timpf, S., Volta, G.S., Pollock, D.W., and Egenhofer, M.J. (1992). A Conceptual Model of Wayfinding Using Multiple Levels of Abstractions, In *Theories and Methods of Spatio-*

- Temporal Reasoning in Geographic Space, edited by Frank, A.U., Campari, I., and Formentini, U. 639. Heidelberg-Berlin: Springer Verlag.
- Timpf, S and Frank, A. U. (1997). Using hierarchical spatial data structures for hierarchical spatial reasoning, In Spatial Information Theory - A Theoretical Basis for GIS (International Conference COSIT'97), edited by Hirtle, Stephen C. and Frank, Andrew U. Lecture Notes in Computer Science 1329. Berlin-Heidelberg: Springer-Verlag.
- Timpf, S. (1998). Hierarchical Structures in Map Series, PhD thesis, Department of Geoinformation, Technical University Vienna.
- Tosta, N. (1994a). Continuing evolution of the National Spatial Data Infrastructure, Proceedings of GIS/LIS '94, Washington, D.C., ASPRS/ACSM, AAG, URISA, AM/FM International.
- Tosta, N. (1994b). Data policies and the national spatial data infrastructure, Proceedings of the Conference on Law and Information Policy for Spatial Databases, Tempe, Arizona, National Center for Geographic Information and Analysis, University of Maine.
- Tosta, N. (1995). National Spatial Data Infrastructures: concepts and challenges, Proceedings of AURISA 95, Melbourne, 20-24 November, AURISA 95.
- Tosta, N. (1997). Building national spatial data infrastructures: Roles and Responsibilities, <http://www.gisqatar.org.qa/conf97/links/g1.html>, (Accessed February 1999).
- Tosta, N. (1999). NSDI was supposed to be a verb, Integrating Information Infrastructures with GI Technology, B. Gittings. UK, Taylor & Francis. 1.
- Turnbull, J. and Loukes, D. (1997). Development of an integrated Canadian spatial data model and implementation concept, Proceedings, URISA'97 Conference, 19-23 July 1997, Toronto, Canada. 12 p.
- Turk, A. (1993). The relevance of human factors to geographical information systems, Human Factors in Geographical Information Systems, D. Medyskyj-Scott and H. M. Hearnshaw. London, Belhaven Press: 15-36.
- Tushman, M. L. and Moore, W. L., Eds. (1988). Readings in the Management of Innovation (New York: HarperBusiness).
- UCGIS (1998). The future of the spatial data infrastructure in Research Priorities Revised White Papers, 1998, UCGIS, 1999.
- United Nations (1997). Proceedings of the Sixth United Nations Regional Cartographic Conference for the Americas, Volume 1, Report of the Conference. New York, United Nations.
- UNRCC-AP (1994). Report of the Thirteenth United Nations Regional Cartographic Conference for Asia-Pacific, E/CONF.87/3, Beijing, 9-18 May 1994.
- UNRCC-AP (1997). Report of the Fourteenth United Nations Regional Cartographic Conference for Asia-Pacific, E/CONF.89/5, Bangkok, 3-7 February 1997.
- UNRCC-AP (2000). Report of the Fifteenth United Nations Regional Cartographic Conference for Asia-Pacific, E/CONF.92/1, Kuala Lumpur, 11-14 April 2000.
- USGS (1997). Formal Metadata – info and tools, USGS, NSDI, web-site, <http://geochange.er.usgs.gov/pub/tools/metadata/>, (Accessed September 1999).
- Van Helden, P. (1996). GIS diffusion in South African local government, Proceedings of the Second Joint European Conference & Exhibition on Geographical Information, Barcelona, Spain, IOS Press.
- Ventura, S. J. (1995). Overarching bodies for coordinating geographic data sharing at three levels of government, Sharing Geographic Information, H. J. Onsrud and G. Rushton. New Brunswick, NJ, Center for Urban Policy Research: 172-192.

- Volta, G., and Egenhofer, M. (1993). Interaction with GIS Attribute Data Based on Categorical Coverages, in: A. Frank and I. Campari (eds.), European Conference on Spatial Information Theory, Marciana Marina, Italy.
- Watson, R.T. (1996). Data Management - An Organisational Perspective. John Wiley & Sons, New York, 568 p.
- Wehn de Montalvo, U. (2000). Access to Spatial Data – What Determines the Willingness of Organisations to Share it?, Proceedings of 4<sup>th</sup> Global Spatial Data Infrastructure, CapeTown, South Africa.
- Weiss, L. S. (1998). Report of the National Spatial Data Infrastructure Measures of Progress Workshop, US Army Research Office: 25 pages (webpage).
- Wildemuth, B. M. (1992). An empirically grounded model of the adoption of intellectual technologies. *Journal of the American Society for Information Science*, 43(3), 210-224.
- Williamson, I. P. (1992). ASEAN – Australian Economic Cooperation Programme, phase II, mid term review, (Australian Consultant's draft report, Melbourne, Australia).
- Williamson, I. P. (1994). Cadastral Systems in the Asia-Pacific Region - Experiences and Lessons, FIG Land Records Conference/Geomatics Atlantic, Fredericton, Canada.
- Williamson, I.P. (2000). Land administration systems in developing countries. Proceedings, International Conference on Land Policy Reform, Jakarta, 25-27 July 2000, <http://www.landpolicy.org/>, (Accessed October 2000).
- Zachman, J. (1987). A framework for information systems architecture, *IBM Systems Journal* 26(3).
- Zaltman, G., Duncan, R., and Holbeck, J. (1973). *Innovations and Organisations*, John Wiley & Sons, New York.
- Zartman, I. W., Ed. (1994). *International Multilateral Negotiation: Approaches to the Management of Complexity*, The Jossey-Bass Conflict Resolution Series, San Francisco, Jossey-Bass Publishers.