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Linking Spatial Planning and Emergency Management through Open Data:

The Reuse of Haiyan's Volunteered Disaster Data to Support Tacloban's Post-Disaster Recovery and Redevelopment

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Abstract

The decline of disaster impacts and losses is a great feat made possible by modern technology and increased awareness and engagement.However, this is not a universal phenomenon. Disproportionate development benefits place emerging economies at a disadvantage to manage their own risks, which results in a reversed trend. This is often attributed to lack of financial and knowledge resources that impede better judgement and appropriate actions. Nevertheless, with the latest information and communications technology (ICT) advancements, innovative solutions surface, such as open data (OD) reuse. This was investigated by the research using volunteered disaster data (VDD) from the recent Haiyan catastrophe. The study argued that VDDs may be reused to improve data gaps necessary for an effective integration of spatial planning and emergency management, which will eventually lead to better resilience and development. The outcomeswere positive, butthere are challenges to be hurdled. Despite the availability of voluminous VDDs, issues regarding interoperability, reliability and perceived acceptability need to be addressed. Indeed, ODs have value and its reuse holds some promise, but its realisationrequires critical changes and improvements to be made.

La diminuzione degli impatti e delle perdite causate dai disastri naturali costituiscono una grande sfida resa possibile dalla tecnologia moderna e da una maggiore consapevolezza ed impegno; ma ciò non accade ovunque. Le economie emergenti, a causa degli spropositati benefici derivanti dal proprio sviluppo, si trovano in una situazione svantaggiata nel gestire i propri rischi, il che si traduce spesso in un'inversione del trend. L'incapacità di fronteggiare tali situazioni è solitamente attribuita alla mancanza di risorse finanziarie e alla mancanza di conoscenza che impediscono un giudizio accurato e l'assunzione di azioni appropriate. Tuttavia, con le ultime innovazioni nel campo del information and communications technology *(ICT), emergono nuove soluzioni come, ad esempio, il reimpiego degli open data (OD). I vantaggi conseguenti all'utilizzo degli open data sono ricercati all'interno di questo lavoro, in particolare utilizzando i dati provenienti dal volunteered disaster data (VDD) circa la recente catastrofe del tifone Haiyan. Lo studio sostiene che il riutilizzo dei VDD è in grado di completare il quadro informativo per consentire un'efficace integrazione della pianificazione territoriale con la gestione delle emergenze. Sebbene l'impiego dei VDD offra a una migliore capacità di recupero e di sviluppo, restano ancora numerose le sfide per il raggiungimento di tale obiettivo. Nonostante la disponibilità di grandi dati VDD, devono essere ancora affrontati diversi problemi che riguardano l'interoperabilità, affidabilità e l'accettabilità sociale. Gli open data hanno un valore e il loro riutilizzo promette un grande potenziale, che deve però essere pero' ancora dimostrato.*

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ACRONYMS AND ABBREVIATIONS

AFP	Armed Forces of the Philippines
ALNAP	Active Learning Network for Accountability and Performance in Humanitarian Action
Apps	Applications
ARC	American Red Cross
ASL	Above Sea Level
CBRN	Chemical, biological, radiological and nuclear
CCIMS	Crisis Information Management System
CLUP	Comprehensive Land Use Planning
DCC	Disaster Coordinating Council
DHR	Digital Humanitarian Response
DHN	Digital Humanitarian Network
DILG	Department of Interior and Local Government
DOH	Department of Health
DOST	Department of Science and Technology
DPWH	Department of Public Works and Highways
DRA	Disaster Risk Assessment
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DRRM	Disaster Risk Reduction and Management
DSWD	Department of Social Welfare and Development
ECHO	European Community Humanitarian Aid and Civil Protection Department
EM	Emergency Management
EMDAT	Emergency Events Database
EMI	Emergency Management Institute
FEMA	Federal Emergency Management Agency
GDACS	Global Disaster Alert and Coordination System
GIS	Geographic Information Systems
GDP	Gross Domestic Product
HHI	Harvard Humanitarian Institute
ICT	Information and Communications Technology
IDP	Internally Displaced Persons
IFRC	International Federation of Red Cross and Red Crescent Societies
IGO	Intergovernmental Organisations
JMA	Japan Meteorological Agency
JTWC	Joint Typhoon Warning Center
LGU	Local Government Unit
LUP	Land Use Planning
MASL	Metres above Sea Level

MDG	Millennium Development Goals
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
MTurk	Mechanical Turk
NEDA	National Economic Development Authority
NDRRMC	National Disaster Risk Reduction and Management Council
NGO	Non-government Organisations
NOAH	Nationwide Operational Assessment of Hazards
NSCB	National Statistical Coordination Board
NSO	National Statistics Office
OD	Open Data
OHI	Open Humanitarian Initiative
OSI	Open Source Initiative
OSM	OpenStreetMap
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAR	Philippine Area of Responsibility
PRC	Philippine Red Cross
PSWS	Public Storm Warning Signal
Q&A	Question and answer
RA	Republic Act
RPS	Rationalizing the Local Planning System (Philippines)
RS	Remote Sensing
SBTF	Standby Task Force
SNTF	Special Needs Task Force
SRTM	Shuttle Radar Topography Mission
SWAT	Special Weapons and Tactics
UHP	Ushahidi Haiti Project
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNISDR	United Nations International Strategy for Disaster Reduction
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
USAID	United States Agency of International Development
USCG	United States Coast Guard
VDD	Volunteered Disaster Data
VOIP	Voice over Internet Protocol
WASH	Water, Sanitation and Hygiene
WB	World Bank

DEFINITION OF TERMS

Climate Change – is a statistically significant change in measurements of either the mean state or variability of the climate for a place or region over an extended period of time, either directly or indirectly due to the impact of human activity on the composition of the global atmosphere or due to natural variability. (Provention Consortium)

Closed Data – data with limited access and restricted use due to copyright, patents or licences

Component Cities - Cities which do not meet the above requirements shall be considered component cities of the province in which they are geographically located. If a component city is located within the boundaries of two (2) or more provinces, such city shall be considered a component of the province of which it used to be a municipality. (NSCB)

Crowdsourcing - is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the 'crowdsourcer' will obtain and utilize to their advantage that what the user has brought to the venture, whose form will depend on the type of activity undertaken.

Disaster – isthe occurrence of an extreme hazard event that impacts on vulnerable communities causing substantial damage, disruption and possible casualties, and leaving the affected communities unable to function normally without outside assistance. (Provention Consortium)

Disaster Risk – is a function of the characteristics and frequency of hazards experienced in a specified location, the nature of elements at risk and their inherent degree of vulnerability or resilience. (Provention Consortium)

Exposure – People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. (UNISDR, ADPC)

Hazard – A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. (UNISDR, ADPC)

Highly Urbanized Cities - Cities with a minimum population of two hundred thousand (200,000) inhabitants, as certified by the National Statistics Office, and with the latest annual income of at least Fifty Million Pesos (P50,000,000.00) based on 1991 constant prices, as certified by the city treasurer. (NSCB)

Independent Component Cities - Cities whose charters prohibit their voters from voting for provincial elective officials. Independent component cities shall be independent of the province. (NSCB)

Mitigation – refers to any structural (physical) or non-structural (e.g., land use planning, public education) measure undertaken to minimise the adverse impact of potential natural hazard events. (Provention Consortium)

Natural Hazard - a hazardous event due to unrestrained forces of nature that causes unacceptably large numbers of fatalities and overwhelming property damage is a Natural Hazard.

Open Data - data that should be freely available to everyone to use, reuse and redistributed as they wish, without restrictions from copyright, patents or other mechanisms of control. (Open Knowledge Foundation)

Post-Disaster Recovery and Redevelopment – refers to activities and measures undertaken after disaster conditions have been stabilised to restore a community's activities to normal; it often follows the emergency response phase.

Preparedness – refers to activities and measures taken before hazard events occur to forecast and warn against them, evacuate people and property when they threaten and ensure effective response (e.g., stockpiling food supplies). (Provention Consortium)

Traditional Data – pertains to data that were produced or generated by traditional sources of public data such as officials or reputable authorities, agencies and governments.

Volunteered Disaster Data – is a type of open data freely generated by individuals or groups during disaster events to support emergency response activities.

Vulnerability – is the potential to suffer harm or loss, related to the capacity to anticipate a hazard, cope with it, resist it and recover from its impact. Both vulnerability and its antithesis, resilience, are determined by physical, environmental, social, economic, political, cultural and institutional factors. (Provention Consortium)

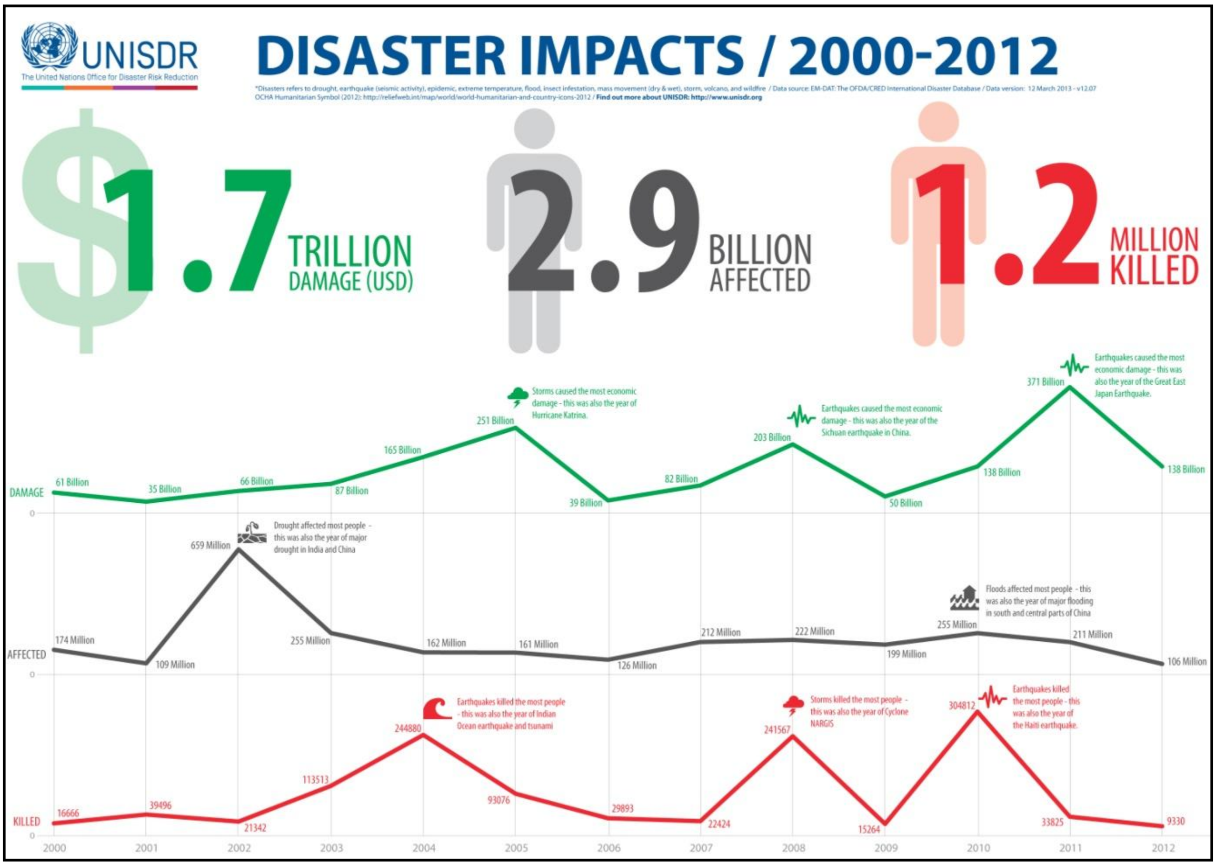
Web 2.0 – the second stage of development of the Internet, characterized especially by the change from static web pages to dynamic or user-generated content and the growth of social media. (Oxford University Press)

1 Introduction

1.1 Background of the Study

In the past decades, an overall decrease in disaster impact trends had been observed. This decline can be ascribed to the heightened disaster awareness and preparations, as well as the improved overall development conditions. However, despite the drop, world economies are still under a grave threat due to the mounting exposure of its fiscal assets and growing population (Velasquez, 2012). This is both valid for well-developed and developing regions, especially in urban areas where higher concentrations of economic activities and people are situated. Nonetheless, a disparity exists between the development benefits that are enjoyed by both. Thiscondition prompts emerging economies to face greater potential losses compared with the former. This is particularly true for the Asia-Pacific region, which is considered to be more predisposed to hazards than any other region around the globe. It is four times more likely to suffer natural hazards than people residing in Africa, and 25 times more likely than those staying in Europe or North America. During 1980-2009, the region has accounted for 38% of global economic losses, which is far greater than its 25% contribution to the global GDP (Xuan & Velasquez, 2010).

Figure 1 UNISDR Disaster Impacts Trend (2000-2012)



Source: UNISDR, 2013

EMDAT also substantiates the claim regarding disproportionate impacts of disasters through its datasets. The trends of natural disaster occurrences, fatalities and economic losses for the last ten years displayed an overall decreasing pattern when plotted. However,it had variations at the country level. This issue is reflected in the disaster data trends of several pre-identified countries, namely Italy, Japan and the Philippines.These countries were chosen to iterate the unequal exposure between countries as influenced by the differences in economic stature and varying geographical characteristics.Italy and Japan were paired to illustrate the varying exposure risks of well-developed economies due to differences in geographical characteristics, while Japan and the Philippineswere matched to exemplify the varying exposure risks due to different economic status and resources.

As shown in Figure 2.Natural Disaster Occurrences for 2004-2013, trends in occurrences for the period of 2004-2013 appear to be generally decreasing, but with a striking difference in the number of occurrences between the European and Asia-Pacific regions. Japan and the Philippines have noticeably higher occurrences compared to Italy. While it has slightly gone up for Japan, the total number of disasters in the Philippines is still slightly higher, which signals a bigger potential for losses. The trend for losses and fatalities are shown below in Figures Figure 3 and Figure 4, which also supports the findings of UNISDR and UNESCAP that economic and social exposures are closely linked together. The trends for both well-developed countries coincide and showeda decrease in losses and fatalities, but conversely, it blew up for the emerging economy.

Despite both being located in the disaster-prone Asia-Pacific region, Japan and the Philippines have differing development and economic conditions. Japan's per capita GDP is measured at US$ 31,267 while the Philippines has US$ 5,137. The human development index also has a huge difference with Japan having a human development index of 0.953 compared to 0.771 of the Philippines. In terms of exposure to hydrometeorological incidents, Japan has about 1.4 times as more people exposed than the Philippines, but should a typhoon of the same magnitude occur, casualties in the Philippines would be 17 times more than Japan (UNISDR, 2009).

With the above example, clearly it is not just geography that influences the increased exposure and vulnerability to disasters. It comes down to the ability of the country to manage its own risks. It highlights the disaster-poverty nexus wherein inadequate resources hinder the full commitment to disaster risk reduction (DRR). For emerging economies, investing in emergency management (EM) such as early warning systems and hazard modelling and simulation have become problematic due to the need to balance their budgets and cut down on fiscal expenditures in order to sustain their growth (Velasquez, 2012).

On the other hand, there are tools that do not require huge outlays to address DRR concerns, but are just as effective. Recently, spatial planning has been promoted as such. In addition, moves to mainstream DRR into development planning have also been escalating. Nevertheless, there are challenges that must be overcome for a smooth integration to happen.

One of these challenges is bridging the data gap in developing regions to permit authorities and communities to fully understand the risks they face. Only with better information can risks be properly identified and well-informed decisions made. All these are crucial in establishing an effective EM system. Therefore, it is imperative that access to reliable information be improved.

Figure 2.Natural Disaster Occurrences for 2004-2013(Data from EMDAT)

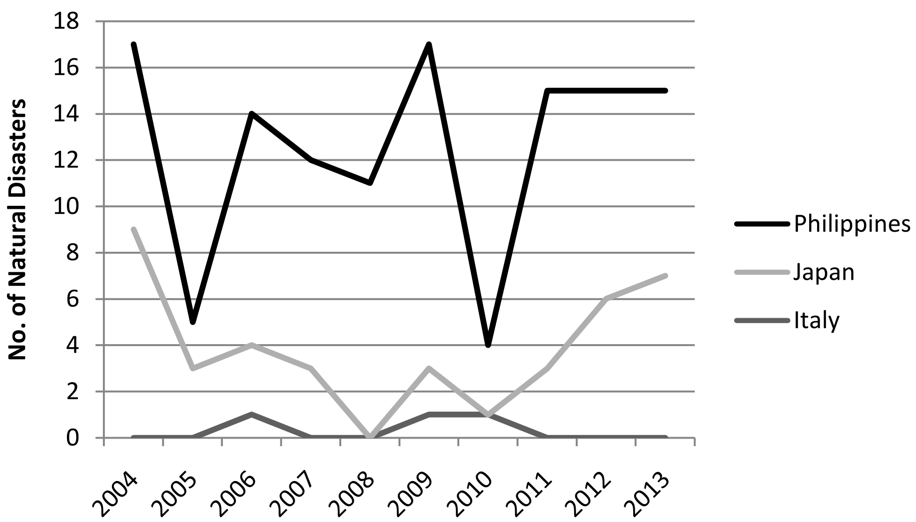


Figure 3Natural Disaster Fatalities for 2004-2013 (Data from EMDAT)

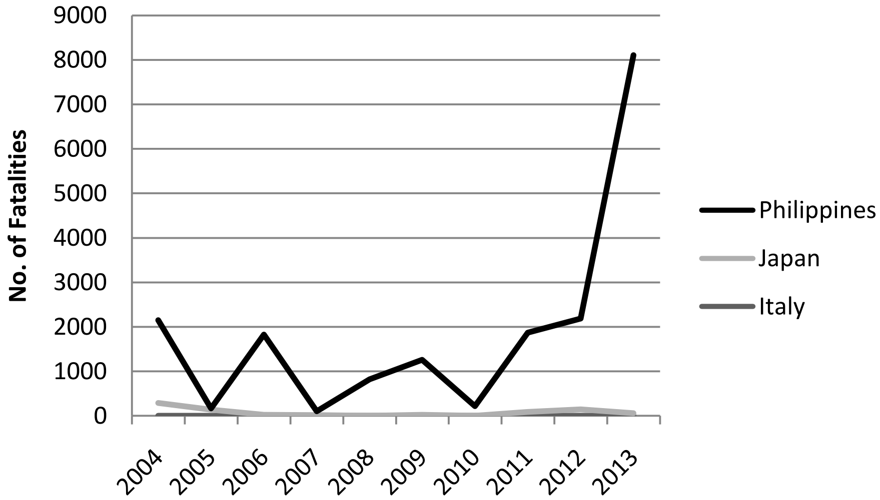
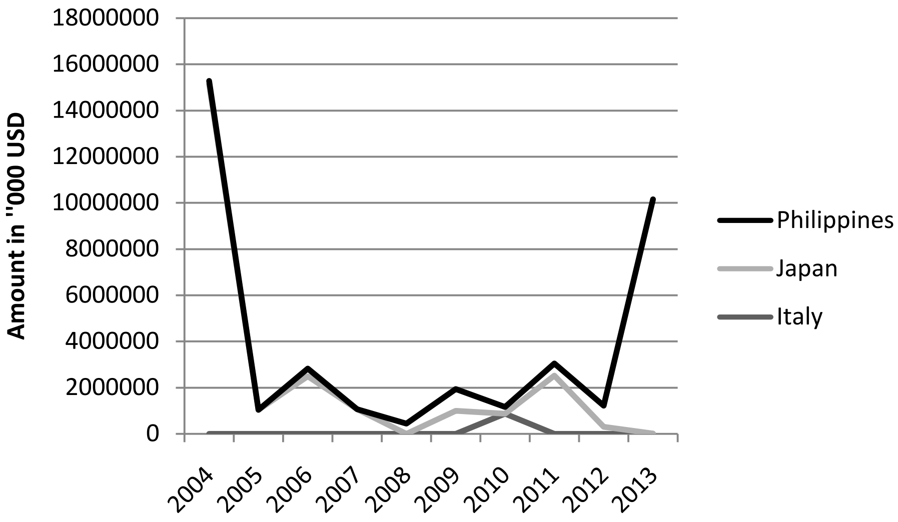


Figure 4Natural Disaster Economic Losses for 2004-2013 (Data from EMDAT)



Most often than not, access to information comes with a price tag that smaller and middle-income countries could not afford. Nevertheless, recent technological advancements could offer innovative solutions to this problematic accessibility.

With the proliferation of the internet and the advent of Web 2.0, information generation, retrieval, and dissemination have become more convenient, not just for authorities and organisations, but for the general public as well. In fact, this situation has led to an increase in the public's participation in civic activities using technology-aided tools, and resulted to the intensified production of freely accessible information, through the form of open data. All these are becoming instrumental in advancing the development and resilience agenda, particularly open data that were collaboratively generated during disasters. This was witnessed in the 2010 Haiti Earthquake, the 2012 Typhoon Bopha and the most recent 2013 Typhoon Haiyan, where modern technologies were utilised to protect lives and properties, and to respond to emergencies. This phenomenon was witnessed invarious activities such as crowdsourcedcrisis mapping, emergency response, and public advisory/ messages broadcasts, with the help of remote sensing and imagery, social media networks and the Internet.

In the recent Super Typhoon Haiyan disaster, numerous alerts have been issued prior to the catastrophe. Affected countries have been warned by meteorological agencies, which they heeded. These warnings were ensued by preparations for the looming disaster. Nevertheless, in the Philippines, these preparations did not suffice. The number of casualties and economic losses still soared unimaginably. As regarding to NDRRMC last update dated 17th of April 2014, the casualty count reached a total of 6300, while total damages amounted to approximately US$ 2,051,710,653.57 (National Disaster Risk Reduction and Management Council, 2014).

Most of the heavy destruction was caused by the storm surge brought by the typhoon. People were dumbfounded that pre-emptive actions were not enough. Despite the availability of information regarding the potential threat of the storm surge, these areas did not fully understand the potential consequences of the hazard.This was corroborated by some of the interviews wherein the people said they were ready for the wind, but not for the inundation (Klonoski, 2013).

Prior to the disaster, the Philippines had already compiled the information regarding potential hazards in the country, including storm surges. In fact, this information was already included in the comprehensive land use plan (CLUP) documents of the affected areas. However, some of the hazard maps were finalised after the proposed land use maps were crafted, and contained very modest values. The storm surge hazard map only anticipated 1-4 metre storm surges, which varied greatly with the estimated 5 metre height as stated in the issued storm surge warnings(Bacani, 2013) and with the actual storm surge height that reached 6 metres above sea level (MASL) (Morgerman, 2014). Scenarios were also not considered and were thus, unavailable. This situation is an unfortunate example that could have probably been averted or cushioned if critical information were reliable, readily available and easily understood.

1.2 Statement of the Problem

Increased disaster awareness and improved efforts to mainstream disaster risk management (DRM) into development have led to a significant progress in EM. In the recent years, the total number of mortalities due to natural disasters has been decreasing(Velasquez, 2012). This has been attributed to the use of integrated approaches, such as risk-sensitive spatial planning, and of modern technologies, such as the internet, geographic information systems, and remote sensing, that have helped bolster development and resilience globally.

However, this condition is not universal. Though there has been a general decrease, mounting disaster trends are still witnessed in various countries, especially in nations of the developing regions. Despite their rising interest and intent to address disaster risks, these disadvantaged countries cannot fully commit themselves to EM due to their constrained knowledge of hazards, and limited resources, which they struggle to balance to sustain their growth. In some countries, there is still a lack of established land use plans at both the national and local levels and policy support is poor. In several other cases where risk-sensitive land use plans are available, it has been prepared without considering crucial information such as disaster damage, loss estimations and integrated capacity assessment(Velasquez, 2012). Such insufficient information hampers the full understanding of disaster impacts and consequences, and prevents the creation of an effective EM system. Unfortunately, as access to reliable information comes with a price tag, many are forced to make do with their outdated baseline data, such as decades old census and infrastructure data, and base maps (Crowley, 2014).

The study recognises the importance of employing integrated approaches to effectively manage disaster risks and protect development gains, but it also acknowledges that to carry this out, access to critical information is necessary. This was evident in the recent Super Typhoon Haiyan disaster.Despite the availability of hazard maps and including it in the land use plans, poor locational choices have led to grave consequences, such as the inundation of designated evacuation centres.

Both the absence of critical information and use of unreliable data regarding disaster risks and its impending consequences make it impossible to prescribe and carry out appropriate measures. Thus, the first step in order to advance a disadvantaged country's DRM is to enhance their access to critical information. The study proposes to address this prevailing data gap in developing regions through the reuse of open data generated during disasters, or what we may call *volunteered disaster data (VDD),* to support post-disaster recovery and redevelopment and future disaster risk mitigation efforts.

1.3 Purpose of the Study

The main goal of the study is to lessen the data gaps in developing regions to contribute to the eventual betterment of their EM and spatial planning systems integration.

The work intends to analyse the value of potentially reusingVDDs that has been freely generated either collaboratively or individually to support the post-disaster recovery and redevelopment, and future risk mitigationof the calamity-stricken areas. This type of open data will be distinguished as *volunteered disaster data* (VDD) to avoid confusion, and to highlight the purpose of its generation, method of production and data contents.

Specifically, the study seeks to:

(1) Identify potential uses of VDDs in the spatial planning process and various stages of the EM cycle
(2) Provide a reuse example through a practical application

1.4 Significance of the Study

The study seeks to understand the role of open data, such as VDDs, in advancing development and resilience through facilitating the integration of spatial planning and emergency management,which are often seen as exclusive.

Essentially, VDDs are originally intended to support emergency response and relief activities. Nonetheless, it contains pertinent information that may be used to supplement outmoded baseline information and local knowledge. Moreover, as disasters are becoming more dynamic with the changing climate, it is now unlikely that past information will suffice and serve as a good indicator of future incident patterns and trends. In turn, this also contributes to enhancing the capacity to develop better plans and strategies that promote thesafeguardingof hard-earned assets through well-aligned EM and spatial planning systems.

The idea of reusing VDDs is not without qualms, but the study hopes to contribute in settling some of these doubts by evaluating its potential value, the possibility of its reuse, its advantages and limitations, and future opportunities.

1.5 Scope and Limitations of the Study

As the overall goal of the study is to improve the resilience and development in emerging regions, the study has chosen the Philippines as its study site. It is considered to be an emerging economy, and coincidentally,it is also the site of the recent massive catastrophe, Super Typhoon Haiyan.

The study will gather volunteered disaster data related to Haiyan in the Philippines and analyse the nature of the data collected. However, due the wide expanse of the disaster, the study will only concentrate on Haiyan's most damaged city, the calamity-stricken Tacloban.

1.6 Structure of the Study

The paper is divided into six (6) parts:

(1) Introduction
(2) Concepts
(3) Methodologies
(4) Case Study
(5) Application
(6) Conclusion and Recommendations

Chapter 2 introduces the concepts used in the study.It serves to clarify how the research is perceived. Some terminologies are also discussed, especially those that may contain some ambiguity. Brief explanations are given to helpavert confusion.

This is ensued by a discussion of the methods employed by the study in Chapter 3. As this can influence and limit the results of the study, it is important to make this known. This will also be useful for those that want to replicate or further study the topic, and for the evaluation of work.

Following the threshing out of technicalities, an overview of the current trends in EM and development leading to the present condition of the study area is presented in Chapter 4. It focuses on how EM is being done in the area of interest, and discusses its implications in light of the recent major disaster, specifically during the preparation and response phases. It then proceeds to provide additional information regarding the specific area for a clearer image of the overall situation.

In Chapter 5, patterns and trends are conveyed and encountered issues during the work are highlighted. Taking these emerging patterns, trends and issues into consideration, the paper finishes with the reaffirmation and/or negation of the initial assumptions made, while also making some recommendations for future research considerations. These affirmations, negations and future considerations are presented in Chapter 6, the final part.

2 Concepts

2.1 The Relationship between Development, Hazards and Disasters

Development and resilience are often misconstrued. They are neither synonymous nor exclusive. One is not an end, nor a means to achieve the other. In fact, there were some cases where in development initiatives have intensified the existing vulnerabilities and even created new ones(Benson, Twigg, & Rossetto, 2007). In order to prevent this from recurring, there must be a clear idea about both concepts.Actions must also be done in a synergistic manner if the quality of life were to be improved whilst ensuring that this achievement withstands the threats of hazards.

The link between development, disasters and hazards is vulnerability. Disasters only occur when a vulnerable population is exposed to the hazard. From the perspective of vulnerability, disasters are caused not just by hazards. They are also influenced by the condition of the exposed elements and the population's overall vulnerability as defined by the economic assets, and demographic and geographic characteristics of an area(NEDA, UNDP, ECHO, 2008).

It is true that development, especially economic development, reduces risks from disasters as it can provide the required financial resources to improve the necessary facilities and technology, and sponsor essential knowledge transfer and training for the recognition and monitoring of disasters. It also allows for the provision of the vital services to communities that lessen their vulnerabilities and boost their resilience (NEDA, UNDP, ECHO, 2008). Following this fashion, many emerging countries channel most of their resources to development initiatives. However, this creates an irony for these countries whenever a disaster strikes.

These inappropriate development choices lead to greater risks. The lack of mitigation, preparedness and overall planning may spell out a lot difference when a disaster occurs as it will push back social and economic growth due to the interruption of development efforts. Recurring catastrophes will even exacerbate poverty conditions and dwarf one's development achievements. When a crisis strikes, the meagre resources that have been allocated for development endeavours will have to be rechanneled to support the rehabilitation and reconstruction. In the end, the costs become much higher due to necessary damage repair and replacement (NEDA, UNDP, ECHO, 2008).

Taking this into consideration, mainstreaming DRR into development planning becomes a logical and cost-effective choice and solution. Vulnerabilities may be addressed by development tools such as spatial or land use planning that employ both regulatory and non-regulatory means and technical processes to effectively modify existing vulnerabilities and reduce disaster risks (Roberts, Rahman, Ronilda Co, Cooray, Tawdid, & Roy, 2011), such as poor location choices for economic activities, infrastructures and settlements. It is also instrumental in addressing some issues such as uncontrolled rapid urban growth and promotingthe appropriate allocation of the scarce land and natural resources (NEDA, UNDP, ECHO, 2008).

2.2 Spatial Planning + Emergency Management = Resilient Development

As early as the 1990s, the need to integrate and mainstream DRR into development has already been identified. However, this action requires a good comprehension of hazards and the ability to analyse its potential effects not just in terms of physical damages or numbers, but also on how it affects the overall development of the various areas in terms of its consequences on projects, programs and policies(Benson, Twigg, & Rossetto, 2007). The knowledge of these relationships allows authorities and planners to better understand social patterns and trends and the influence of land use allocations towards vulnerabilities, such as the choice of informal settlers to inhabit high-risk locations or for instance, increased vulnerability indices through mixing incompatible or conflicting land uses. In this light, spatial planning becomes instrumental in addressing or worsening the threats of disaster risks (Roberts, Rahman, Ronilda Co, Cooray, Tawdid, & Roy, 2011).

2.2.1 Spatial Planning and its data requirements

There is not a single definition for spatial planning, but for a common understanding, the definition given by the United Nations Economic Commission for Europe (UNECE) was chosen as it incorporates the common elements found in other definitions. UNECE defines spatial planning as “a key instrument for establishing long-term, sustainable frameworks for social, territorial and economic development both within and between countries. Its primary role is to enhance the integration between sectors such as housing, transport, energy and industry, and to improve national and local systems of urban and rural development, also taking into account environmental considerations” (United Nations Economic Commission for Europe, 2008). Professional disciplines such as urban, regional, land use, environmental, transport, economic, social, and community planning make use of spatial planning (Spatial planning, 2014).

Spatial planning practices vary greatly between countries, but most of them share some common features, such as using it for goal setting, strategy development and policy coordination (United Nations Economic Commission for Europe, 2008), which all requires research and careful investigation. Indeed, spatial planning is intrinsically a knowledge-intensive activity. Planners regularly deal with voluminous materials on statistics and geography for research and investigation.Even the most banal changes in zoning or development proposals do not escape and require documentation, which also results to an immense amount of information such as minutes, memos, transcripts and notes. (Goodspeed, Knowledge Management for Planning Organizations, 2011).

In most cases, planners generally rely on traditional data, including information on hazards, which are normally curated by mandated agencies. These agencies (a) gather, analyse and map hazard data; (b) monitor and disseminate critical hazard information to the public; and (c) make recommendations for actions to mitigate the impacts of the identified relevant hazards. Some specific sources include historical accounts, instrumental records, geologic and geomorphic studies, geotechnical assessments, modelling, trigger agent analysis, and professional opinion (NEDA, UNDP, ECHO, 2008).

Outputs of spatial planning exercises are land use plans and physical frameworks that depict the spatial features necessary to achieve the desired development scenario of an area. Land use plans facilitate the interaction between people and land resources to allow them to maximise its benefits and direct it towards the attainment of its identified development goals. Land use plans are time-bounded and often have a long timeframe(NEDA, UNDP, ECHO, 2008). In this light, it has a lasting impact that may be difficult to alter or reverse. Therefore, careful preparation is necessary to avoid unfavourable effects.To achieve this, the need for a well-grounded research and information base is again emphasized.

Studying the various sectors or components of an area is necessary for the conduct of spatial or land use planning. Familiarization with their datasets is necessary for the creation of well-informed plans and strategies. The common data requirements for integrating DRR concerns are displayed in Table 1.

However, for planning to be an effective risk reduction and emergency management tool, satisfaction of the data requirements is not enough. There are other challenges that must be met such as the following:

(1) Inadequate information on the rate of occurrence and severity of the hazards
(2) Varying risks due to weather extremes and unpredictable patterns
(3) Intractable existing land uses
(4) Political cooperation deficiency
(5) Local ownership support and implementation

With consideration to the posted challenges, the question now becomes "how can the two fields be integrated successfully?" Is there is a generic formula or standard that may be adopted to ensure success? Sadly, there is no generic formula or standard because conditions and capacities vary from one country to another. However, there are seven (7) factors that have been identified as critical to the success of the mainstreaming process. This was developed by the Provention Consortium for the use of development-oriented organisations that support hazard-prone countries. Nevertheless, it is also a good reference for planning authorities, governments and emergency professionals. The critical factors they have identified are the following:

Table 1 Common Spatial Planning Data Requirements for Integrating Disaster Risks

Sectors / Category	Data examples
(1) Physical / Infrastructure	• Land area • Characteristics of land resources (hydrology, geology, slope aspects) • Land use, land suitability, and land classification • Land tenure • Weather patterns • Transportation (roads, ports, airports) and communication facilities • Existing and proposed facilities, routes, service coverage
(2) Social or demographic data	Size, density, growth rate, urban-rural distribution, age, gender
(3) Economic	• Key sectors: agriculture, fishery, production forestry, manufacturing, trade, industry, services, tourism • Employment / unemployment rates • Income or value of production per sector • Export products, markets, volume by sector • Existing and proposed support infrastructure
(4) Environment	Environment and natural resources, environmental quality
(5) Institutional	• Organisational structure and capacity • Income and poverty (Average family income, poverty indicators) • Basic social services: Housing, health, education, sanitation, security • Public works, water supply, drainage, solid waste • Power • Existing and proposed facilities • Levels of service of basic social services
(6) Hazard Information	• Consequence Analysis (including past damages and losses) • Exposure

Adapted from: ADPC RCC Guideline 3.2, 2011

(1) Awareness raising
This refers to the better understanding of EM's relevance to sustainable development, and stresses the need for greater accountability towards risk reduction and disaster-related losses and consequences. It highlights the importance of risk assessment and mitigation as it directly impacts sustainable development and poverty reduction endeavours.

(2) Enabling Environment
This includes the encompassing policies that promote prioritisation of EM as a development issue and challenge.

(3) Development of Tools
It is the availability of programming and assessment tools for comprehensive risk identification and assessment to warrant appropriate decisions and actions are taken.

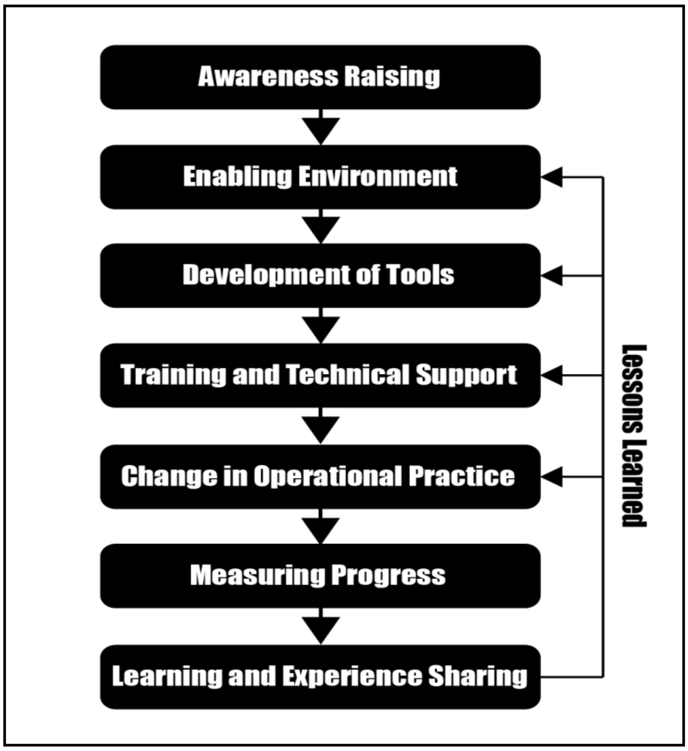
(4) Training and Technical Support
It indicates the provision of necessary technical training and support for the integration of emergency management concerns into development.

(5) Change in Operational Practice
- Early detection of hazards and relevant disaster information for proper planning, decision, and action
- Ample and reliable support information for accurate risk assessment and mitigation measures
- Citizen and government cooperation for cost-effective information management, including relevant data collection, sharing and analysis
- Comprehensive treatment for both low and high probability risks with due consideration to hazard frequency, probability and impact levels
- Promotion of responsible, non-discriminatory and transparent consultation with all stakeholders
- Proper maintenance of development investments

(6) Measuring Progress
This specifies that EM targets should be integrated in the development goals to provide a common framework and performance indicator for stakeholders.

(7) Learning and Experience Sharing
This points out that the necessity for cooperative monitoring, learning and sharing of mainstreaming experiences between various stakeholders.

Figure 5 Critical Factors for a Successful Mainstreaming of EM into Development Planning



Source: Provention Consortium, 2007

Out of the seven (7) critical factors, items 1 and 2 prove to be the less problematic ones. EM has been gaining recognition in the past decades, and due to this, more government, organisations and communities endeavour to support it (Tiefenbacher, 2013).This translates tothe creation of an enabled environment.

On the other hand, the satisfaction rate for items 3-7 greatly vary as it is influenced by a number of things such as the country's fiscal and technical capacity, development priority, and political support. These items are closely linked together and create a chain effect when a criterion is not met. Perhaps, the most challenging is item 5 as it requires a change in the operating procedures, stakeholder interactions and responsibilities, and the reallocation of resources. It also requires some investment in technology in order to meet some of the requirements such as building or improving the information base for hazards, which is a basic prerequisite for successfully incorporating disaster risk concerns into development planning and establishing an effective EM system to respond to various adversities and threats.

2.2.2 Emergency Management and its data requirements

In 2007 many organizations gathered at the Emergency Management Institute (EMI) to define a set of principles for EM. They defined EM as “the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters”(FEMA).

As they noted, the mission of the whole emergency management process is to protect communities by coordinating and integrating all activities necessary to build, sustain, and improve the capability to mitigate against, prepare for, respond to, and recover from threatened or actual natural disasters, acts of terrorism, or other man-made disasters. Therefore, it can be understood that the process involves four types of activities: (1)Prevention& Mitigation, (2)Preparedness, (3)Response and (4)Recovery. Each phase is detailed below.

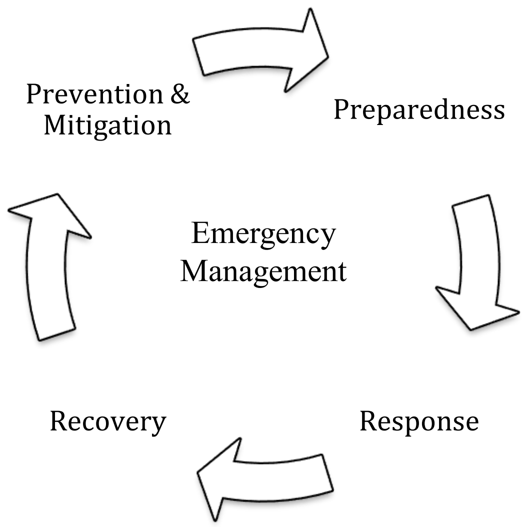


Figure 6 Emergency Management Cycle

(1) Prevention & Mitigation

This phase refers to activities and policies aimed at preventing an emergency, reducing the likelihood of its occurrence, lowering the vulnerability of a population and minimizing the harmful effects of future disasters. These activities should be carried out long before the occurrence of an adverse event and repeated after its completion. This phase begins with the identification and assessment of hazards and moves to planning and implementation of long-term measures. Examples of these measures are construction of protective structures such as dykes or water drains, plans for occupation of land, laws and penalties, adaption of better standards and techniques in engineering and allocation of resources.

(2) Preparedness
This phaseincludes plans and activities that are continually held prior to the disaster's occurrence. It consists of actions to extend a group's capability to successfully respond to emergencies. It also includes the designing of emergency plans, personnel training, conducting inter-organizational exercises, on-going evaluation of plans, resources and equipment maintenance, and conducting studies and forecasts about the impacts and needs that may arise in the event of a particular disaster. Moreover, measures involving the civilian population can also be adopted, such as volunteer training, testing communication systems and warning and evacuation exercises(Vivacqua & Borges, 2012).

(3) *Response*
This phase begins immediately after an incident and ends when the situation has been stabilized. It aims at saving lives and preventing major economic losses and environmental problems. Some characteristics such as unpredictability, speed of the event, number of the people involved, uncertainty about the situation, unavailability of resources, pressure and stress on those involved, have made this phase so complex. In principle, it consists of putting previously developed and exercised plans into action. However, due to the uniqueness of each emergency, plans usually cannot be executedin the exact same way and requiressome adaptation. Therefore, the personnel involved also need to take actions and create new procedures during the emergency response. As Vivacqua& Borges noted "the main activities in this phase include the mobilization and coordination of resources, risk assessment, prioritization of goals and analysis of risks, medical, search and rescue guidance and providing shelter for the affected" (Vivacqua & Borges, 2012).

(4) *Recovery*
The recovery phase starts as soon as the emergency is controlled. Recovery may last for weeks, months or even years to complete and its main goal is to repair, rebuild or regain what was lost in the disaster. It consists of actions taken to return the community back to normal.These actions may be short-term such as the restoration of vital lines for the affected population or long-term such as restoring the local economy or rebuilding the infrastructure. However, following the "build back better" principle, this stage provides a unique opportunity to undertake measures to reduce the risks or effects of future disasters by merging it with the mitigation phase. (Kennedy, 2008)

These four EM phases can be considered as a unique workflow composed of a sequence of connected activities that is enabled by a structured organization of resources, defined roles and information flows, into an effort process that can be documented and learnt(OASIS Emergency Management TC, 2006).

The data that provides the necessary information to build up a coherent picture of the existing and developing situation to support rational decision-making, and the development of appropriate informatics for such activities is called emergency management data. This data must back up the whole EM process and deliver the essential information for each stage.

However, each of the four EM phases has certain information requirements and constraints. Sometimes, the required information is the same, but the processing time and representation may differ. In addition, time constraints for both processing and verification of validity may also be dissimilar among phases.

For an overview of the necessary information of each stage, a table by Vivacqua and Borges is used. It represents the main characteristics of each EM phase. In Chapter 3: Methodology, the taxonomy and comprehensive ontology of EM data will be elaborated.

Table 2Emergency Management Phases with Characteristics and Information Requirements

Phase	Information needed	Processing	Outcomes	Time dependency
Mitigation and Prevention	Probability of occurrence of each consequence, potential effects, Areas affected, People affected	Simulation, Training	Alterations to neighbourhoods or potential emergency source	Lowest
Preparedness	Number of People affected in each location, resources available, evacuation routes, safe havens	Planning, Evaluating alternatives, Decision making	Plans and procedures	Low
Response	People in danger (location and quantity), structural hazards, resource location and status, team activity, emergency focus	Prioritizing actions and areas to be processed	Actions to mitigate emergency	High
Recovery	People affected, services disrupted, dependency between services	Prioritizing services and locations to be restored	Actions and plans to restore normality	Medium

Source: Vivacqua& Borges, 2012

As aforementioned, EM is rather complex due to the highly interdependent character of its components and of the potentially affected systems. The rise in the affected population, growth of involved parties, multi-level communication, and availability of new resources such as more advanced technologies also add to this complexity (Coskun & Ozceylan, 2011).

2.3 Technology, Emergency Management and Spatial Planning

Technology has always been at the forefront of development. The austere innovations that paved the way for the industrial revolution eventually led to further technological and economic advancements (Maeng & Nedović-Budić, 2008). Thus, allowing us to make that leap from the period of the simple machines to a more complex one that we now know and enjoy as the digital age. Indeed, we have come a long way in terms of technological development. This advanced phase that we find ourselves in has enabled us to move and engage in a much wider scope that is beyond our physical confines. It has given us new stimulation and possibilities that were once unthinkable. It forces us to rethink and redefine our idea of space, communication and responsibilities, and reassess the processes and systems for the conduct of our various affairs and trade.

The expanded ability of the people to gain a wider coverage and reach resultedto an increase in the public's engagement in civic activities. This has been observed in the field of DRM and even spatial planning. Technology also enables affected communities to quickly transform themselves into first responders, send requests and messages, provide critical information, match assistance needs with providers or support rapid damage assessments (Vinck, 2013).

However, even with general advancing trend in technology and disaster response, lack of access to crucial and reliable information for mitigation and preparation still prove to be very costly especially for countries and areas in the developing regions. Unfortunately, these are also the same countries that are greatly threatened by disasters. Any occurrence jeopardizes their new investments and stunts their growth and development. Thus, in these modern times, there is a need to improve this condition. An option to ease this imbalance in access is by taking advantage of the proliferation of open data.

2.4 Towards openness and collaboration

2.4.1 Open Data

With the rise of the World Wide Web, public access to the mounting supply of available information has grown rapidly and continues to grow exponentially. Technological advances such as the diffusion of the internet, the rising usage of mobile technologies and remote sensing techniques allowed global communities such as governments, various organizations (international, non-government, etc.), businesses, and even individuals to generate, access, use and share huge amounts of newly created and previously restricted data. Often, information access translates into empowerment to make better informed decisions, to generate solutions to problems, to enhance economic activities, to improve the quality of life, as well as to preserve it during emergencies (Stauffacher, Hattotuwa, & Weekes, 2012).

The idea of open data is that certain data should be freely available for everyone to use or reuse and redistribute as they wish, without any restrictions, such as copyright, patents or other mechanisms of control. Open data's operative words are *availability and access, reuse and redistribution, and universal participation*. Firstly, the data must be completely available and with a reasonable reproduction cost, preferably it is downloadable through the Internet. The data must also be available in a convenient and modifiable form, and must be provided under terms that permit reuse and redistribution including the intermixing with other datasets. Finally, everyone must be able to use, reuse and redistribute - there should be no discrimination against fields of endeavour or against persons or groups. For example, 'non-commercial' restrictions that would prevent 'commercial' use, or restrictions of use for certain purposes (e.g. only in education), are not allowed(Open Knowledge Foundation, 2012).

Apopular example of this interaction and knowledge construction is the Open Source Initiative (OSI). In open source software development, there is a joint effort where people are free to contribute, and thus, generating a substantial product. The perfect example is Linux, but others have also followed suit. There is also Wikipedia, which is a collectively created encyclopaedia. After its success, other wikis have also started in several subdomains (travel, dictionaries, books, maps, etc.), proving the effectiveness of the approach across a wide range of domains(Vivacqua & Borges, 2012).

Another fine example of open data is open government data.It is considered as a remarkable resource in a lot of countries such as the United States, France, United Kingdom, Norway, Canada, etc. Many individuals and organizations collect wide arrays of data in order to perform their tasks. Governments are particularly significant in this respect, not just because of the quantity and centrality of the data it collects, but also because most government data is should be open to the public by law. Therefore, it could be made open and available for others to use(Open Knowledge Foundation, 2012).

This huge dataset can be considered as the new raw material of 21stcentury. As Harvey Lewis mentioned, "across the world, hundreds of thousands of different data sets have been made available on official open data portals. For instance, data.gov, the national US portal, lists nearly 380,000 data sets; and the French national portal, data.gouv.fr, lists over 350,000. In the UK, the three largest open data portals, data.gov.uk, www.ons.gov.uk and data.london.gov.uk, link to over 37,000 unique data sets between them, covering categories ranging from government spending to energy consumption" (Lewis, 2013).

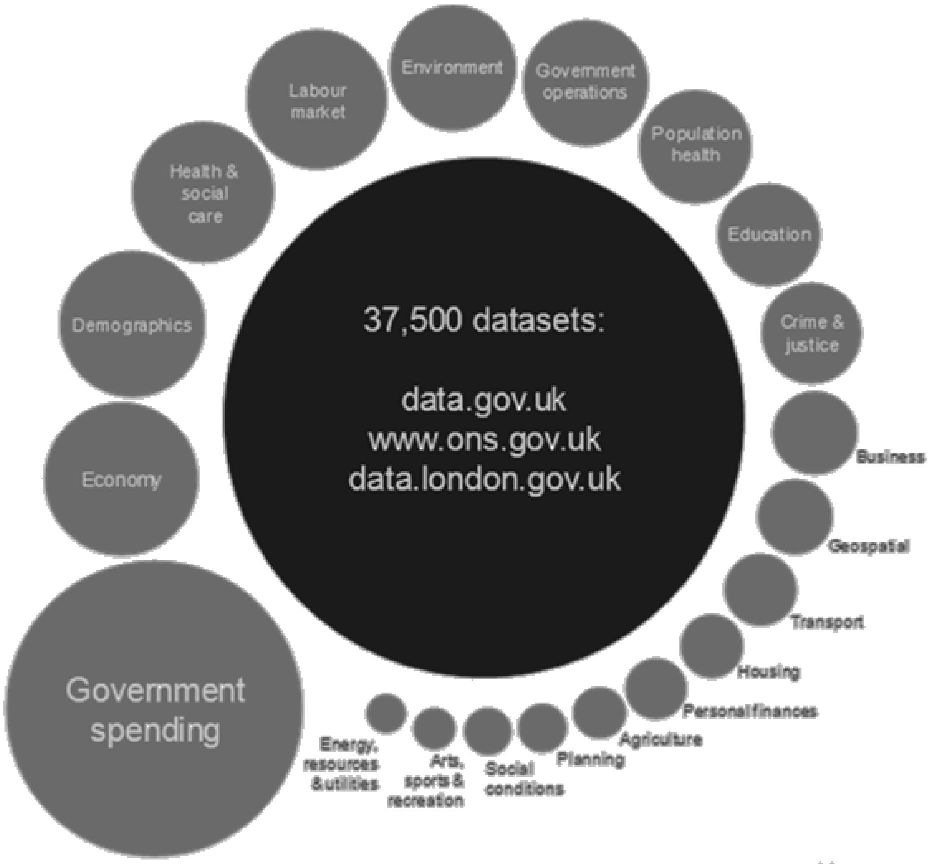


Figure 7 UK datasets categories (Image courtesy of Open Government Partnership)

Complementing the intensifying trend of opening government data has been the growing commitment of international organisations such as the United Nations (UN), World Bank (WB), and other aid and humanitarian response communities to open their datasets in order to improve crisis information management and humanitarian response. The UN's Crisis Information Management Strategy (CiMS) stresses the importance of sharing information and ensuring that active systems in place amongst the UN agencies and its partners are interoperable.

Importantly, they have alsoopenedtheir analysis of datasets and decision making frameworks. This is a unique move outside of its traditional domains of comfort and control that emphasizes on two-way nature of using open data.

Open data does not only include data from governments but also from non-government organizations (NGOs) who are pushing for increased openness and transparency. To give an example, there is the Open Humanitarian Initiative (OHI) from NetHope, which is an association of 34 international NGOs. It was launched toimprove information sharing amongst humanitarian organizations and increase information management capacity both within humanitarian organizations as well as within governments in disaster prone countries.(Olafsson, 2012).

During disasters, where one faces life and death situations, an informed decision is crucial for the protection of vulnerable populations. In such scenarios, the importance of openly available comprehensive datasets emerges. Both context and crisis data such as location of the hospitals, road access, telecommunications installations, population statistics, affected areas, direct and indirect damages, availability and situation of resources are all pieces of information that complement each other in order to provide a vivid picture of the critical situation or emergency, which in turn allows the emergency managers to make informed decisions and take proper actions.

The devastating 2010 earthquake in Haiti was a turning point for information management. It highlighted the importance of open and interoperable data. It clearly demonstrated that even actors outside the UN system possess their own sophisticated technology platforms, and are able to produce, disseminate and archive information much faster than governmental and intergovernmental actors. Key information after a sudden-onset crisis often came from sources outside the UN and official governments channels – for example with mapping and geographic information systems (GIS) information, health infrastructure related information, ground conditions and ad hoc internally displaced people (IDP) camp locations(Stauffacher, Hattotuwa, & Weekes, 2012). These conditions eventually led to the popularization of using collaborative tools and volunteer generated data sources besides the traditional sources in emergency management.

2.4.2 The Rise of the Crowds

Crowdsourcing is portmanteau of two words "crowd" and "outsourcing". The idea goes back to 2006 when Jeff Howe and Mark Robinson, editors at Wired Magazine, coined the term "crowdsourcing" after conversation about how businesses were using the internet to outsource work to individuals(Howe J. , 2006). As they came to the conclusion that what was happening was like "outsourcing the crowd,"it quickly led them to the word crowdsourcing. According to both, crowdsourcing can simply "represent the act of a company or an institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but it may also be undertaken by sole individuals. The crucial prerequisite is the use of the open call format and the large network of potential labourers"(Howe J. , 2006).

Soon after *crowdsourcing*was coined by Howe, due to the blurry scope of the word, many definitions have been offered by different authors from variousfields of expertise. As Mazzola and Distefano argued, crowdsourcing is a problem solving tool; “an intentional mobilization, through web 2.0, of creative and innovative ideas or stimuli, to solve a problem, where voluntary users are included by a firm within the internal problem solving process, not necessarily aimed to increase profit or to create product or market innovations, but in generally, to solve a specific problem(Mazzola & Distefano, 2010). Another definition is offered by Grier.He refers to crowdsourcing as“a strategic model to attract an interested, motivated crowd of individuals capable of providing solutions superior in quality and quantity to those that even traditional forms of business can”(Grier, 2011).

Furthermore, Enrique Estellés-Arolas and Fernando González Ladrón-de-Guevara developed a new integrated definition of crowdsourcing after studying more than 40 different definitions of the word in the scientific and popular literatures. In their definition "crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage that what the user has brought to the venture, whose form will depend on the type of activity undertaken"(Estellés-Arolas & González-Ladrón-de-Guevara, 2012).

Consequently, it can be understood that crowdsourcing has emerged out of the need to combineexisting scientific and professional knowledge with the “wisdom of the crowd” to support the problemsolving process. According to Surowiecki, “under the right circumstances, groups are remarkably intelligent, and are often smarter than the smartest people among them”(Surowiecki, 2004). The principal axiom of this approach is that no one knows everything; everyone has a specific expertise, and therefore, solutions can be reached by combining everybody’s knowledge and experience.

Therefore, as Papadopoulou et al claimed, “crowdsourcing can be considered as a process evolving through the following steps: the online release of a problem, the generation of alternative solutions by the crowd (participants), the evaluation of the proposed solutions, the selection of the best provided solution and the exploitation of the selected solution by the company or institution that initially posted the problem online. Such a process can be facilitated by the adoption of new web technologies that offer the crucial advantage of *bringing people together*. Different views and perspectives can lead to different solutions, some of which may be unexpectedly remarkable”(Papadopoulou & Giaoutzi, 2014).

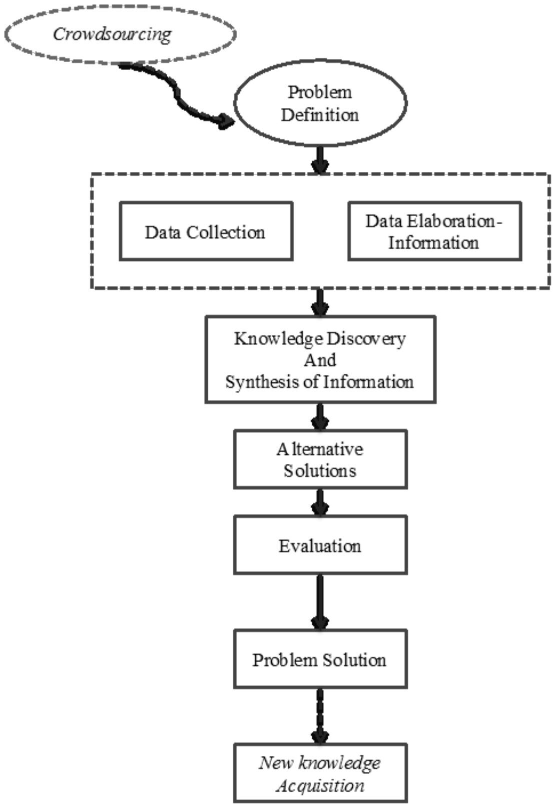


Figure 8 Concept of Crowdsourcing for problem solving

2.4.2.1 Classifications

Crowdsourcing itself encompasses many aspects such as social and economic activities, research and science areas, business and development strategies, emergency management and humanitarian relief, etc. Thus, crowdsourcing systems can be used to accomplish variety of tasks. In this light, crowdsourcing may also be categorised according to its domain of studies. Five (5) classes emerged as the major categories of crowdsourcing.It is believed that these 5 classescontain all the aspects of other crowdsourcing types. They are as follows: (1) Crowdvoting, (2) Crowdfunding, (3) Open Innovation, (4) Microtasking and (5) Crowdcreation. They are elaborated further in the next sections.

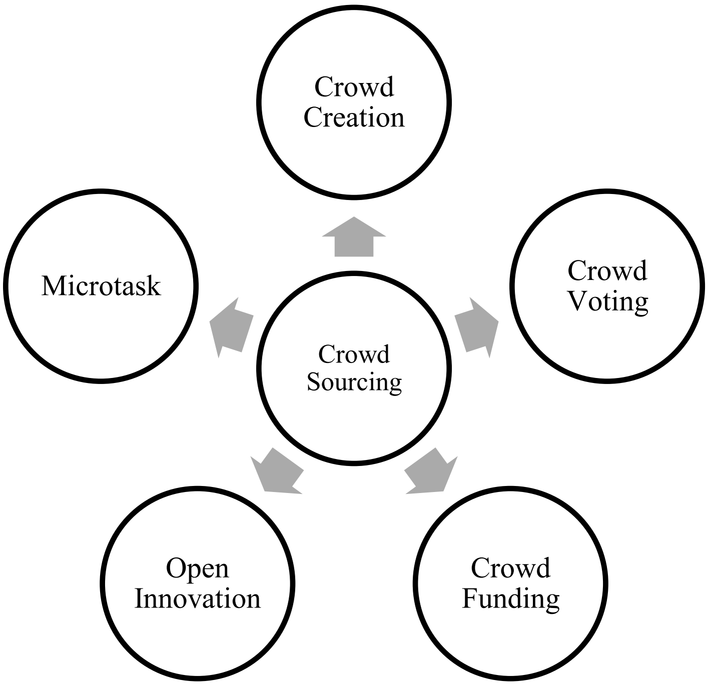


Figure 9 Crowdsourcing classification

2.4.2.1.1 Crowdvoting

Currently, voting is no longer something that the public has to do every couple of years. People vote everyday through the internet or on their mobile phones. Voting has been integratedin everyday culture and people have the opportunity to vote for everything. "Crowdvoting leverages the community's judgment to organize, filter and stack-rank content such as newspaper articles, applications, music and movies. It is the most popular form of crowdsourcing, which generates the highest levels of participation"(Keifer, 2010).

"Collective decisions made by millions of internet users is not only useful for its content but also it can work as a comprehensive classification system where users vote on which news stories of the day deserve attention (Digg.com) or what are the top movies (IMDB). There are even some examples that show the importance of crowdvoting in business and marketing."Threadless, the T-shirt maker, provides a good example. It inspects and approves all its products by user consensus before any larger investment is made into a new product. "Users also have the ability to check the 'I'd buy it!' box next to the scale, which is a strategy called 'collective customer commitment'. The dual benefits of giving customers a vote is to have their commitment and the company knows how much demand exists for every shirt it produces. Small wonder then that every shirt sells out" (Sivers).

2.4.2.1.2 Crowdfunding

Crowdfunding involves financial contributions from online investors, sponsors or donors to fund for profit or non-profit initiatives or enterprises. It is an approach to raising an amount of money for a business, project, product or even humanitarian resource in crisis situation. This will directly connect the people who have money to the people who need it. There are three types of contribution: (1) Donations, Philanthropy and Sponsorship where there is no expected financial return, (2) Lending and (3) Investment in exchange for equity, profit or revenue sharing.

The Daily Crowdsource mentioned some advantages of this new fundraising method. They are as follows: "(1) *Better Market Research*- Running a crowdfunding project is a very practical method for determining market demand. It not only asks potential users if they want your service, but forces them to make a payment if they do; (2)*Accessibility*- With a web based platform in place, funders have the ability to give any pledge amount at any time, and the project has the ability to be shared via social-media..Project pages can also be easily spread to blogs and other media; (3) *Transparency*- Being able to see what is involved in the creation of a product, as well as getting to know the funders through social-media, video, and profiles, creates transparency and trust between funder and the project holder; (4)*Low Cost*- Most platforms do not charge to host your crowdfunding campaign unless your project is successful, and the cost of a social-media campaign is less than other methods of promoting fundraisers; (5)*Flexibility*- To begin a crowdfunding campaign, it is expected that your final product or business is not yet created. This gives your business processes more flexibility, allowing products and ideas to fail, at the concept stage, with minimal risk and cost"(Bratvold, Armstrong, & Treves, Crowd Census, 2013).

Crowdfunding is mostly used by artists, charities, scientists and start-ups to raise money for projects such as filming a documentary, cancer research, providing vital line for affected population in disasters and many more. Examples for crowdfundingactivities during disaster events are Facebook's "Care & Share" application that aimed to raise money for affected population in the Philippines during the Yolanda Typhoon in 2013 and #BANGONPH, which is a more comprehensive platform thatdoes not only raise donations for the Philippines, but also provides updated information regarding the conditions of the affected areas so that resources may be better allocated.

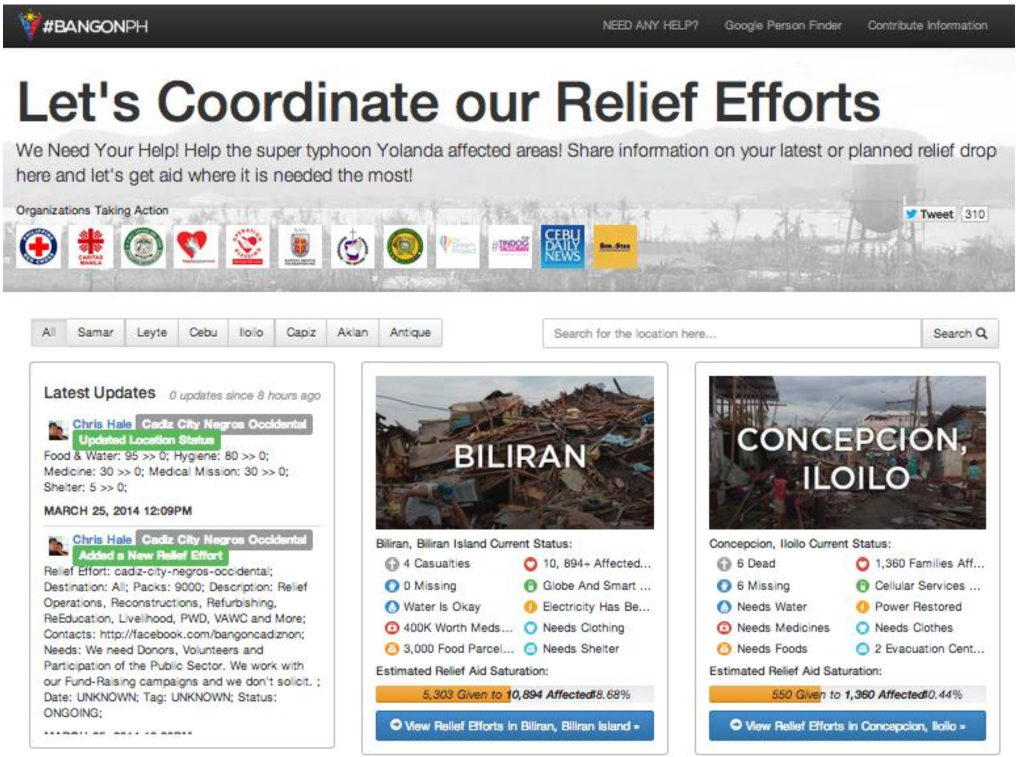


Figure 10 BANGONPH Coordinate and fundraising platform

2.4.2.1.3 Open Innovation

Open innovation provides a platform for the pool of dispersed contributors outside of the entity or group to generate, develop and implement ideas. In a world of widely distributed knowledge, where the boundaries between a firm and its environment have become more permeable, companies cannot afford to rely entirely on their own research and ideas to maintain a competitive advantage(Blattberg, 2012). Therefore, these platforms are an effective way of crowdsourcing people's thoughts and ideas on a research or development. This allows people with varying backgrounds andperspectives to collaborate for a functional profit makingendeavour. Moreover, it eliminates the space and time limits and assists *bringing people together.*

For instance, InnoCentive, a crowdsourcing platform for corporate research and development,posts difficult scientific problems for crowdsto solve and offersmonetary incentives ranging from $10,000 to $100,000 per challenge(Brabham, 2008).

Another relevant example of an open innovation is "Geeklist." A platform that consists of two parts:the *idea* and the *project*. In the idea section, crowds are not necessarily specialists, and they can present their ideas regarding the announced subject. On the other hand, the project section is more geared towards experts. It is whereongoingactivities are shown together with the aims, other contributors, and the development process. Involvement in each of the project is free and opento everyone.

Figure 11 Open Innovation- Geeklist for Typhoon Haiyan in Philippines 2013

Adding to the other open innovation examples is Climate CoLab, where scientists ask for people's ideas to addresssome of the biggest issues of the world.This platform is a socio-technical system designed to help thousands of people around the world collectively develop plans for addressing global climate change. The Climate CoLab combines several design elements, including model-based planning and simulation, on-line debates, and electronic voting. Since its introduction in 2009, it has been continuing to attract a stream of new and returning visitors from all over the world, who generate interesting and high quality plans to address climate change (Cooper, Khatib, & Treuille, 2011).

2.4.2.1.4 Microtasking

Microtasking involves breaking a large project into tiny, well-defined tasks for a crowd to work on. Each individual task is the result of the breaking-up of a larger project,where one task is considered as one unit of work. Theobjective of the project is to get work done for free by volunteers or by people who can investvarying amounts of money. Costs can differ dramatically based on the size and skill of each specific task.

To date, there is no standardization of microtasking, and a unit of work means differently to each company. It ranges from the low end of 2-3 seconds of work to the higher end of over 30 minutes of writing. Time commitment is not the only measurement used, a workers' skill is also a determining factor(Bratvold & Armstrong, The definitive guide to Microtasking, 2012).

Indeed, it is not so much about giving the crowd easier tasks, as it is about building a strategy around the fact that different people are good at different things, have different amounts of time to commit, or simply have different interests. Examples of commonly requested microtask projects are translations, transcription, digitization, content creation, image & video tagging, categorization and web search.

As David Bratvoldindicated in their research, “enterprise clients utilize crowdsourcing for the following reasons: faster, easier, cheaper and higher quality” (Bratvold & Armstrong, The definitive guide to Microtasking, 2012). These are elaborated further below:

Faster – Work becomes faster as the project is broken into microtasks& assigned to a several workers who can be completeit quicker than any single person would.

Easier – Automated management systems can make the process seamless, removing the need for time commitments involved with human moderation.

Cheaper – Costs can be lowered through the automated process of breaking up tasks &distributing it to workers that require lesser premium such as those living or working in the developing countries

Quality– Higher quality may be obtained through task redundancy, and discounting unqualified resultsfrom receiving compensation.

Microtasking in the EM domain is exemplified bythe MicroMappers platform.This web-based microtasking application is specifically customized for Digital Humanitarian Response (DHR). The purpose of these apps as Patrick Meier noted “is to quickly make sense of all the user-generated, multi-media contents posted on social media during disasters by using microtasking and making it as easy as a single click of the mouse to become a digital humanitarian volunteer(Meier, MicroMappers: Microtasking for Disaster Response, 2013).

They have already developed and customized six *Clickers* using the free and open source microtasking platform CrowdCrafting: TweetClicker, TweetGeoClicker, ImageClicker, ImageGeoClicker, VideoClicker, VideoGeoClicker.

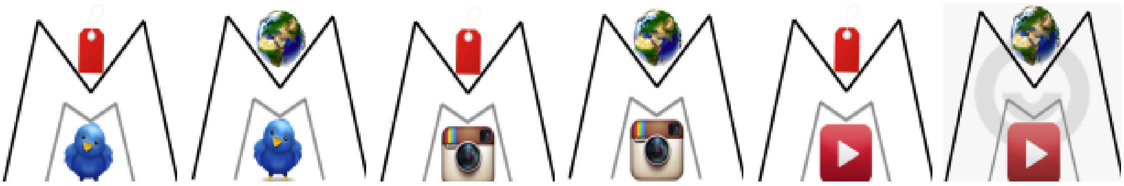


Figure 12MicroMappers applications

The process is simple. First, tweets are tagged by volunteers eitherfrom the UN, FEMA or other relevant organisations. Since each tweet is tagged repeatedly by various volunteers, the quality of the classification is somewhat controlled. This control follows the concept of crowdvoting.Afterwards, the tagged tweet is passed on to theTweetGeoClicker for geo-tagging purposes. All these steps are being done by volunteers in a relatively small time, which makes microtasking a valuable tool to process huge amounts of data there were once impossible to process quickly by individuals and even by single organisations.

Another kind of microtasking is *cloud labor*, whichtakes advantage of a distributed pool of virtual labourers, available on-demand to fulfill simple to complex tasks. In this case, crowdsourcing is used to connect labour demand and supply. Virtual workers perform activities that range from easy to specialized tasks(Root, 2012). A famous example of cloud labor is Amazon's Mechanical Turk (MTurk), which is an internet marketplace where individuals coordinate the use of human intelligence to perform tasks that computers are currently unable to do(Amazon Mechanical Turk, 2014).

However, there are also some cases wherein users are unaware that they are contributing, and yet it still is effective in completing certain tasks. This scenario is regarded as implicit crowdsourcing, which indirectly involves users who are completingan entirely different task, but a third party gains information based on the user's action. Some examples include ESP games, where users guess the images that are later turned into labels that are used to tag Google images (ESP game, 2013), and reCAPTCHA,whichasks people to solve CAPTCHAs for avoiding spam, while also contributing to digitizing texts and annotating images (Google).

2.4.2.1.5 Crowdcreation

The best-known forms of crowdsourcing are creation activities. Tapping of creative talent pools to design and develop original art, media or content. Crowdsourcing is used to tap online communities of thousands of creative individuals to develop original products and concepts, including photography, advertising, film, video production, graphic design, Architecture and interior design, apparel, consumer goods and branding concepts, perform language translation or solve challenging scientific problems.

While trying to elaborate the creative crowd phenomenon, Howe makes a reference to the popular New Yorker cartoon that says'*On the Internet no one knows you are a dog.*'This is themain principle of crowdsourcing. "No one knows you don't hold a degree in organic chemistry or that you are not a professional photographer. Gone are pedigree, race, gender, age and qualification with the only criteria remaining to be the quality of work itself." Crowdsourcing is not only effective for sourcing new tasks and products such as arts and literature, but also for solving real-world problems. It was also explained by Howe that"most of the brightest people in research organizations attended the same universities and therefore, leverage similar heuristics for problem solving."Breakthrough thinking may benefit from some amount of inexperience.(Keifer, 2010).

Figure 13Crowdcreation- New Yorker Cartoon

Distributed knowledge can be considered as crowdcreation, which consists of development of knowledge assets or information resources from a distributed pool of contributors. Crowdsourcing becomes usefulin developing, collecting, and disseminating knowledge and information through open questions and answers (Q&A), user-generated information systems, news, citizen journalism and forecasting(Distributed Knowledge).

Linux is again a perfect example for this type of crowdsourcing, as well asTopCoderthat promotes creative software development through competitions(Keifer, 2010), and SoundCloud, which is an online audio distribution platform thatallows its users to submit, record, promote and share their originally-produced sounds(Labrecque, vor dem Esche, Mathwick, Novak, & Hofacker, 2013).

Furthermore, crowdsourcing was also used for atmospheric readings in order to have more accurate information. Some developers have built an app called WeatherSignal, which collects data from temperature sensors built into smartphone batteries and submits them to provide comprehensive, localized weather readings in urban areas. The ultimate goal though is "to have an army of users submitting information in real time"(Robinson, 2013). As smart phones are now equipped with various sensors,more information can be collected such as temperature, pressure, light intensity, magnetic flux and humidity.

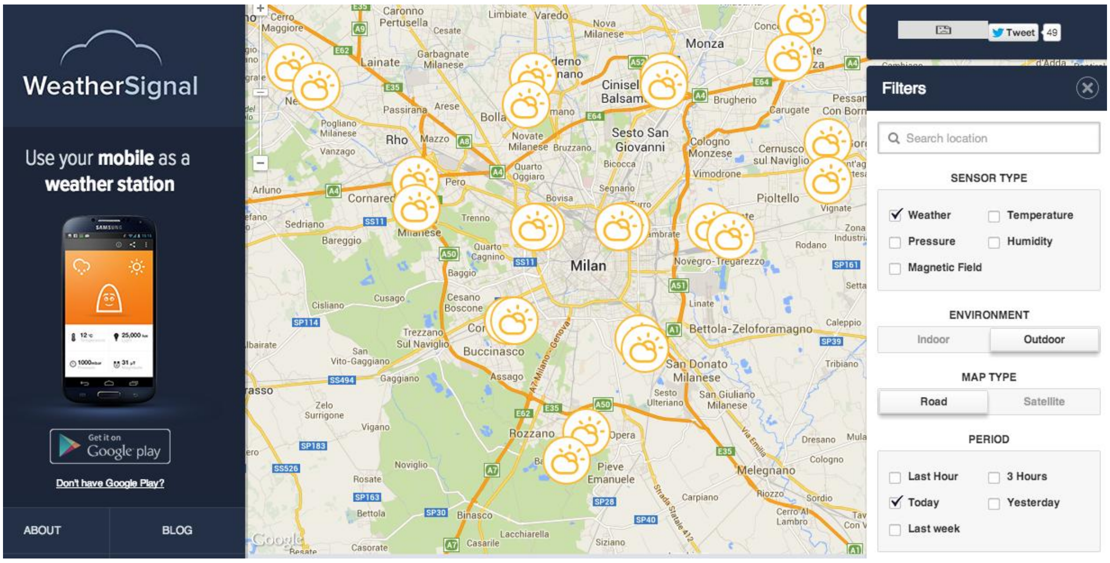


Figure 14 Crowdsourcing Atmospheric Readings- WeatherSignal

2.4.3 Crowdsourcing in Emergency Management

Numerous benefits can be derived from the increasing amount of verifiedopen data for crisis information management, humanitarian response operations and development activities.The combination of open data with new technologies and movements such as crowdsourcing and crisismapping has createda hugeimpact on modern society. Crowdsourcing does not only provides new critical knowledge, during a humanitarian crisis, but it also acts asa means to validate existing information, improve accountability, increase the effectiveness of humanitarian operations, assess the delivery of government services, improve governance, and monitor elections and market information(Stauffacher, Hattotuwa, & Weekes, 2012).

Effective decision-making in EM rests on the ability to gather accurate and reliable information about the disaster environment and the needs of the affected population. In fact, one of the biggest issues during emergencies is the lack of real-time information communication. As Gilbert argued, “disaster is first of all seen as a crisis in communicating within a community—that is, as a difficulty for someone to get informed and to inform other people”(Gilbert, 1998). Therefore, crisis mapping and crowdsourcing can be a valuable tool during disasters in order to collect useful real-time information. This comes from the fact that there is an increasing desire from the citizens to share information through social network not only in the peace time but also during disasters. This is also noted by Cavelty as she states that “crisis mapping leverage the innate desires of people to share information during emergencies.” Crisis mapping is both a process and a result that joinsdifferent streams of crowdsourced information,which is verified, classified and envisaged by volunteers using open-source mapping platforms and remote sensing (RS) technologies such as satellite imagery (Cavelty & Giroux, 2011).

The advancement of ICT has impacted EM, especially the humanitarian sectorin many ways. Society has quickly adapted to the technology as statistics revealed that in 2010 mobile phones amounted to 5.3 billion unitsand that over 2 billion people can now use the internet, and with half a billion of them accessing itthroughtheir mobile phones. Meanwhile, Facebook users are approaching atotal population of one billion,and more than a hundred million active Twitter users are sending over one billion tweets every week. Finally, over500 million Skype users are now enjoying free international calls thanks to voice over internet protocol (VOIP) technology. Consequently, both crisis-affected communities and global volunteer networks are turning digital. This means that the former are increasingly becoming the source of relevant crisis information, while the latter are becoming more adept at managing and visualizing this information on live crisis maps(Meier, 2011).

The abovementionedfacts highlight the increasing rolesof crowdsourcing and crisis mapping in emergency management. As crisis mapping is becoming a staple component of modern disaster response and management, it will be helpful to understand its features and characteristics. Itwill be discussed further in the following section.

2.4.3.1 Crisis Mapping

Crisis mapping is usually conducted with the aim of producing spatial representations of key geographic data relevant to a response. According to Wikipedia, “crisis mapping is the real-time gathering, display and analysis of data during a crisis, usually a natural disaster or social and political conflict such as violence and election”(Crisis Mapping, 2014).

Originally, it was conceptualized by the Harvard Humanitarian Institute (HHI) in their two-year program on Crisis Dynamics and Early Warning. The first version of crisis mapping was launched in 2007 in a project examining how mobile technologies, geospatial data, and citizen-based reporting are influencing humanitarian action and disaster response. After recognizing the tremendous existing potential, HHI established the International Network of Crisis Mappers in 2009. It is a global network of some 6,500 members in over 160 countries actively interested in the application of live mapping technologies to crisis situations. As mentioned in their website, “*Crisis Mappers* leverage mobile & web-based applications, participatory maps &crowdsourced event data, aerial & satellite imagery, geospatial platforms, advanced visualization, live simulation, and computational & statistical models to power effective early warning for rapid response to complex humanitarian emergencies”(CrisisMappers).

2008 was a milestone for crisis mapping as the first Ushahidi map was launched. This web-based platform allowed Kenyan citizens to report human rights violations during post-election unrest. Activists used Ushahidi's website to submit their reports via web-form, email and text message. Reports from mainstream media were also mapped. This enabled the crowd to effectively disseminate and collect information to help verify eyewitness accounts of violence in the media and to ensure that areas in need of humanitarian assistance were visible to humanitarian organisations and donors. Since then, Ushahidi's idea was used to crowdsource information for use in emergency response following other recent crises including Haiti, Chile, Pakistan, Russia, Syria, Tunisia, Egypt, New Zealand, Sudan, Libya, Somalia and, most recently, Philippines. What makes Ushahidi significant is its ease of use, low expense, and its open source nature(Meier, New information technologies and their impact on the humanitarian sector , 2011).

Crisis mapping is still evolving, but generally, it has four core pillars or phases: Information gathering, visualization, analysis and decision support. The first step is gathering of information. Nowadays, there are more channels and methodologiesdata collection that are made possibleby new technologies, such as social media space like Twitter, YouTube, Instagram and Flickr. In addition, this information may also be collected by crowdsourcing methodologies. The key component, however, is that the data collected must have a geographic component so that the information can be plotted on maps. Mapping the data creates a clearer picture of the situation. Visibility and intuitiveness are important components of crisis mapping.which highlight the importance of geo-spatial analysis for better informed decision-making, which comprise the fourth and final pillar of crisis mapping(Meier, New information technologies and their impact on the humanitarian sector , 2011).

The ultimate purpose of crisis mapping is to increase the situational awareness and resilience of the community by speeding up the information gathering, response and communications planning by providing low-cost dynamic maps. This means that the crisis mapping platform is an effective tool for dynamic decision making,which enables users to simulate different scenarios by considering the vast number of variables and the apparent uniqueness of each scenario, and thereby,allowing them to identify the best way forward.

The following case studies show how crisis mapping and new technology can enhance aid efficiency, transparency and humanitarian operations.

2.4.3.1.1 *Ushahidi in Haiti Earthquake*

The Ushahidi Haiti Project (UHP) was conceivedafter the earthquake near Port au Prince on January 12, 2010. It wasa volunteer-drivenactivity that centred on producing a crisis map. Information about the humanitarian crisis and response were mapped in near real-time by volunteers. These were taken from a variety of sources including: SMS, Web, Email, Radio, Phone, Twitter, Facebook, Television, list-serves, live streams, situation reports(Morrow, 2011).

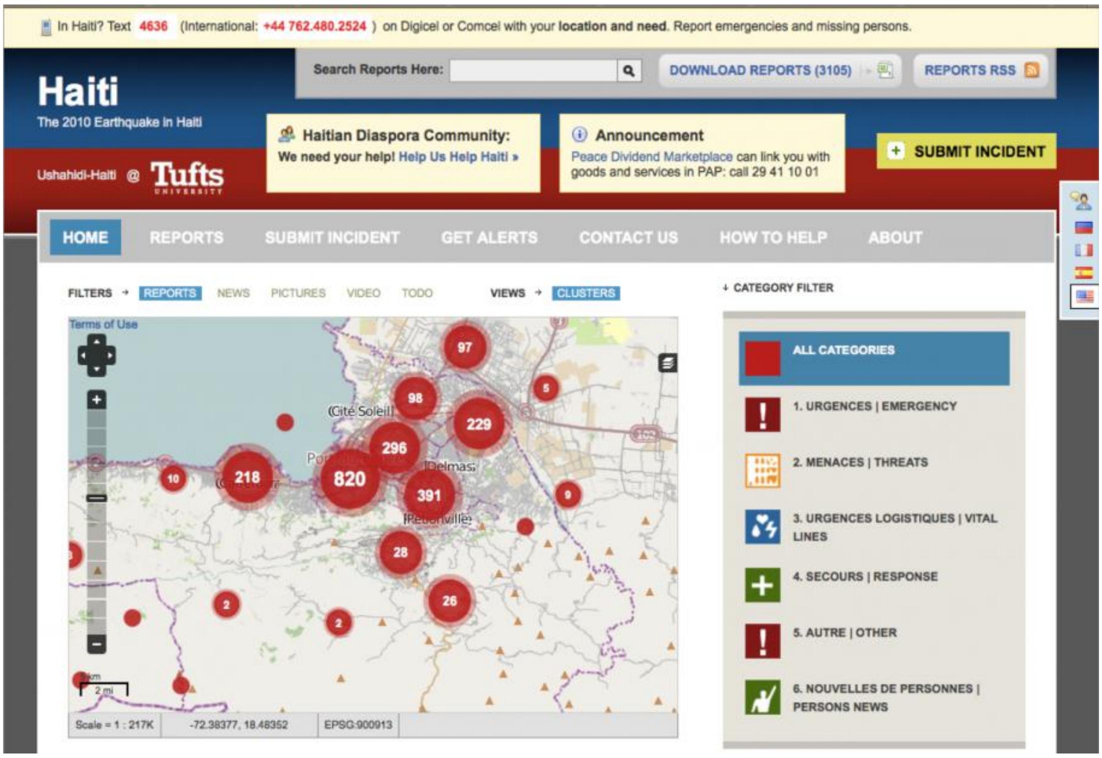
“The UHP addressed key information gaps (1) in the very early period of the response during the first days and weeks post-quake before UN and other large organizations were operational, (2) by providing situational awareness and critical early information with a relatively high degree of geographic precision, (3) by providing situational information for smaller NGOs that did not have a field presence in Haiti, (4) by helping smaller, privately funded responses to more appropriately target needs and, (5) by facilitating private citizen actors”(Morrow, 2011).

The UHP-collected information was usually utilised for situational awareness. Using OpenStreetMap (OSM) and other platforms like Mission 4636, it had effectively used crowdsourcing strategies to map a translated and geo-coded stream of data that was eventually connected to the volunteers of UHP with the support of CrowdFlower. OSM and Mission 4636 created improved open source maps and translated messages respectively.These innovations played an important role as primary sources of information for UHP’s dynamic map(Morrow, 2011) 4636 project volunteers translated 25,186 SMS messages and numerous e-mail, Web, and social media communications, resulting in 3,596 reports that were actionable and included enough relevant information to be mapped on Ushahidi(McKenzie, 2010).

Most of the received reports contained requests that may be categorised as “vital lines,” which pertain to food, water, and shelter. In the first week, the next most common reports were of available services available, such as locations of distributions points, field hospitals, and of emergencies, such as reports of immediate medical needs and isolated persons. These decreased with the growth of new services and the stabilisationof the situation on the ground (Heinzelman & Waters, 2010).

The information for the UHP reports were used by organizations such as the U.S. Federal Emergency Management Agency (FEMA), United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), the U.S. Agency for International Development (USAID), Marine Corps, the U.S. Military and Coast Guard to direct assistance. Haiti’s crisis map represented the most comprehensive and up-to-date map available to the humanitarian community, and it successfullyorganised communication, which permitted its integration into process by providing organizations with the technical ability to automatically accessthe series of reports for use in their response systems. CDAC-Haiti’s Jacobo Quintanilla states “the beauty of what Ushahidi does is that it opens the gates of information to anyone interested, allows citizens in crisis to seek help and helps to foster dialogue between affected communities and services providers”(Quintanilla, 2010).

Figure 15 The Haiti Crisis Map at the End of Operations
(Image from:Ushahidi Haiti Project (UHP))



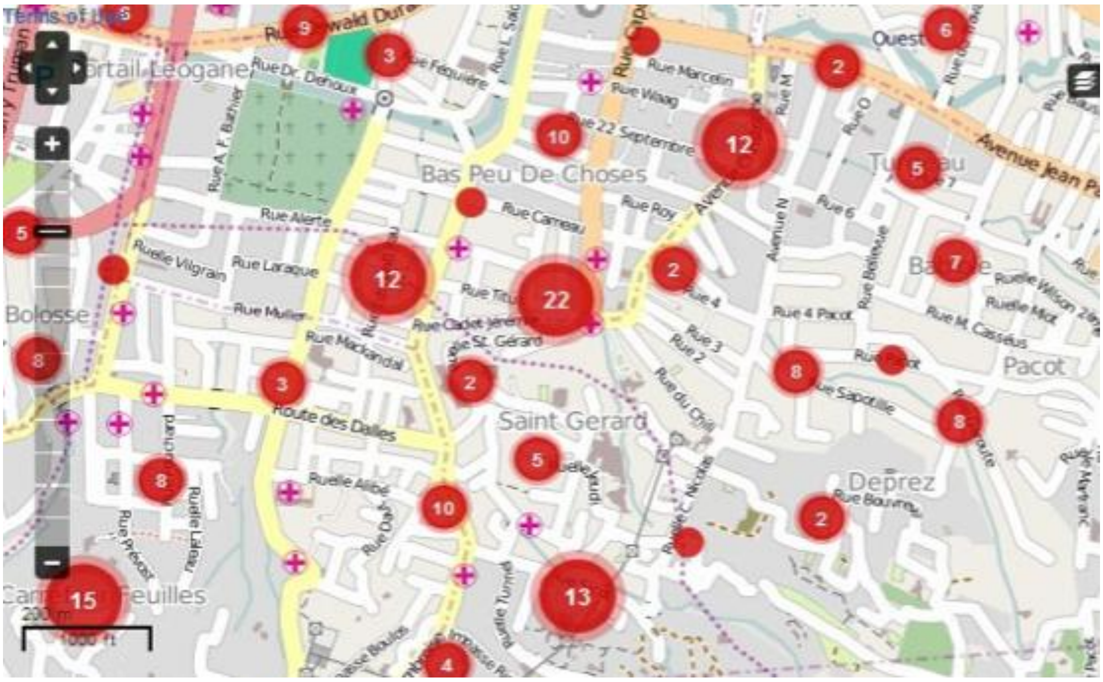


Figure 16 Close up of the Haiti Map withindication of number of reports within an area
(Image from:Ushahidi Haiti Project (UHP))

2.5 The Role of Open Data in Integrating Spatial Planning and Emergency Management

As opposed to EM that makes use of improvised data, spatial planning data usually relied on well-known collections of government-generated datasets for their work, including statistics and geographic layers from national and local sources. Despite being considered as official or traditional, these datasets are notperfect, and planners and citizens are well-aware of it (Goodspeed, The Coming Urban Data Revolution, 2011). However, things are beginning to change with the increasing engagement of local communities in civic activities such as humanitarian action. During large scale catastrophes, this increase in participation results in the mounting generation of freely available disaster information in the form of various open data. The web acts a facilitator. It is providing an avenue for individuals in the onslaught of a disaster to provide assistance to the affected communities and responders (Vinck, 2013)This phenomenon highlights the potential benefits of open data and collaborative efforts between governments, organisations, individuals and the private sector (EUROCITIES, 2013).

Open data is being advocated for a host of reasons. Proponents from developed regions argue its potential economic benefits, such that costs will be minimised as it prevents duplication of work. On the other hand, the emerging nations are rallying for a different purpose. Some of them believe that it can be a tool to achieve better governance, poverty reduction and sustainable development. Nonetheless, due to open data's infancy, there is little research that may support these various claims (Schwegmann, 2012).

Despite this, open data still boasts some advantages. One of these advantages is the improvement of interoperability. Interoperability denotes the ability of diverse systems to work together. In this case, it is the ability to intermix different datasets. This is important because it allows the different components to work together withoutthe limits of time and space, and italso opens up new possibilities for interaction and knowledge construction by large groups of people. This ability to 'componentize' and to plug components together is essential to building large, complex systems, which can be put to use in many situations, including emergency management and spatial planning. The framework of this study is based on this.

Despite the study focusing on an emerging economy, the study does not lean completely towards the open data perspective of the developing countries, nor does it dismiss the well-developed nations' opinion on the economic benefits of open data. The reuse of open data in the form of VDDs is actually grounded on both perspectives.

Taking this and other concepts into account, the framework of the study is structured such that it assumes that there are both traditional and 'new data contributors.' Evidently, the traditional data sources produce and curate the traditional data, while the presence of the new data contributors, with the aid of technological tools, is breaking ground and creating new datasets in the form of the freely accessible open data.

Ideally, traditional data is comprehensive and up to date. However, in reality, it is not. This becomes an entry point for open data in the information exchange process, wherein it can provide supplemental information to improve the current data gaps.

The diagram below illustrates the conceptual framework of the study. It shows the information requirements of both fields: emergency management and spatial planning, with observable overlapping data types / categories. While both fields rely on traditional data, open data may facilitate a link and an information exchange between the two, which enhances their integration, and eventually, strengthens and promotes better resilience and sustainable development conditions.

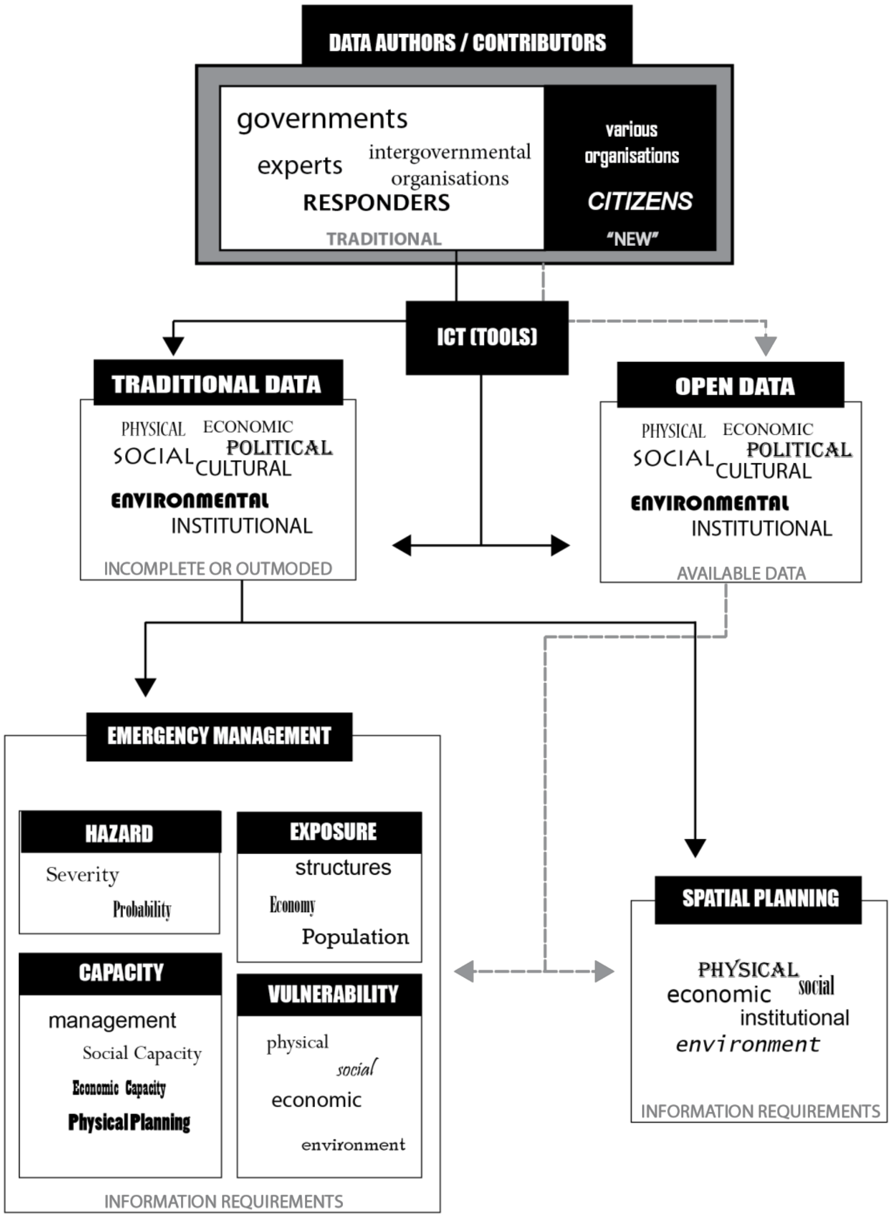


Figure 17 Conceptual Framework of the Study

The diagram is simplified using the image below. It depicts data authors who use ICT tools to generate open data, whichare freely accessible to be reused and adapted for various purposes. It also shows that open data may be used to minimize the gap between EM and spatial planning by linking them together, which will eventually move resilience and development together.

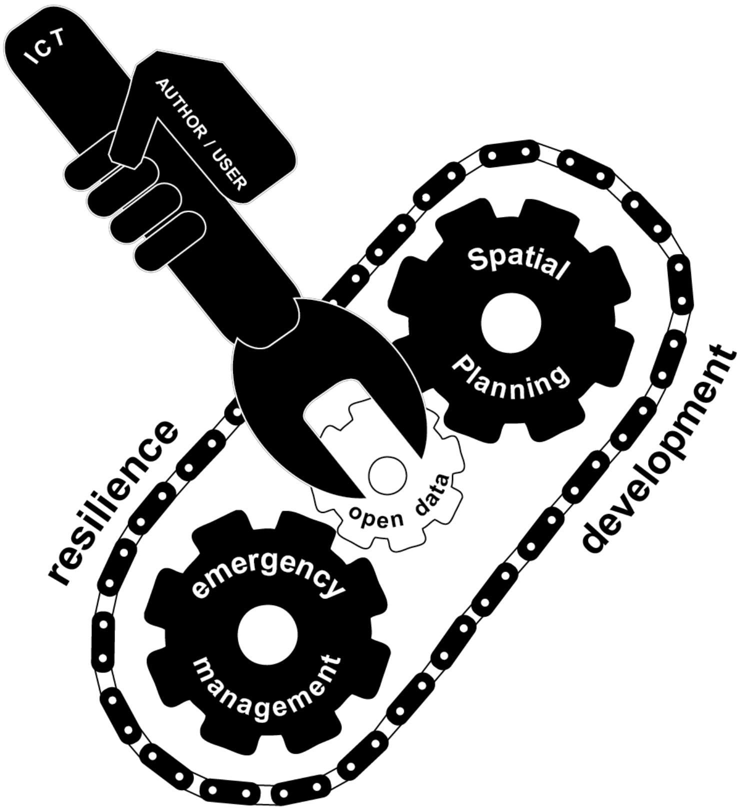


Figure 18 Simplified Representation of the Study's Concept

3 Methodologies

3.1 Data Collection

The data collection centred on open data, which is freely accessible to the public for viewing or for use. With respect to open data's production, both traditionally and unconventionally or collaboratively produced data were gathered in the course of the study. 'Closed data' was also gathered to complement and aid the analysis and test the proposed practical data reuse.

As opposed to 'closed data' whose collection required coordination with the document owners or authorities, collection of open data was mostly done virtually with the aid of technological tools such as the internet and the computer. Access was unrestricted, but minimum requirements must be satisfied, such as having capable equipment to store and process the information and a good data connection, especially for accessing and downloading large data. A combination of methods was used to obtain these data. They are as follows:

1. Search Engine with specific keywords
2. RSS Feeds from news websites
3. Social Media
4. Subscriptions to relevant sites
5. Government / Organization Websites

As Haiyan practically got the whole world talking, it generated massive amounts of information. It would have been impossible lest practical to gather everything. Thus, data collected during the study is not exhaustive. It only provides a practical example of several kinds of data that may be produced and gathered during crisis situations.

3.1.1 Using specific keywords on search engines

With Web 2.0's introduction, more opportunities and possibilities opened up on the internet. It made interaction possible, and thus, people do not just get information, they can also generate and disseminate them.

Nowadays, the search engine is the most common way to find any piece of information that anyone wants. There are several popular search engines such as Google, Bing, and Yahoo. All of them do a good job at crawling the web and searching for the specific keywords that one inputs.

This process was highly used during the data collection. Some of the keywords that were used are the following:

1. Haiyan
2. Typhoon
3. Super Typhoon
4. Yolanda
5. Damage
6. Destruction
7. Crisis Map
8. Affected Area
9. Affected Population
10. Update
11. Rescue
12. Relief
13. Storm Surge
14. Flood
15. Tacloban

These keywords were used either as a single phrase or in combination. Depending on the keyword/s used, a single search may yield millions of results or none at all. This appears to be an issue as it can be both exhaustive and exclusive. Most of the time, it is just plain overwhelming. Data is often displayed according to the source's popularity or ranking. Therefore, due diligence from the researcher or user is somehow required.

3.1.2 Using RSS feeds

RSS stands for Rich Site Summary. It is a good way to receive updates from websites that you have configured to appear on your RSS reader. It allows you to get the latest content without having to visit the sites individually. The only drawback is that it only pushes the latest content shared by the source, and old content, unless previously retrieved, may be missed.

During the Haiyan incident, several news websites were configured for the RSS feeds such as BBC, Google News, and Philippine-based media sources. The feeds were retrieved using either the built-in reader of the web browser or through a standalone client.

It had proved to be useful as you get a quick overview of the updates. Depending on a user's technical capability and knowledge, it is also possible to customize the RSS feeds to filter events using keywords too. This will tailor the updates to only display the important issues that one wishes to follow. Unfortunately, this was not done during this study.

3.1.3 Monitoring Social Media

Dealing with social media bears some similarity to both using the search engine and RSS feeds. Depending on the social media network and platform that one is using, it may be customized as well. However, if there is high activity, there is also a huge possibility that certain information may be skipped or covered up by another. The most common social media platforms that were used during Haiyan are Twitter and Facebook. Both were monitored for updates and crucial information.

The rate of social media's evolution is quite surprising. In the past, it was purely used for personal and non-critical information. These days even public authorities use and promote it to increase their interaction with constituents as well as other institutions and non-government organizations.
During the super typhoon, the generated social media messages were monitored not only by the Philippine government, but by the international community as well. In fact, the United Nations requested a group of digital volunteers to sort out messages that were posted over twitter and tagged by the volunteers as promoted by the Philippine government. The use of hashtags was encouraged for easier coordination and direction of disaster information and rescue requests. Unfortunately, this data was not readily available during the research. Nonetheless, it does show some potential on how social media may be further developed to support civic activities such as humanitarian response.

3.1.4 Subscriptions and memberships to organizations and forums

Another source of open data and information were the websites of organizations and even online forums. However, this approach somehow falls in between open and closed data as some sites require membership prior to granting access and sharing the information. In spite of this, memberships and subscriptions are often free of charge. This approach is advantageous for the data generator and publisher as it can monitor who is accessing the data and sometimes, even its purpose for doing so. This monitoring may allow improvements to be carried out in order to cater to the users' needs much better in the future. It also provides some security for both the data producer and the end user.

Data security is another issue that is closely linked to the generation, publishing and use of open data. However, there is already a host of information that discusses this. Thus, it will not be elaborated in this study.

Just as with the other three sources, subscriptions and memberships were also instrumental in gathering the information that was obtained for the study. Some of the sites that were frequently accessed are Google communities, Humanitarian Response, GDACS, ALNAP, and Reliefweb.

3.1.5 Government and Non-government Organizations' Websites

Haiyan proved to be a landmark and milestone for the emergency management communication in the Philippines. Though it wasn't the first time that the Philippine Government and its agencies turned to cyberchannels, these alternative channels became mainstream during this calamity.

It also updated its websites promptly and even uploaded copies of sensitive documents that one would usually need to request an access to, such as situational reports and updates. Perhaps, this was highly influenced by the commitment of the Philippines to the open data policy.

A big advantage of using these sites were the validity and reliability of the published information since it is coming from a reputable source. However, discrepancies may also arise, as with the case of Haiyan. Some reports published by two different agencies may contain varying figures such as reports done by the NDRRMC and the DSWD. Nonetheless, the obtained information is still valuable despite some nuisance, and there is also an opportunity in the future to improve the coordination between agencies to avoid the recurrence of such issues.

3.2 Data Sorting

The collection is followed by the sorting of the obtained information. Given the immense amount and assortment of information that have been generated and gathered, it appeared that it would be helpful to classify them according to its various characteristics. Thus, the use of taxonomies and ontologies seemed appropriate in order to achieve this goal.

Taxonomies and ontologies go hand in hand. In order to develop a good ontology, a decent taxonomy is necessary as it will become the basis.Both the taxonomy and ontology are elaborated in the succeeding sections.

3.2.1 Taxonomy

The taxonomy is a classification of the entities that form the subject-matter of the domain of interest. In other words, taxonomy is the practice and science of classifying things and concepts, including the underlying principles of such a classification. The different groupings ofa taxonomy are called terms.

Creating a taxonomy automatically creates an ample vocabulary of the subject under study. The resulting vocabulary may be used by any stakeholder for its projects. It is also a good way to ensure that entities are not missed.

The study developed a taxonomy for the identified terms: Hazard, Exposure and Resource. This is to better recognize and understand the terms of each class. The taxonomy of a disaster consequence would be the same as the exposure since the consequences of an incident also consider the same aspects.

3.2.1.1 Hazard Taxonomy

A hazard is a situation that poses a level of threat to life, health, property or environment. This threat can be either natural or human-induced. The hazards resulting from human activities are called manmade hazards, while hazards from the physical elements are known as natural hazards(FEMA).

3.2.1.1.1 Natural Hazard

Natural phenomenon occurs due to the unrestrained forces of nature. When it happens in a populated area, it triggers a hazardous event. A hazardous event from a natural phenomenon that causes unacceptably large numbers of fatalities and overwhelming property damage is considered a natural disaster. Thus, exposure is essential for a phenomenon to become a hazard or a disaster(Organization of American States. Dept. of Regional Development and Environment, 1990).

Six terms are proposed for the taxonomy of natural hazards. They are based on the classifications presented in the book entitled*Primer on Natural Hazard Management in Integrated Regional Development Planning.* The classifications that were presented in the book were considered to be comprehensive and reliable. The identified terms were atmospheric, seismic, other geologic/hydrologic, hydrologic, volcanic and wildfire (ibid). These include all natural hazards and each contains subcategories, which is illustrated in the taxonomy diagram.

It is worth mentioning that humans can do very little or even nothing to change the incidence or intensity of most natural phenomena. However, they play a crucial role in ensuring that these natural events are not transformed into disasters by their own actions. It is important to understand that human interventions can increase the frequency and severity of natural hazards. For instance, when the toe of a slope is removed to make room for a settlement, the earth can move again and bury the erected settlement. Human intervention may also cause natural hazards where none previously existed. Volcanoes erupt periodically, and it is known that their ejected materials later form rich soils. In general, the areas around volcanoes are not hazardous, but when they are occupied by farms and human settlements automatically turn hazardous due to exposure of a population. Lastly, human interventions reduce the mitigating effects of natural ecosystems. Destruction of coral reefs removes the shore's first line of defence against ocean currents and storm surges. This is a clear example of an intervention that diminishes the ability of an ecosystem to protect itself. An extreme case of destructive human intervention is desertification, which by its very definition, is a human-induced "natural" hazard(Organization of American States. Dept. of Regional Development and Environment, 1990).

All these are crucial to developing an effective emergency plan. If human activities can produce or magnify the detrimental effects of natural phenomena, they can also eradicate or reduce them (ibid).

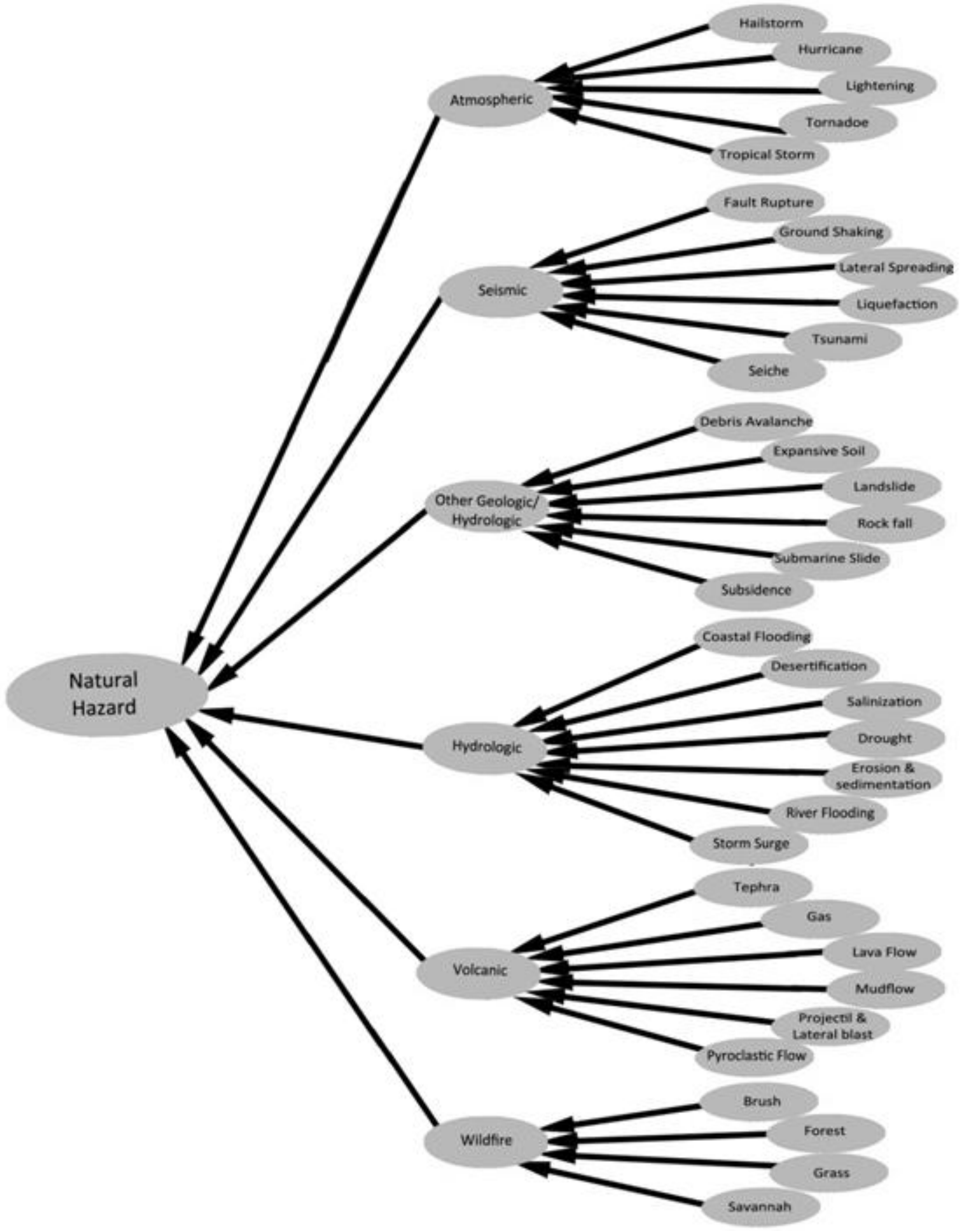


Figure 19 Taxonomy of Natural Hazard

3.2.1.1.2 Manmade Hazard

Modern society's continuous pursuit for further technological improvements has caused an increase in the frequency of adverse events, and this increasing trend has been evident in the past decades. Depending on the source, manmade hazards are classified differently. Several classifications were proposed by the FEMA and the International Federation of the Red Cross and Red Crescent Societies (IFRC). Taking these proposed classifications into consideration, the study came up with two subcategories for manmade hazards: sociological and technological.

Sociological hazards are consequences of community disorders such as various crimes (i.e. arson) and civil disorders. It can also be due to political or religious disagreements such as war, terrorism or national insecurity.

On the other hand, technological hazards include a wider range of manmade incidents. Accidents that happen in industries like nuclear power plants, chemical factories and mining areas as well as service disruptions (i.e. power and telecommunications failure) are all problems of modern communities. Other types of technological hazards are structural collapses like the failure of dams, buildings and other infrastructures. It also includes transportation accidents like a plane crash, ship sinking or grounding, heavy vehicle accidents on roads or railways, and even accidents in outer space all fall within this category. In addition, problems due to hazardous materials contamination like fallouts or CBRN (chemical, biological, radiological, nuclear), fires, cyber attacks, famine, and food insecurity also form part of this class as are threats to human life, property and security.

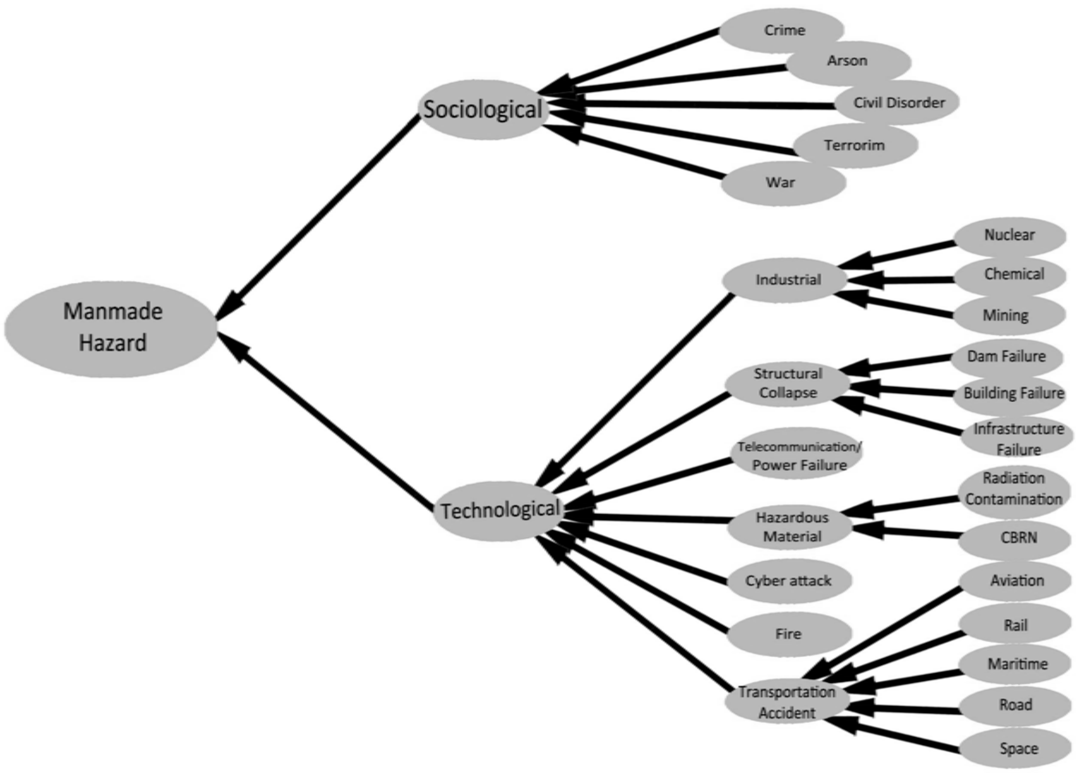


Figure 20 Taxonomy of Manmade Hazard

3.2.1.2 Exposure Taxonomy

As illustrated by the volcano example in section 3.2.1.1.1, in areas where there are no human interests, natural phenomena is not considered as a hazard nor does it cause disasters. Exposure is a necessary component of every crisis or disaster. Therefore, the recognition of its different terms is essential in emergency management. Its identification allows proper attention to be given to each at the various stages of the emergency management cycle. For the exposure taxonomy, four terms are proposed. They are: population, critical facility, building and infrastructure.

The first class is population, which refers to the inhabitants of the affected areas. This is one of the most important exposure terms. The second class is composed of critical facilities. Due to the functions or services they provide, they have been placed in a separate class. Some of these facilities play crucial roles in emergency situations such as fire stations, police stations, emergency management control rooms and medical centres. Keeping them in a separate group allowsthe collection of more detailed information regarding its conditions.Some examples include educational centres (i.e. schools, universities and kindergartens), industrial plants, and cultural sites.

The next term is building. It has three sub-classes such as residential buildings, commercial and public buildings, and infrastructure. It includes all the essential networks such as water, sewage, electricity, gas and communication, which are all extremely important. The transportation networks are also included in this group. It usually consists of roads and railway networks, airports and seaports.

All the terms under this taxonomy should be considered separately in each phase of the emergency management to effectively reduce disaster consequences and be prepared for them.

Figure 21 Taxonomy of Exposure

3.2.1.3 Resource Taxonomy

Since the global resources to help deal with catastrophes are limited, it is imperative for emergency managers to target their resources strategically, taking into account severity, scale and underlying causes(UNOCHA, 2008). Thus, the taxonomy of resource helps in improving the coordination and allocation of resources to ensure they reach the places where they are most needed.

The first term of this taxonomy is monetary, which consists of all the provided financial help from various sources at different levels. Donation, fund and loan in local, national and international levels form this class. In addition, money from taxes and insurance collectionsare also included.

The following term is human resource,whichcan be further classifiedaccording to the nature of its organisations. This is highly based on OCHA's classification since it appeared to be more comprehensive and relevant. OCHA has filtered the humanitarian responses by clusters, organization type, functional roles, etc. Thesewere arranged according to the organisation type and presentedin a more general way to cover all human resources in every crisis situation.

The subclasses of this terminclude the following: civilian, which includes volunteers or special needs task forces; police and military; fire and rescue; medical practitioners, non-governmental organization (NGO) in local, national and international levels; intergovernmental organization (IGO) such as the UN; government agencies; academic and research teams; and media.

The third taxonomical term is vehicle, which refers tothe transportation used when responding to an emergency. These vehicles are usually operated by designated that often belong to the government. Nonetheless, there are also others that are run by charities, non-governmental organizations and evenprivate companies.

There are various types of emergency vehicles,such as*police and security vehicles*(i.e. police car, motorcycle, special weapons and tactics (SWAT) vehicle or bomb disposal vehicle);*fire and rescue vehicles*(i.e. mountain rescue vehicle, lifeguard vehicle, hazardous material team vehicle, search and rescue team vehicle, mine rescue vehicle and fire apparatus including various specialist units such as turntable ladder);*medical vehicles*(i.e. ambulance, rapid response car, ambulances, air ambulances and organ transplant or blood supply vehicles);*civil emergency vehicles*(i.e. park ranger vehicle and public utility crews dealing with gas, electricity or water or to repair defective equipment on scene);*recovery vehicles*(i.e. tow trucks). Besides these, ordinary vehicles may alsobe used during emergencies such as *public transport* vehicles, *private* vehicles and commercial vehicles for *transporting goods*. All of theseare useful for evacuation, response and recovery phases, and are all considered as vehicular resources.

The fourth term is vital line supply. It consists of all the essential needs for human beings to be alive and healthy such as nourishment and food, water, clothes, personal hygiene, fuel and necessary drugs and medical.

Next is the list of all the places that can be used as evacuation centres or shelters during an emergency. This includes educational centres, such as schools and universities, churches (or temples), sports centres, hotels, community halls, assembly areas and makeshift shelters such as privately-ownedhouses or offices. Among all these, schools are the most frequent to be used as evacuation centres because they usually have a big areathat can host large populations. Moreover, they are present in every district.

The last category of resource refers to the equipment thatare used for emergencies. They are categorised according to the equipment catalogue of the IFRC:

(1) Equipment for personnel security for physical protection enhancement such as body protection equipment (ear noise protection, gloves, goggles, helmet, jacket, mask, rubber boots), safety in transport (life vest, locator, safety raft), personnel and team equipment (bedding, kitchen, tables & chairs, nets and tent);

(2) Power supply and electrical equipment like battery, voltage control and inverter, lighting, cables and accessories, generator, kits and solar;

(3) Radio and telecommunication such as satellite communication, telephone, VHF/UHF radio, mobile communication vehicle, interoperable communication, information technology equipment for cyber security enhancement;

(4) Water and sanitation equipment like pump, tank, hose and pipe, valve and tap, treatment and decontamination equipment, testing, sanitation and treatment products;

(5) Medical Equipment like sterilization, surgical and medical equipment, linen and operative field, x-ray machine, cold chain, laboratory and disposal equipment;

(6) Tool and hardware equipment such as hardware (nail, glue, rope, safety hook, hurricane strap, padlock and more), general purpose tools (hammer, drill bits, digging bar, blades and hacksaw and more), mechanical tools (fuel pump, jack, toolkit and winch), agricultural tools (Axe, hoe, shovel, rake and more), measuring instrument, evacuation equipment (sleds, pads, chair for non-ambulatory people) and emergency equipment like fire control, search and rescue operational equipment and all the necessary equipment for different operational organizations and;

(7) Heavy machinery such as road equipment.

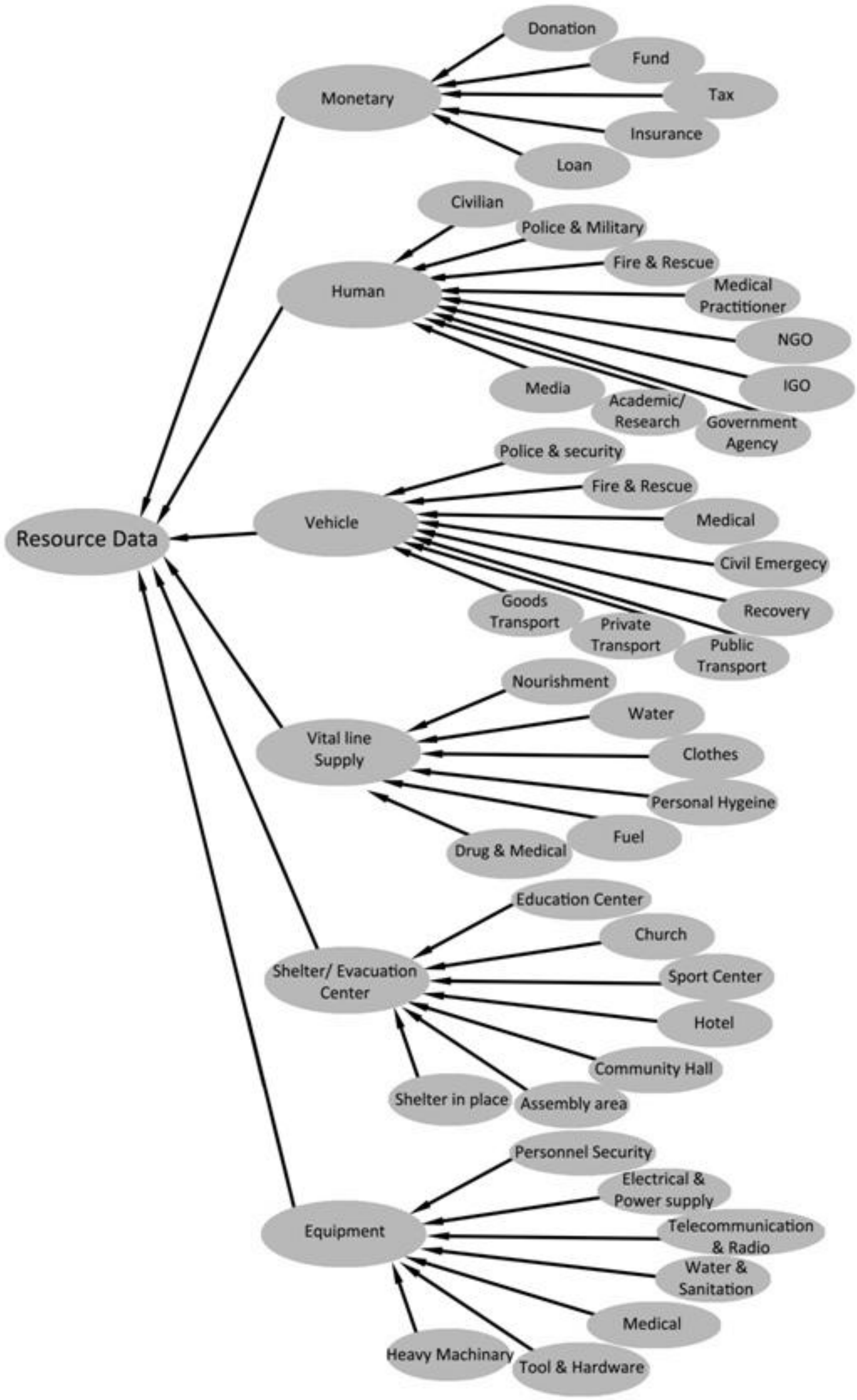


Figure 22 Taxonomy of Resource

3.2.2 Ontology

After the initial classification of the EM data, the issue now shifts to its organisation. How can the numerous terms and its associated data be represented in a more efficient manner?The answer to this problem is development of a comprehensive ontology. The definition of ontology and its role in emergency management is described in the next paragraphs.

Ontology originally comes from philosophy. The word element *onto-* comes from the Greek word *ὤν, ὄντος*, means "being", "that which is" present participle of the verb *εἰμί* ("be"). As a branch of philosophy, ontology is the science of what is, a systematic account of existence, which explicitly specifies how to represent objects, concepts and other entities that are assumed to exist in some areas of interest and the relationships that exist among them.

Ontology is often used by philosophers as a synonym of metaphysics that deals with the nature of being. It helps to hierarchically structure knowledge about things by subcategorizing them according to their essential (or at least relevant and/or cognitive) qualities(Howe D.).

A good ontology must provide a definitive and exhaustive classification of entities in all spheres of being. On one hand, it must provide a definitive answer to questions, such as "what classes of entities are needed for a complete description and explanation of all the going-on in the subject?," while on the other, it should be exhaustive to include all types of entities in the classification, including types of relations by which entities are tied together to form larger wholes (Smith, 2003).

As Gruber noted, a body of formally represented knowledge is based on conceptualisation. Therefore, an ontology is an explicit specification of a conceptualisation since in artificial intelligence systems, what "exists" is that which can be presented. The ontology builds up an "is-a" relationship among entities in order to better understand the whole concept. Ontology development is one key activity that routinely relies on visualisation. By building ontology diagrams the relationship can be easily seen and studied(Gruber, 1993). Thus, it is believed that the ontology can play a significant role in general task of improving the ability to handle information. Galton et alalso stated two distinct reasons for this. First, ontology can ensure coherent and correct conceptualisation of the real-world domains providing the subject matter of the information to be handled. For example, in emergency management referring to a recurrent lack of consistency, noting that the terms displaced person, evacuee, beneficiary, and missing person, or again, the terms stock, supply, intake, and donation, are often used more or less interchangeably. Also, the same is true with terms such as input, data, and information, which points to a second role that ontology can assume, which isthe task of conceptualising not the subject matter of the information, but the information itself(Galton & Worboys, 2011).

Furthermore, during emergency situations, information may be produced in different levels, and can be used by stakeholders in different stages. As Mejri stated, "during contingency response, information may be produced in the operative processes, but it is also useful for decisional ones. It may also be produced in the decisional level, and furthermore re-used into the operational processes. Conceptually, this information corresponds to instances of some classes of information identified during the emergency preparedness stage when constructing an emergency plan". Therefore, constructing shared ontologies permit to build specific knowledge bases which describe specific domains and hugely increases the potential for knowledge reuse, a major need in emergency management. This can be considered as one important role of ontology in emergency management(Mejri, 2010).

3.2.3 Ontology of emergency management data

Data that supports the whole process of emergency management is produced in different stages. It can be historical data from past events or the general information about buildings, infrastructures, critical facilities, resources or even the inhabitants of the studied area. Data that can be located and gathered immediately are considered as the context data. On the other hand, the data generated during crisis events, which is generally used for emergency management, is considered as the crisis data. Information about resources and exposures and their characteristics fall within the context data, while data about Hazard and its evolution and damages and losses as consequence of the disaster belong to the crisis data. Both are essential for a good emergency plan and should be take in to account in all phases of emergency management in order to reduce the negative effects of the disaster.

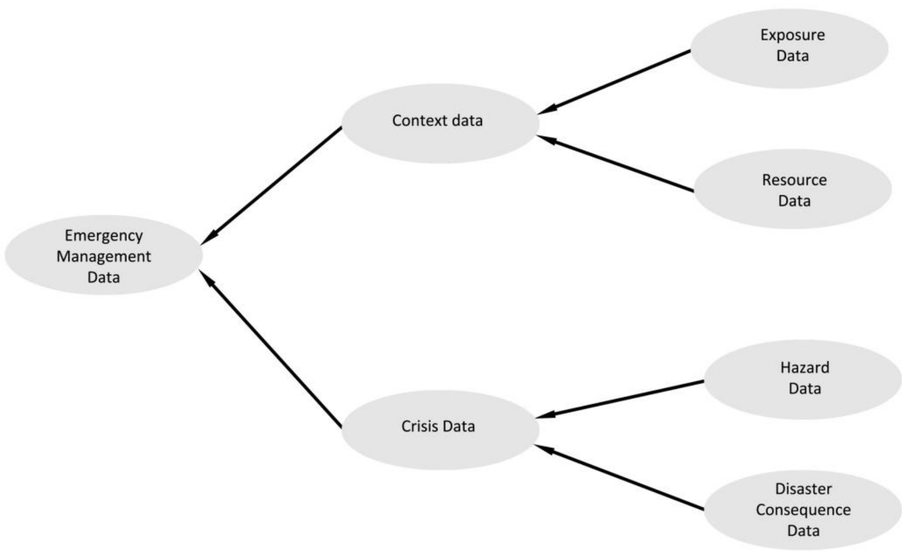


Figure 23 Ontology of Emergency Management Data

Therefore, by considering the difference between these kinds of data we decided to make two subcategories for emergency management data. The first one as it can be seen in the above ontology diagram is context data, which includes the exposure data and resource data, while the second is crisis data. Crisis data consists of hazard data and disaster consequence data.

These four categories: exposure, resource, hazard and disaster consequence, build the pillar of emergency management cycle. The necessary information for this cycle is included in at least one of these four categories. Each will be described further in the following texts.

3.2.3.1 Context Data

The subcategories of context data are exposure and resource. Both considered as context data since there is an "existing" relation among them. Exposure and resource data can be found not only in crisis situation but also in peacetime and can be used in all phases of emergency management cycle.

3.2.3.1.1 Exposure Data

The definition of exposure by itself is a person or an object, which is exposed to a certain kind of hazard at a definite time period. The data that supports this definition is considered as exposure data.

Without any exposed entity to a hazard, there will be no crisis situation.Thus, understanding exposure and its implications in emergency management is crucial. Better understanding can improve the planning process and make it more adaptable and flexible to the situation. This data is also useful all throughoutthe emergency management cycle, from the mitigation and planning phase untilthe response and recovery phases.

In general, the exposed objects can be subcategorised into four groups: population, critical facility, building, and infrastructure. These four groups cover all the necessary information that needs to be taken into account.

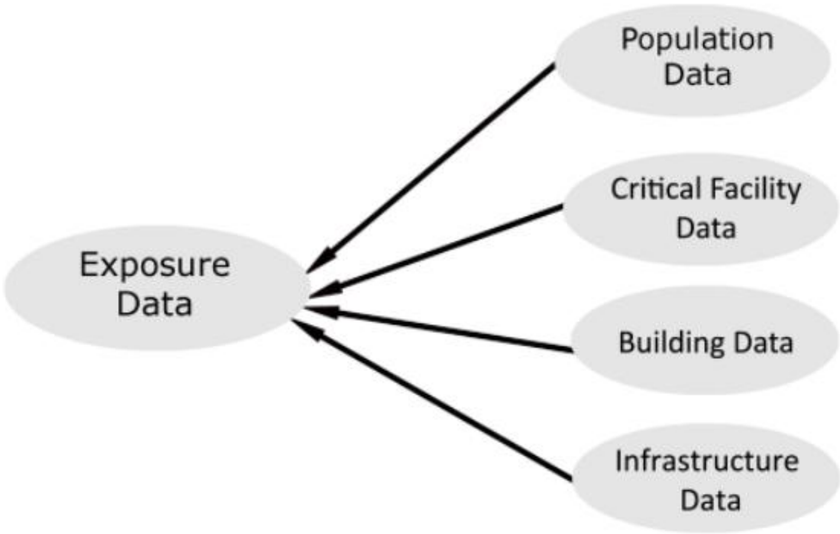


Figure 24 Ontology of Exposure Data

3.2.3.1.1.1 Population Data

One of the main goals of emergency management is to reduce losses and save lives. The life of a person is the most valuable thing as it cannot be replaced. Therefore, information about inhabitants in the area of interestmust be obtained.

Demographic dataprovides information about the gender and age distribution of the inhabitants. In crisis situations, the elderly (people agedover 65 years) and children (agedbelow5 years) need special attention.It is a must to provide them with the necessary help and equipment to ensure their safety before and after the event. Even during the emergency planning, these groups should be taken into account to make sure that an adequate and comprehensive plan is in place.

Likewise, in emergency management, it is important to know where are the most populated areas, such as the city centres or downtown areas, or coastal cities very close to the sea. However, having the density distribution data may still be improvedthrough time differentiation, such as having it in two different time spans (day and night). This will make it more effective since the density may change depending on the hour and activities involved. For example, during the day, density is higher in the places where most offices and public buildings are located, while, during the night, residential areas have the most density.

Moreover, social clustering and well-being conditions of the population are essentialateveryEM stage. For instance, during preparation, this kind of knowledge affects the plans and requirements (i.e. the elderly or disabled people might require some special facility or equipment, etc.).

Another useful data that should be considered is the general health situation of the population. This elaborates information about the handicapped or disabled population and the patient population. The city should have access to these records since they are considered as a special attention group. These groups must be taken into account separately in emergency management cycle. In addition to these groups, culturally and linguistically diverse population must also be considered in the countries with high immigrant populations.

As an example, in New Hanover County North Carolina There is group called Special Needs Task Force (SNTF) who their duty is to provide help and resources to people with special needs. It is composed of health and adult agencies and volunteers with related education who work with special needs individuals on a daily basis and offer their services when special needs individuals are at greatest risk.

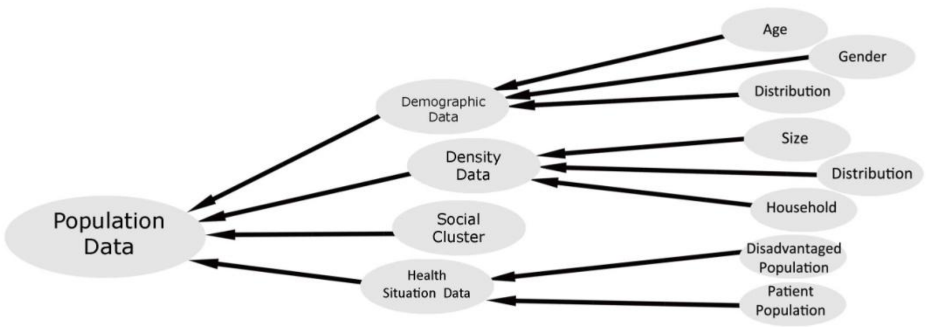


Figure 25 Ontology of Exposure-Population Data

3.2.3.1.1.2 Critical Facility Data

In each city, there are extremely important facilities that should be considered in EM, either for their contents or their functionality, and sometimes,for both. The museums serve as a good example. They are considered as critical facilities because of the cultural heritage, and losing them or damaging them would result to an irreplaceable loss. On the other hand, police or fire stations are important due to their functionalities. During crisis situations, these stations play an important role in helping people, saving lives, and ensuring security. Another example is the hospital, which can be considered for both the functionality and contents. It is essential to ensure the functionality of hospitals during emergencies, and to add to this, there are also patients located inside the hospital that may be considered as a special attention group that requiredspecial care.

After the identification of the critical facility category, it will be necessary to indicate its location and condition. Levels of maintenance,such as recent retrofits and renovations, interdependency with lifelines, whichpertain to power sources(i.e. with standby generators or power supply, or fully dependent on lifeline networks), and its transformability cover the description of a critical facility.

The material that has been used in the structure of the facility and its design characteristics such as number of the floors, existence of basements and places of voids define the physical characteristics of a critical facility. The different characteristics will have an influence depending on the type of hazard.For example, greater number of floors inside a facility is better in case of floods, but worse in case of an earthquake. Therefore, this data should be provided and consideredduring the entire EM cycle.

Other aspects that can be considered are functional capacities of the facility and its accessibility condition. Serviceability or functional capacity shows how many people or organizations can benefit from this facility and it is important in find out to what extent the facility can provides services in the interested area. Lack of redundancy is one of the major problems of facilities in catastrophic events especially in the islands and places that connect to rest of the city with bridges. Studying accessibility of the facility can indicate these problems and bring them under attention.

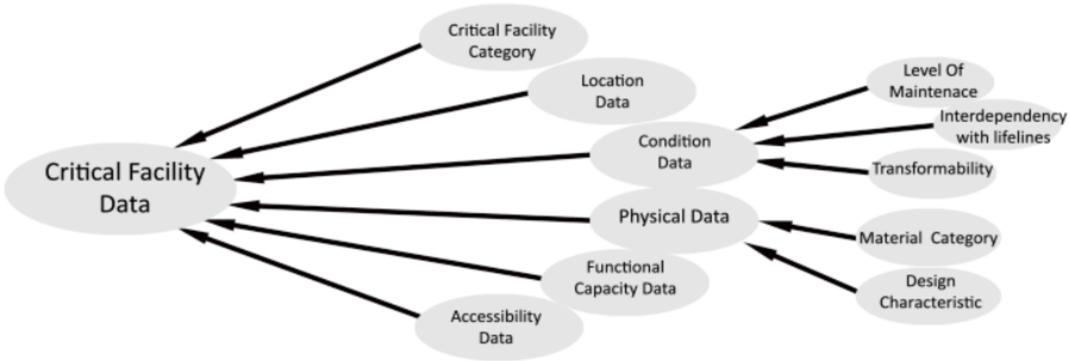


Figure 26 Ontology of Exposure-Critical facility Data

3.2.3.1.1.3 Building Data

Similar to the critical facility, buildings should also be taken into account as part of the exposure since its damages can cause economic loss or casualties like people trapped under debris, which is an indirect damage of building. The necessary building data is somehow similar tothe critical facility. Both have the following: building, physical characteristic, locations, accessibility and condition data, which were also described in the taxonomy section.

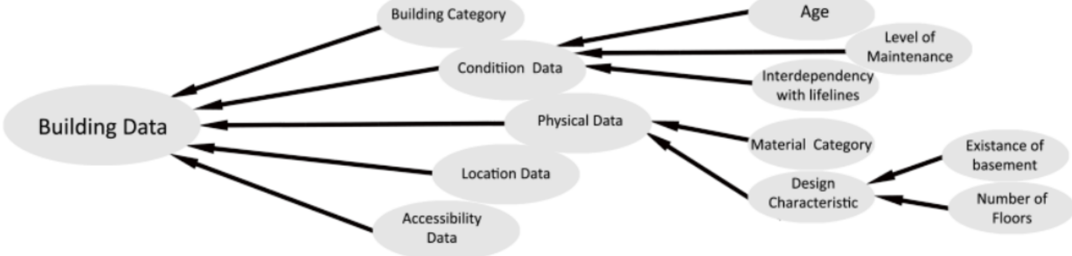


Figure 27 Ontology of Exposure-Building Data

3.2.3.1.1.4 Infrastructure Data

Infrastructure plays an important role in every society since it provides people energy power, water, communication and transportation network. In every crisis situation,a communication networksare essential. Its functionality must be ensured in order to disseminate information, warnings, needs and orders correct and in proper time. As an example without proper communication network people cannot ask for help and dealing organizations cannot coordinate adequately. In the same way, transportation networksare also critical. In an emergency,most of the operationsdepend on transportation networks. Apart from this, the functionality of lifelines such as electricity, water and gas on one hand can save lives after the impact by providing essential needs of people and on the other hand can ensure the functionality of dependent systems such as communication system and hospitals.

As we try to illustrate the importance of the infrastructures above, it is obvious that it should be taken into account as a fundamental term of exposure and be considered not only in crisis situation but also in recovery and planning by trying to reduce their vulnerability to the hazard.

The data that is useful in emergency management are infrastructure category, distribution data that consists of position and direction of the network, condition data like age, level of maintenance and interdependency to other lifelines, physical characteristics such as material category and design characteristics and at last accessibility data.

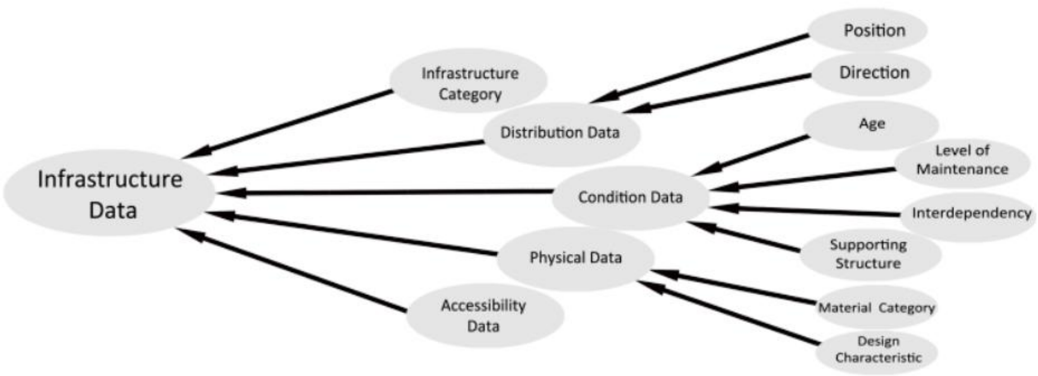


Figure 28 Ontology of Exposure- Infrastructure Data

3.2.3.1.2 Resource data

Another key point in every emergency management cycle is resource management. It is crucial to carefully manage resources such as personnel, teams, facilities, equipment and supplies to meet incident needs. Resource management should be flexible and scalable in order to support any incident and be adaptable to changes. FEMA proposed a finite process for resource management, as shown in figure below, with a distinct beginning and ending specific to the needs of the particular incident.

It is also worth mentioning that the emergency management cycle proposed by FEMA can be separated into two parts: resource management as an element of preparedness and resource management during an incident. The preparedness activities (resource typing, credentialing and inventorying) are conducted on a continual basis to help ensure that resources are ready to be mobilized when called to an incident.

Utilization of the standardized resource management concepts such as typing, inventorying, organizing and tracking will facilitate the dispatch, deployment and recovery of resources before, during and after an incident.

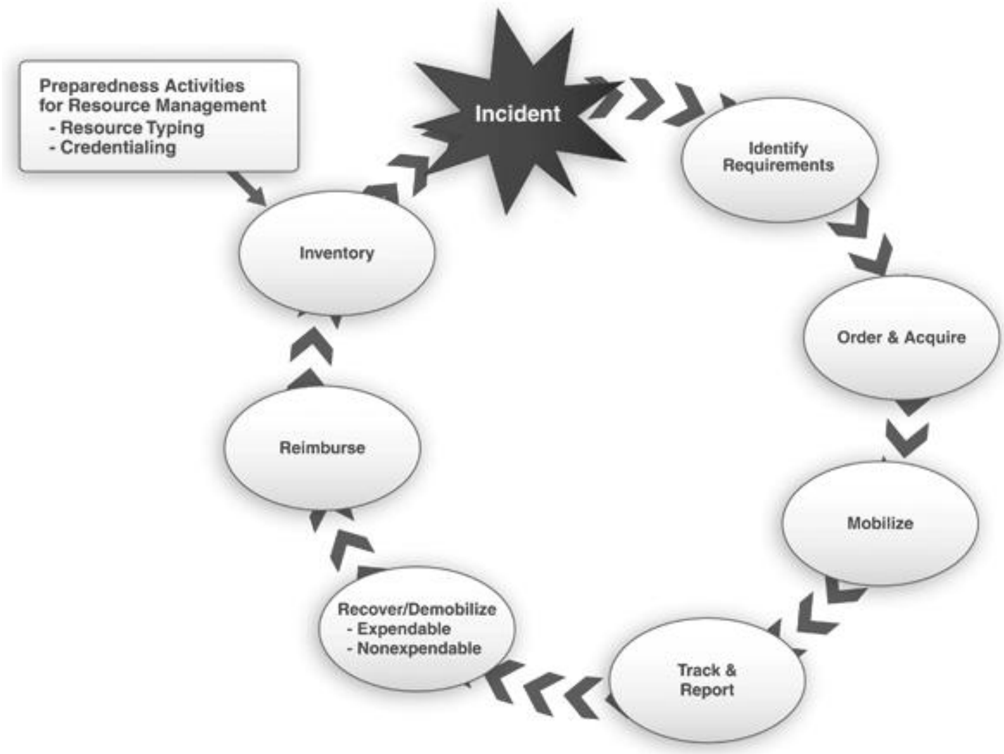


Figure 29 Resource Management Cycle

Efficient and effective deployment of resources requires that resource management concepts and principles be used in all phases of emergency management and incident response and ontology of resource data is a prerequisite of that.

The resources were split into six subcategories such as monetary, human, vehicle, vital line supply, shelter and evacuation centre and the last one equipment. The details of each one of them are explained in taxonomy diagram before. In the ontology it is important to know what is the category of the resource, its status that indicate its availability, its location to better coordinate the deployment, its amount and number and specific information like capacity or special skill and accessibility.

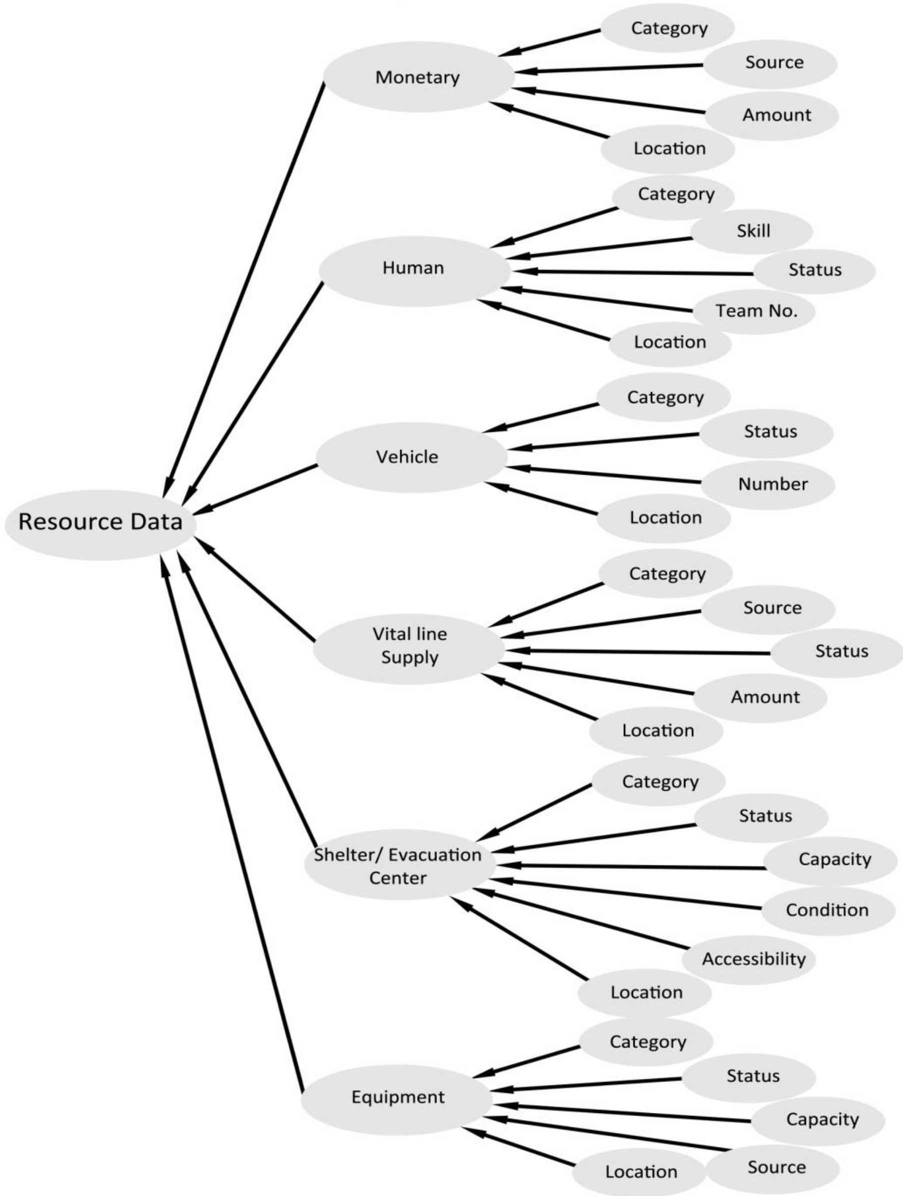


Figure 30 Ontology of Resource Data

3.2.3.2 Crisis Data

Crisis data is an emergency management data, which is produced during crisis. This data comes from heart of event, thus helps to develop a vivid picture of the incident, its consequences and existing situation during an emergency. Monitoring crisis data and process it can make an extreme improvement in emergency management. The data can provide necessary information of on-going situation and by collecting and processing them in proper time can make a huge improvement in adequate decision-making and response phase. But crisis data can also be important in other phases of emergency management such as recovery and planning. Since for having a productive emergency plan it is essential to fully understand the incident and its consequences in order to consider all of its aspects to mitigate them if it is possible or better be prepared for them.

The data that can be found during the emergency whether describe the incident by itself, which is called Hazard data or providing information about the effects of its impact that is named Disaster consequence data.

3.2.3.2.1 Hazard Data

One of the main factors of any emergency management is recognition of hazard and its features because without hazard there is no need for emergency management.

According to the United States Coast Guard (USCG)'s definition, hazard means "Any incident or event, natural or human caused, that requires an organized response by a public, private, and/or governmental entity in order to protect life, public health and safety, values to be protected, and to minimize any disruption of governmental, social, and economic services"(U.S. Coast Guard, 2006).

In general, there are two kinds of hazard, natural and manmade hazard. The details of these two categories are explained in taxonomy of hazard. Here in this thesis we mostly focused on natural hazards. Since each hazard has its own unique features, in the ontology we tried to consider all the features that may differ from one to another.

Hazard data is divided into three subcategories. These are monitoring data, alert information and Incident data. They describe different phases of an incident from the beginning of hazard, when its potential for turning to a disaster increases and finally when the incident happens and its evolution in all stages. The hazard may stop in each phase or may continue till the end.

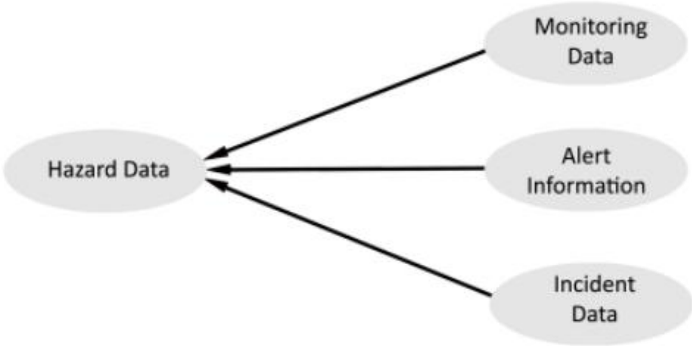


Figure 31 Ontology of Hazard Data

3.2.3.2.1.1 Monitoring Data

In this subcategory after indicating the type of event and the time, there is information about the location of the hazard, which differs from one to another. Considering the type of hazard it can be coordinate, address, origin, centre and movement data. For an earthquake, it is identifying by its epicentre, but for a terrorist attack it is the address or coordinates. Then data about strength and intensity of the event should be monitored in order to find out when it is proper to move to the next phase, which is alert information.

Forecast information provides us a general perspective of the whole event in near future. It consists of weather condition information such as temperature, precipitation, wind and pressure data. Data about the hazard position and its evolution pattern could be so helpful in getting prepared in an emergency. Moreover the forecasted time of happening and its duration play an important role in proper decision making and planning.

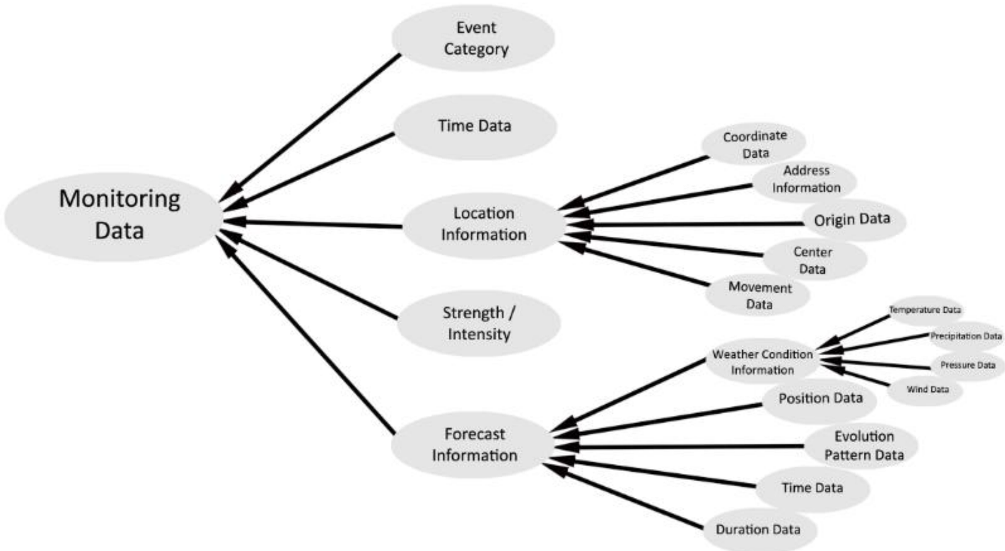


Figure 32 Ontology of Hazard-Monitoring Data

3.2.3.2.1.2 Alert information

Each event has sort of threshold that by passing them comes from monitoring stage to alert. These thresholds are calculated precisely for each one of them by scientists and should be used and compared uninterruptedly. When a hazard reaches its threshold it becomes an incident. This stage is so important for emergency managers since they have still some time before disaster happen and by making proper decisions and in time actions, they can reduce the negative consequences of the impact. However, there is always certain possibility of not happening the event therefore the probability data is key point of this problem.

To provide coherent and comprehensive alert information it is necessary to indicate the event category, location information, time and duration data. Besides, there is level of the alert, which illustrates the intensity of the hazard and may change from one event to another. For example, alerting system for typhoon consists of four levels of signal that come from less intensity to high (signal No. 1 with wind speed between 30~60 kph and signal No. 4 with wind speed more than 185 kph), on the other hand for hurricane there are five categories distinguished not only by wind speed and its effect but also by water surge.

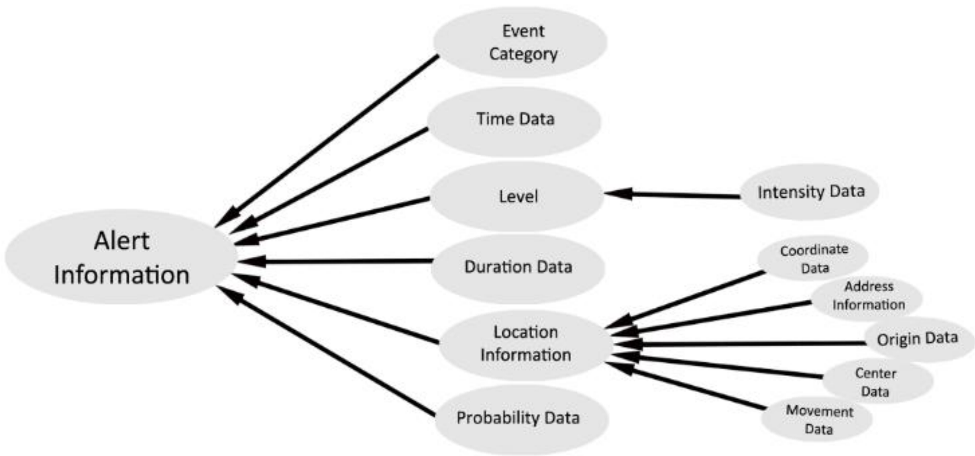


Figure 33 Ontology of Hazard-Alert Information

3.2.3.2.1.3 Incident data

This data is produced after the occurrence of a disaster event. This data provides a clear picture of situation of the event, which includes the type of the event, time of the impact, its duration and intensity. Information about the location of the incident and in case of existence the direction and movement data of the hazard are also important to have.

Hazard should be monitored continuously by the proper monitoring devices regarding the type of event so that updated data can be provided in each stage for emergency managers to take proper action. Therefore, an ontology of hazard data is extremely effective in order to ensure the existence of the necessary data for emergency management process.

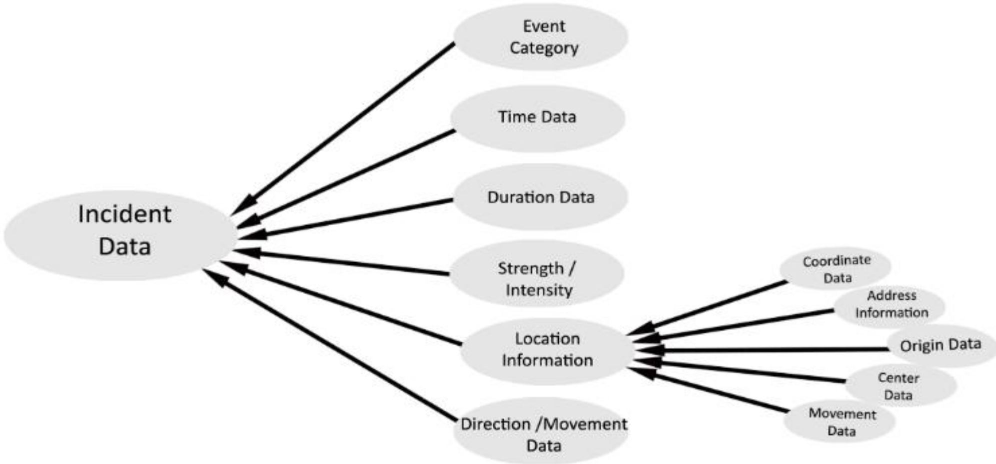


Figure 34 Ontology of Hazard-Incident Data

3.2.3.2.2 Disaster Consequence Data

This part of the ontology describes the classification of disaster consequence data. This data is produced after the impact and provides information regarding the adverse effects of the disaster on the exposed elements. These consequences are classified into two subcategories: direct consequence data and indirect consequence data.

Disaster consequence data can be useful in different phases of emergency management. As an example, all the represented concepts are useful during the development of an emergency plan as it covers the effects of the disaster, which may be combined with the estimated vulnerability from different scenarios. In addition, it is also valuable in the emergency response phase sinceithighlights the information on damaged infrastructures, buildings or critical facilities, and improves coordination of aid and resources to ensure that they exist in the places where they are most needed. The same goes for the recovery phase, where the information about damages and displaced population is relevant. Furthermore, the data of indirect consequences are also practical for the long-term emergency and development planning processes.

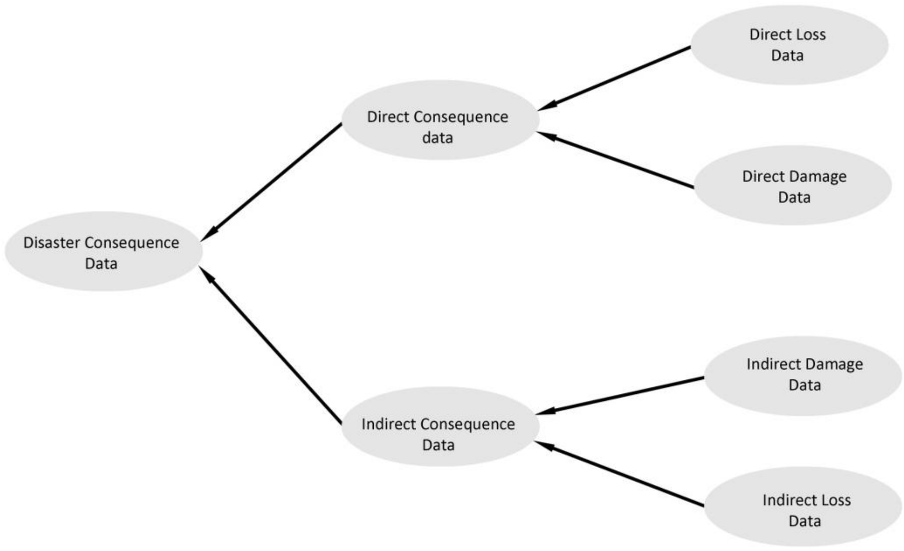


Figure 35 Ontology of Disaster Consequence Data

3.2.3.2.2.1 Direct Consequence Data

Consequences of a disaster are divided into two parts; loss and damage. As direct loss data can mention the population loss data like fatalities. These are the people that are dead by direct impact of an incident like people drawn in the flood or trapped under debris. The other one is loss of products like the destruction of warehouses and storage of the factories, which lead to losing all the products during the disaster.

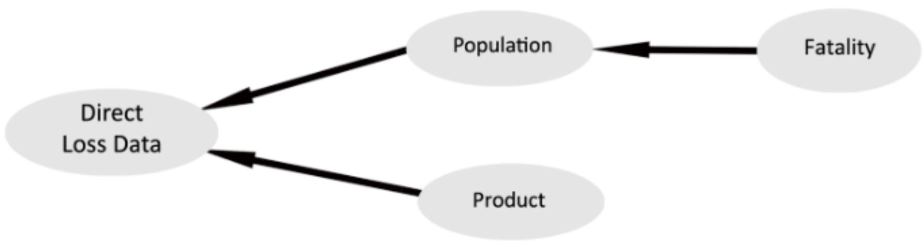


Figure 36 Ontology of Disaster Consequence- Direct Loss Data

Moving to the second classification, which is direct damage data. This includes all the damages to the mentioned exposures. It starts with the building damage data that consists of physical and functional damages to the building. On one hand destruction of building structure such as skeleton, foundation, external and internal elements, on the other hand damages to the lifelines of the building like water system, electricity and gas system plus destruction of content of the building assumed as non-structural damage that all are part of the physical damage data. Since damaged building loses its functionality so that its inhabitants are forced to move out to some provided shelters or become homeless therefore displaced population data is a functional damage of the building.

Critical facility damage data are the same as building damage data except in functional damage it is more general due to different functionalities of the facilities. Therefore here instead of displaced population, we used the term service disruption damage data in order to encompass all the imposed functional damages.

To continue on the direct damage data, the third class is population damage data that has one subcategory in common with building damage data, which is displaced population data. The other two subcategories are representing data of injured and missed people during the crisis.

The last class of exposure that needs to be considered in the direct damage data is infrastructure damage data. Here for each of them separately, physical and functional damage data are presented. As an example in physical damage of road network, damages of different kinds of roads, highways and bridges must be take into account and in functional damage of electricity network the blackout data, voltage fluctuation and disruption of the electricity must be considered. More details can be seen in the ontology diagram.

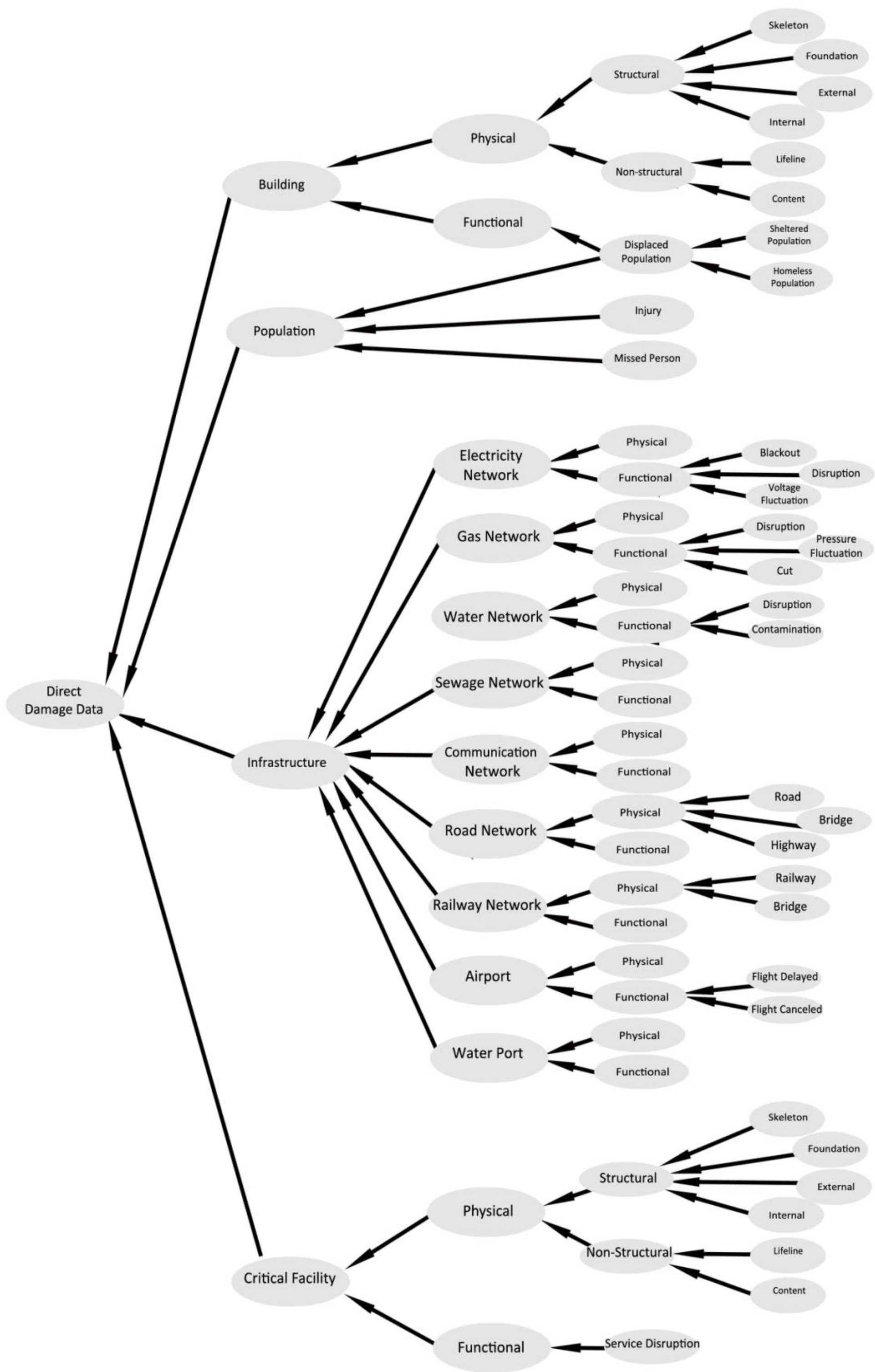


Figure 37 Ontology of Disaster Consequence-Direct Damage Data

3.2.3.2.2.2 Indirect Consequence Data

The last fraction of the ontology of emergency management data is indirect consequence data that like the direct consequence data is divided into two parts of loss and damage. These are secondary negative effects of the disaster, which by combing its data with the result of systemic and functional vulnerability can provide a good database for using in emergency management cycle,especially in emergency recovery and planning stages. Destruction of industries, factories and offices cause business and trade interruption in local or international level and bring damages to the economy on the one hand and increase the rate of unemployment on the other hand. People who have lost their houses, jobs, and weredisplaced, suffer from social disruption. All of which are considered as indirect damage data.

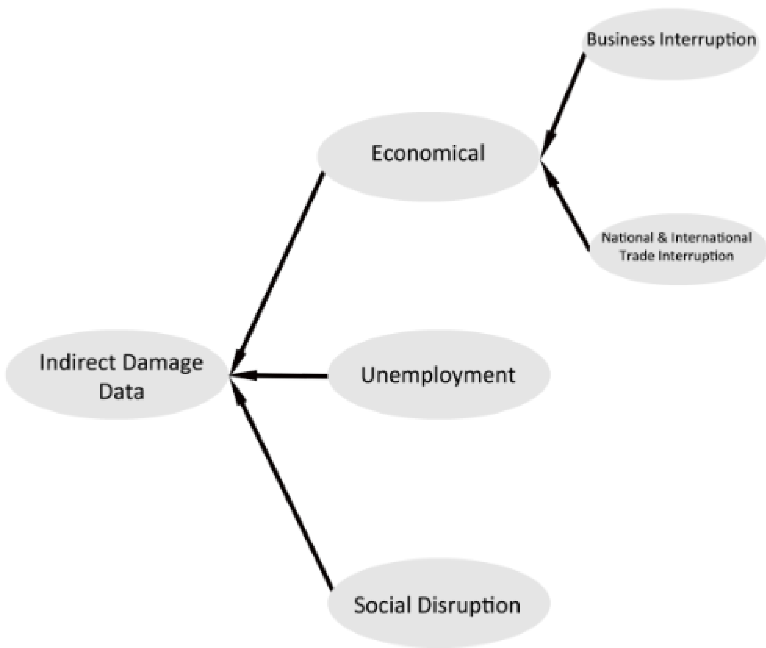


Figure 38 Ontology of Disaster Consequence-Indirect Damage Data

Some people die because of the direct impact of a disaster and some other due to the inaccessibility of roads to the hospitals, problem in hospital functionality, lack of medical services or food and many more. This loss of population is considered as indirect loss data. Furthermore, the same is true for loss of product where produced goods are destroyed as a result of problems in transportation, preservation or simply loss of connection between buyer and producer due to dominant chaos. Blocked roads and transportation networks because of the debris of destroyed buildings cause problem in accessibility. Finally loss of security due to looting, group violence or robbery is a big problem in every crisis situation that should be under consideration in any emergency plan and also in emergency response and recovery phases as well.

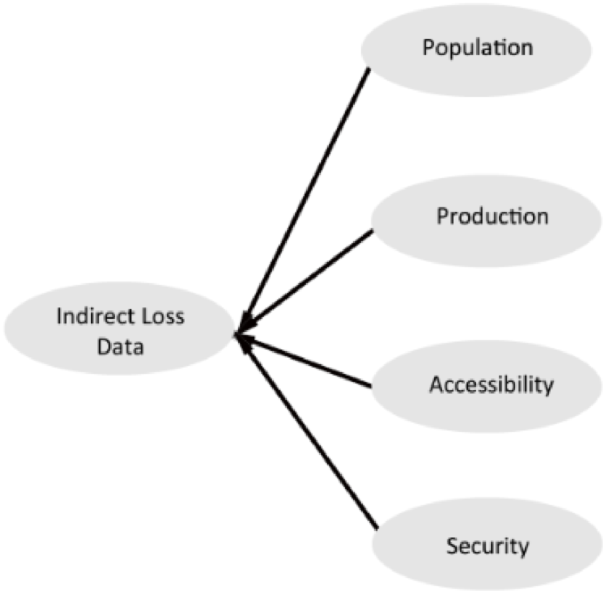


Figure 39 Ontology of Disaster Consequence-Indirect Loss Data

3.3 Data Analysis

As illustrated in section 3.2, available disaster data have varied characteristics and contain different information. Most of the time, a single data may fall into several categories, which creates some confusion. Nonetheless, this can be somehow resolved by identifying one's need. How is the data intended to be used? For which purpose? In each emergency phase, there are varying needs, but by specifying them, the effort is directed towards appropriate and useful information that will help satisfy the identified needs.

In the emergency management cycle, information requirements change from one phase to another. For instance, the information that one needs for quick decision making during the response phase is often different from the information that can be useful for future planning during the recovery stage. Due to the time factor, precision and accuracy might weigh a little less during the response. On the other hand, these two are necessary to come up with adequate measures and appropriate plans in the recovery planning, as well as in the pre-disaster planning.

Despite the varying needs that a data must fulfil as in the case of emergency management, a clear purpose allows the data to be grouped and regrouped to accomplish one's requirement. However, several factors are worth considering such as the nature and scale of the event, the motivation for data generation, data access and restrictions, data formats and the nature of the provided information. These can influence the data and its reuse potential. For spatial planning purposes, the Provention Consortium has developed a Hazard Information and Data Requirements Chart.

To better understand the information needs for planning, we have used the aforementioned guideline. The table below provides information about the common natural hazards, data requirements for planning, data types and sources, and assessment methods for each identified hazard. It makes a good reference especially for non-technical and scientific persons, and even for other professionals that are starting to integrate disaster risk management into the planning process.

Table 3 Necessary Hazard Information for Planning

Hazard Type	Information necessary for Planning	Data Types / Sources / Assessment Methods
Hydrometeorological		
- Floods (river and coastal)	- Extent and location of flooded or flood-prone area - Depth and duration of flood - Velocity of water flow - Rate of rise in water level and discharge - Amount of mud deposited or held in suspension - - Frequency and timing of occurrence (including seasonality) - Rainfall (and snowmelt) volumes and intensities	- Historical records of frequency, location, characteristics and impact of past events - Meteorological data: rainfall (and snowmelt) records and monitoring (e.g., rain gauges) - Topographic mapping and height contouring around coastlines, river systems and catchment areas; geomorphological mapping; sequential inundation stages mapping

	in flood-prone areas and their surroundings - Natural or man-made obstructions to flows and flood-control structures - Warning period - In coastal areas: tidal ranges and patterns of on-shore winds; height of sea-surges induced by cyclones	- Natural resources and land use mapping - Estimates of capacity of hydrology system and catchment area - Hydrological data on flows, magnitude (including flood peak discharges) and frequency of floods, river morphology, infiltration properties of soil - Hydrological estimates of future flood discharges, flows and associated characteristics; flood frequency analysis - In coastal areas: tidal and sea-level records, meteorological data on wind speeds and directions - Long-term and seasonal weather forecasts; climate change models
- Windstorms (including hurricanes, tornadoes and tropical cyclones	- Locations and extent of areas likely to be affected - Frequency of occurrence (including seasonality) and directional patterns - Velocity and direction of wind; wind and gale severity scales (e.g., Beaufort); local hurricane/typhoon scales - Associated pressure conditions, rainfall and sea/storm surges - Warning period	- Historical and climatological records of frequency, location, characteristics (including cyclone and tornado paths) and impact of past events on the project area and neigh- bouring areas (or countries) facing similar conditions - Meteorological records of wind speeds and direction at weather stations - Long-term and seasonal weather forecasts; climate change models - Topography and geomorphology of affected land areas (where there is risk of flooding from heavy rainfall or sea surges; see also flood data)
- Drought	- Rainfall levels, deficits - Frequency and timing of rainfall and drought occurrence (including seasonality); length of drought periods - Water levels (groundwater, rivers, lakes, etc.) - Water retention qualities of soils - Warning period - Associated biological features (e.g., pest	- Rainfall and snowmelt monitoring (e.g., rainfall gauges) and mapping - Soil type and moisture content surveys/analysis - Water source surveys and monitoring - Vegetation surveys (including mapping, aerial photographs) and crop production monitoring - Historical records of

	infestation, invasive plants)	frequency, location, characteristics and impact of past events (including long-term records of rainfall fluctuations) - Long-term and seasonal weather forecasts; climate change modelling
Geological		
- Earthquakes	- Location and extent of known seismic hazard zones, epicentres, faults, fault systems, etc. - Magnitude (energy release at epicentre) and intensity (severity of ground shaking) of earthquakes in the area - Other geological, geomorphological, hydrological features that influence ground shaking and deformation - Potential secondary effects: landslides, mudslides, avalanches; floods resulting from dam failures or tsunamis; fires; pollution from damage to industrial plants - Frequency of events	- Zoning and micro-zoning (mapping/ recording all seismological, geological, hydrogeological parameters needed for project planning in a given area, based on sources below) - Maps of seismic sources (faults, fault systems) - Geological, geomorphological maps and surveys (see also landslides) - Data on past occurrence of earthquakes, their location, characteristics (magnitude, intensity, etc.) and effects - Calculations of maximum ground accelerations
- Volcanoes	- Location of volcanoes and current state of volcanic activity (active, dormant, extinct) - History, frequency and character of each volcano eruptions and the processes that produce them - Areas at risk from eruptions; radius of fall-out or direction of flow of eruptive materials - Volume and type of material ejected (e.g., ash falls, pyroclastic flows, lava flows, lahars, gas emissions) - Explosiveness and duration of eruption - Warning period	- Geological studies and maps, based on geological survey evidence of frequency, extent, nature of previous eruptions - Hazard/zoning maps (based on geological data) - Historical records of frequency, location, characteristics and impact of past events - Monitoring and observation/recording of precursory phenomena (including seismicity, ground deformation, hydrothermal phenomena, gas emissions)
- Landslides	- Volume and type of material dislodged, area buried or affected, velocity - Natural conditions affecting slope stability (composition and structure of rock and	- Identification of location and extent of previous landslides or ground failures by surveys, mapping, aerial photography - Mapping/surveys of rock formations and

	soil, inclination of slopes, groundwater levels) - Other external triggers: seismicity, rainfall - Vegetation and other land use (including building activities, landfill, man-made mounds, garbage pits, slag heaps, etc.	characteristics, surface geology (soil types), geomorphology (slope steepness and aspect), hydrology (esp. groundwater and drainage) - Historical records of frequency, location, characteristics and impact of past events - Identification of probability of triggering events such as earthquakes, cyclones, volcanic eruptions - Vegetation and land use mapping and surveys - Zoning maps, based on the above

Source: Provention Consortium

The table presented comprehensive information requirements for the integration of the various hazards into the planning process. However, the study will only focus on hydrometeorological hazards as it only deals with the case of Super Typhoon Haiyan.

Initially, the gathered data was sorted and classified according to the following:

(a) Data coverage / scope (area of interest)
(b) Data format or file type (i.e. map, report, satellite image, etc.)
(c) Data source (author or owner of the data)
(d) Production and publication methods (collaborative production? open data?)

Planning is often area specific so data coverage or scope is necessary. Apart from the data coverage, other details regarding the data must also be taken into account such as the data format, source, and production publication methods. The data format provides information regarding the data representation. This is an important consideration in the ability to reuse the disaster data and combine it with other gathered information. Other considerations include the origin, production and publication methods of the data. The source of the data provides an insight about the reliability of the published information and its acceptability, while the production and publication methods may also provide further information on the data accuracy, and access and reuse limitations.

Afterwards, the developed taxonomy was applied to identify the contents of the data (i.e. hazard, exposure and resource), and was further broken down into details using the ontology for each taxonomy. Any important information that was unidentified as a criterion was noted in the remarks.

The end product was a comprehensive table that serves as a reference to ensure that all the acquired information were identified and none were missed. It also aids the search process for specific and practical information. This also allows for easier regrouping according to the needs and priorities of the user, or in this case, the research study.

From the table, data were selected and extracted according to the objectives of the study. Since the main focus of the study is to evaluate the potential value of volunteered disaster data in development planning, it was also crucial to understand the basics of the planning process and its required datasets.

In the Philippines, the common datasets covered several areas. Apart from the geospatial and demographic information, it also required information on the area's economy, environment and natural resources, and the local government unit's structure and capacities.

As we are focusing on Tacloban, this dataset requirement, along with the Provention Consortium's chart and other aforementioned criteria (data scope / coverage, data format, source and production methods) were used to guide the selection of the data to be used in the application.

The final step involved the software-aided post-processing of the raw data to extract the useful information that may be used as inputs for planning process. After completion of the post-processing, a comparison of the available data was made using overlay analysis. In this part, similarities and variations were noted. This process also allowed some trends to be identified, while also making some validation regarding the reliability of the data.The results of the analysis will be elaborated more in Chapter 5.

Table 4 Required Datasets for Spatial Planning

Spatial Planning Data Requirements		
Population and Social Services		
1	Population Size	
2	Age- Sex Distribution	
3	Household	
4	Population growth /projection/doubling time	
5	Population Distribution / Urbanization	
6	Social Clustering	
7	Status of well-being of population	
Economy		
1	Economic Structure	
	1	Types (Primary, Secondary, Tertiary)
	2	Level of Urbanization
	3	Structural Shift
2	Area Specialization	
3	Structural Shift	
4	Linked Activities	
5	Money Flow	
Physical and Spatial Base		
1	Land and Land Uses Inventory	
2	Area Coverage	
3	Thematic Maps	
	1	Land Classification
	2	Slope
	3	Elevation
	4	Physical Constraints
	5	Present Land Use
	6	Road Network / Infrastructure
	7	Protected Areas
	8	Area coverage
4	Map overlay analysis	
	1	Land Supply
	2	Vacant Land
	3	Decision Zones
5	Infrastructure Support	
Environmental and Natural Resources		
1	Natural Resource Inventory	
2	Environmental Assessment	
LGU Capacity for Planning and Management		
1	Organizational Structure and Functions	
2	Planning Section Structure and Functions	
3	Fiscal Management Capability	
4	Development Orientation	
5	Intergovernmental Relationships and Functions	
6	Public participation	

Source: RPS

4 Case Study

4.1 Integrating Disaster Risk Reduction into Development: The PH Scenario

The early recognition, unfortunately, did not translate into early adoption. It was not until recently when circumstances have clearly worsened that perspectives and paradigms started to transform. The Philippines is no exception to this pervasive reactionary trend.

In the past decade, it has been experiencing an increase in disaster occurrences: in 2009, Metro Manila was submerged due to Typhoon Ketsana (PH name: Ondoy), in 2012 Typhoon Bopha (PH name: Pablo) hit the country, and before 2013 came to a close, the Philippines suffered two unfortunate blows in the form of a 7.2 magnitude earthquake in October and a category 5 super typhoon in November, which wreaked havoc and unimaginable consequences. The earthquake had destroyed not just homes and businesses, but also several heritage sites that are valuable and irreplaceable, while the super typhoon has wiped out towns and virtually reduced them to mass graves and wastelands.

Table 5 Total Amount of Damages and Losses due to disasters in PH

Resilience of natural systems enhanced with improved adaptive capacities of human communities in average annual damages and losses	Amount of damages and losses to properties due to natural disasters, environmental hazards, human-induced and hydro-meteorological events (in million PHP)		
	Average for 2004-2010	2011	2012
	19,272.70	**25,294.26**	**39,919.85**

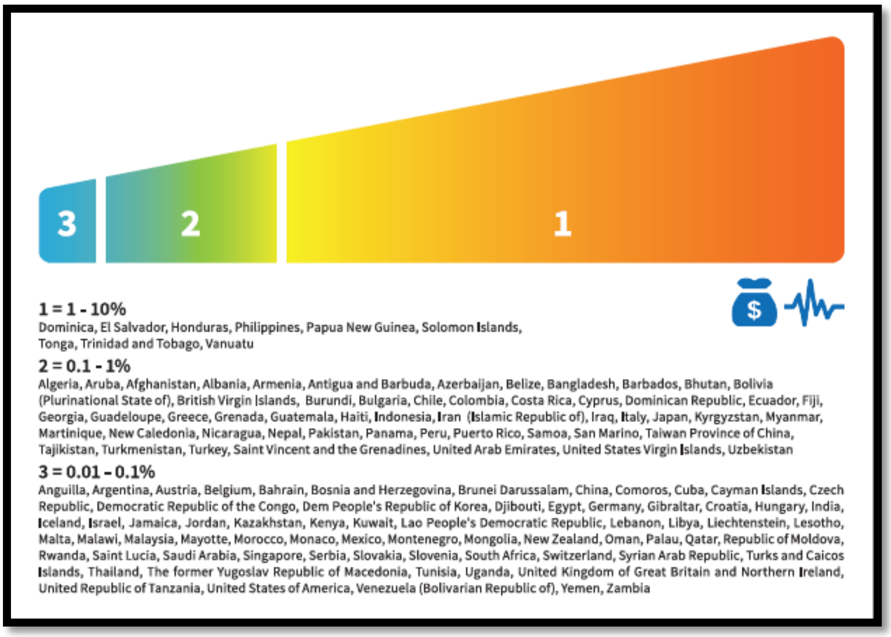
Source: NSCB, NDRRMC

In the 2013 Global Assessment Report, it listed the Philippines, as one of the top vulnerable countries for specific disasters in terms of potential losses. This highlights that the country's fragility is not only due to its geographical location, but also because of its socio-economic condition.

As disasters do not distinguish between social and economic classes, it may be said that they are great equalisers. Economies of developed and developing areas are both endangered of experiencing huge losses should a disaster strike. However, the proportion of the effect is never equal. Economies in the developing regions such as those located in the Asia-Pacific region face a greater threat, especially those with a huge part of their population still living under the most vulnerable conditions (UNISDR & ESCAP, 2010). Most developing countries, like the Philippines, are still plagued with problems of poverty, and due to this, post-disaster recovery and redevelopment becomes very difficult. In addition, the recent growth is endangered of being stunted or erased, and would result to starting from scratch once more.

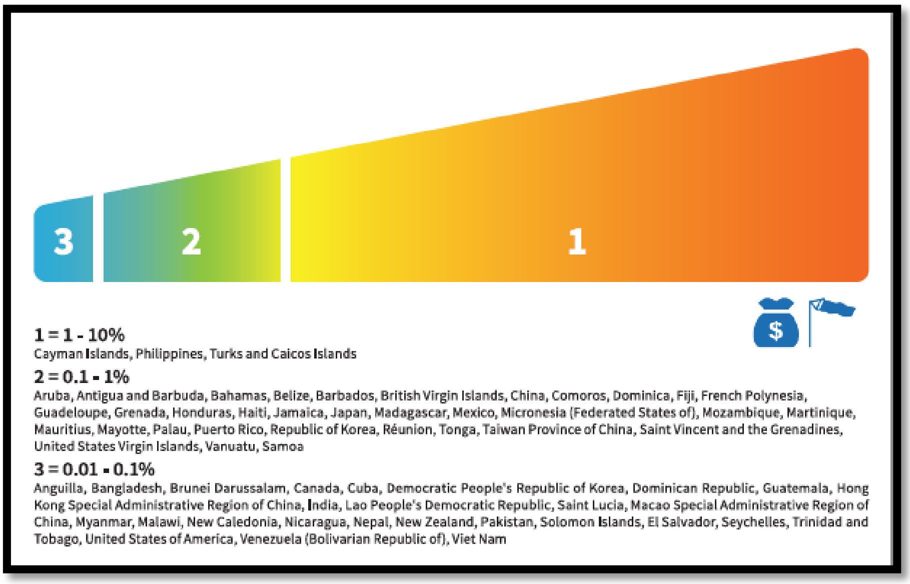
With this realisation, the Philippines decided to revise its legislative framework to strengthen the country's disaster risk management system. In 2010, the Philippine Disaster Risk Management reached a turning point. It acknowledged that the impact of disasters can be actively relegated, and overhauled its previous DRM legal framework, PD 1566, which it had used for decades. It was superseded by Republic Act (RA) No. 10121, also known as the Disaster Risk Reduction and Management (DRRM) Systems Act, to keep up with the changing times and varying needs.

Figure 40 Annual Average Losses from Earthquakes as a percentage of urban produced by risk class



Source: GAR 2013

Figure 41 Annual Average Losses from Cyclonic Winds as a percentage of urban produced by risk class



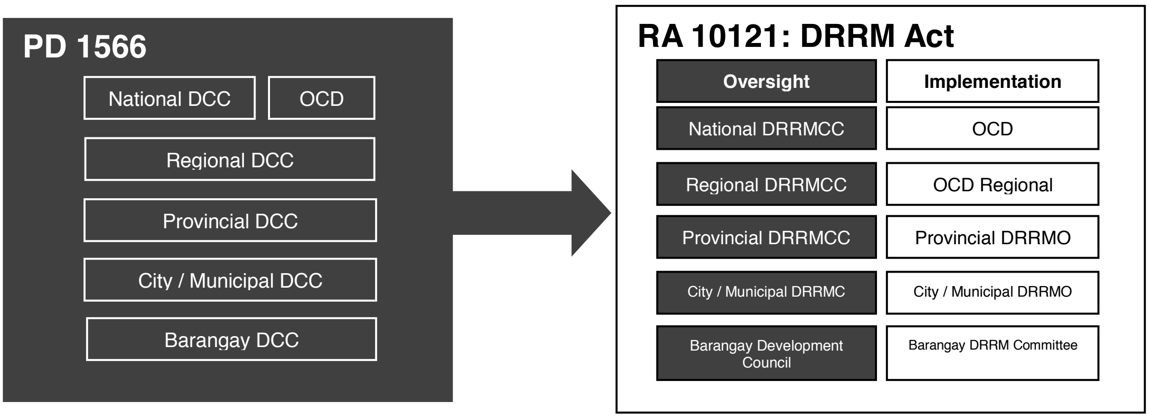
Source: GAR 2013

Table 6 Philippine Disaster Risk Management Timeline

Period	Disaster Risk Events	Disaster Risk Management Features / Changes	Relevant Laws
Pre-colonial (Before 1521)	**(1)** Natural disasters (Storm, rain, wild animals, etc.)	**(a)** Early warning system (possibly through a town crier) **(b)** Primitive weather forecasting **(c)** Infrastructure-based disaster mitigation **(d)** Architectural solutions	
Spanish colonisation (1521-1898)	**(1)** Natural disasters (earthquake, floods, volcanic eruptions, epidemics, pests); **(2)** Water disasters; **(3)** Insurgencies	**(a)** Change in construction materials and architectural design **(b)** Disaster observation recording **(c)** Formal weather observations **(d)** New equipment: universal meteorograph **(e)** Seismic observations **(f)** Typhoon warning issuance **(g)** Early first aid	
American / Japanese Occupation and Commonwealth Period (1899-1946)	**(1)** Natural disasters; **(2)** WW II	**(a)** Inclusion of man-made disasters (wars, armed conflicts) **(b)** Introduction of laws and aid institutions **(c)** First weather bureau; first weather map **(d)** Introduction of civil protection; first civil emergency administration	Act No. 31 / 1901 EO 335 / 1941 EO 337 / 1941 EO 36
Post-WWII (1947-2010)	**(1)** Natural Disasters **(2)** Man-made disasters	**(a)** Disaster and Calamities Plan (1970) **(b)** Calamities and Disaster Preparedness Plan (1988) **(c)** National Disaster Coordinating Council (NDCC) / Office of Civil Defense (OCD) **(d)** Calamity fund **(e)** State of calamity declaration by President	RA 1190 / 1954: Civil Defense Act EO 74 / 1967 EO 151 / 1968 EO 116 / 1968 EO 159 / 1968 LOI 19 / 1972 PD 1566 / 1978 Proc. 296 / 1998 EO 137 / 1999
2010 - Present	**(1)** Natural Disasters **(2)** Man-made disasters	**(a)** Paradigm shift: Preparedness and Response ->Risk Reduction and Mitigation **(b)** Integration into spatial and development planning and climate change adaptation **(c)** Participatory approach **(d)** NDCC -> NDRRMC **(e)** Calamity fund -> DRRM fund **(f)** State of Calamity declaration by local council / President	RA 10121 / 2010

In the past, disaster preparedness, response and emergency relief had been the focus of the various actions. Conversely, this act proposes to reduce and mitigate disasters before its occurrence. It has aimed for a more decentralised and participatory approach by empowering the local government units, actively involving civic organisations and communities, and by employing the bottom-up approach as opposed to the previous top-down method. Local DRRM councils have been formed to support this. The existing organisation was restructured for a clearer delineation of the oversight and implementation functions, and membership was also expanded to reflect the shift to a participatory paradigm. Now, the membership to the Disaster Risk Reduction and Management Councils (DRRMC) has been extended to other organisations deemed instrumental to its successful execution such as civic organisations, the private sectors and other governmental agencies (Agsaoay-Saño & Vera, 2010).

Figure 42Organisational Restructuring after RA 10121



Adapted from: DRR Net Phils.

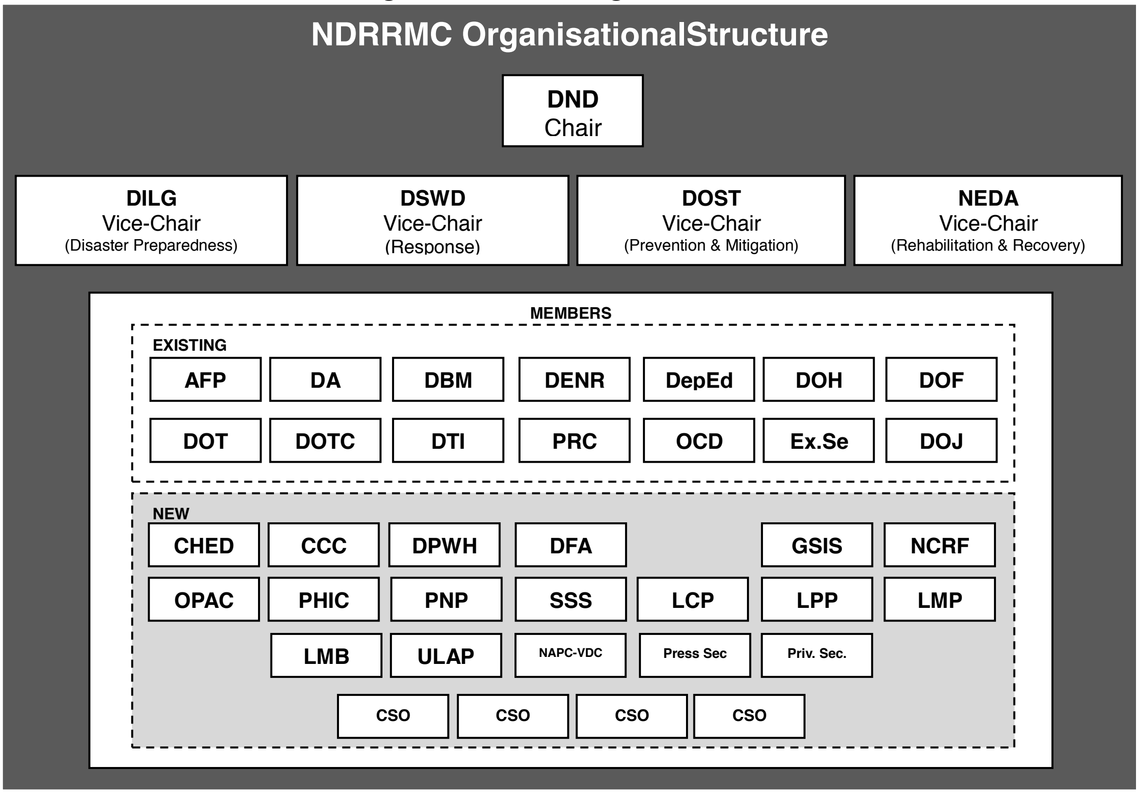
However, this move also meant that preparedness and response for, during, and after a disaster have also changed. Response and intervention are now guided by the following criteria:

Table 7 Reponsible authorities / responders and their scope

Responsible Authority / Responder	Scope of damage / effect
Barangay Development Council	One (1) barangay is affected
City/Municipal DRRMCs	Two (2) or more barangays are affected
Provincial DRRMC	Two (2) or more cities/municipalities are affected
Regional DRRMC	Two (2) or more provinces are affected
NDRRMC	Two (2) or more regions are affected

Source: DRR Net Phils.

Figure 43 NDRRMC Organisational Structure



Source: DRR Net Phils.

This change creates a greater sense of independence and responsibility among the local authorities, and also coincides with the country's spatial administrative strategies. In addition, it also promotes an increased participation through decentralization and bottom-up strategies.

On the other hand, while the existing structure encourages greater integration in the spatial planning activities and enhances the self-sufficiency of the local government units to respond to disasters, it also indirectly limits the role of national government during local disasters. Previously, state of calamity declarations can only be made by the president, but with RA 10121, local councils may now declare a state of calamity within their jurisdiction. By declaring a state of calamity, remedial measures are put into place. They are as follows:

1. Imposition of a price ceiling on basic necessities and prime commodities
2. Prevention of overpricing/profiteering and hoarding of prime commodities, medicines and petroleum products
3. Programming/reprogramming of funds for the repair and upgrading of public infrastructure
4. Granting of no-interest loans by government financing institutions to the most affected population

Depending on the scope and magnitude of the disaster, external aid or intervention may also be made requested by the president upon the national council's suggestion(Agsaoay-Saño & Vera, 2010).

Apart from the aforementioned, the new law also provides a stronger backbone for the reduction and mitigation activities, which were not originally included in its disaster management cycle and not allowed to be financed by the calamity funds. Its enactment transformed the prevailing disaster management system and procedures, giving more priority to prevention through DRRM integration into spatial and development planning and climate change adaptation.

As a result, local government units and technical agencies are now working together to better understand the hazards, vulnerabilities and risks in their areas so that it can be properly addressed using various tools such as land use and development plans.

In 2005, the READY project, a nationwide mapping of hazards, was conceived. It seeks to standardise and institutionalise DRM measures and processes across the country, while at the local and community levels, it aims to strengthen the capacities of the most vulnerable municipalities and cities to enable systematically address the potential hazards, vulnerabilities and risks through self-prepared disaster risk management plans. 43 provinces were identified by the national disaster management council to benefit from this undertaking(NEDA, UNDP, ECHO, 2008).

The first 27 provinces identified as candidates for the initial mapping were Benguet, Abra, IlocosNorte, Ilocos Sur, Cagayan Valley, Isabela, Nueva Vizcaya, Quirino, Pampanga, Zambales, Aurora, Cavite, Laguna, Rizal, Catanduanes, Antique, Iloilo, Bohol, Leyte, Southern Leyte, Eastern Samar, Northern Samar, Zamboanga Del Sur, ZamboangaSibugay, Agusan Del Sur, Surigao Del Norte, and Surigao Del Sur (ibid).

The next 16 provinces were identified in 2007 with specific target cities or municipalities. These are Cebu (Metro Cebu), Pangasinan (Dagupan City), Bulacan (Doña Remedios Trinidad, San Miguel), Agusan Del Norte (Butuan City), Western Samar (Catbalogan City), Agusan Del Norte (Butuan City), CamarinesNorte (Daet), Quezon (Lopez-Calauag), Oriental Mindoro (Calapan), Aklan (Kalibo), Batanes (Basco), Zamboanga del Norte (Dipolog City), Bukidnon (Malaybay City), Davao Oriental (Mati), Mountain Province (Bontoc), and Lanao Del Sur (Malabang) (ibid).

The READY project provides expedient data that will be useful for the DRM activities of the various cities and municipalities. However, a concern arises from the lack of necessary resources and training of the technocrats and bureaucrats to be able to use them for their own interests and goals of addressing the hazards and risks present in their localities.

Furthermore, information access also becomes a concern as not all of the administrative regions in the Philippines have the appropriate technological tools and budget to carry out expensive comprehensive hazard assessment surveys. Most of them rely on the national government to provide them with the necessary information. Generally, this is acceptable as it promotes a harmonized approach. However, as disasters are more dynamic these days, it may be difficult to depend on past data to serve as an indicator of the future. The new and emerging trends entail a reconsideration of the present knowledge and methods for risk assessment.

As with the reliance of the Philippines on outmoded facts, it may be putting itself in harm's way rather than steering out of it. In this case, we see the importance of the updated information's availability and accessibility, which is instrumental to resilience-building and development as it ensures timely delivery of facts. Thus, well-informed decisions can be taken by the authorities during planning, preparation, response, and recovery phases. To expound on this further, the recent super typhoon will be taken as an example, to create a visualisation of how risks are being managed and responded to.

4.2 PH DRRM in action

4.2.1 The Perfect Storm: Super Typhoon Haiyan

Before 2013 came to a close, it had put the Philippine Disaster Management to another tough test. One disaster came after another. On October 2013, a 7.2 quake rocked the central region of the Philippines. As if this was not enough, the following month, a super typhoon swept the same region, but due to its nature, it spread its terror on a much wider scale.

4.2.1.1 Cradle to grave: Super Typhoon Haiyan's Formation and Dissipation

Super Typhoon Haiyan started out as a low pressure area (LPA), which was first spotted on the 2nd of November 2013, along the island of Pohnpei, the Federated States of Micronesia (FSM). Due to favourable environmental conditions in the area, it rapidly intensified into a Typhoon. Within three days, it had attained a Saffir-Simpson Hurricane Wind Scale (SSHWS) Category 5 status (Joint Typhoon Warning Center, 2013)moving westwards with its predicted path to cross the Philippines, Vietnam and China(Japan Meteorological Agency, 2013).

As forecasted, Haiyan entered the Philippines' Area of Responsibility (PAR) on the 6th of November, and was assigned 'Yolanda' as its local name(Flores, 2013). It had made its first and subsequent landfalls on the 8th of November. Its presence was brief as it loomed over the country only for a day. Nevertheless, the devastation it caused was huge due to its exceptional force.

When it made its exit on the 9th of November, it had already weakened and turned northwest. It headed for Vietnam, and made a landfall as a severe tropical storm on the 10th of November. Very few casualties were noted due to the weaker intensity, and also due to the intensive preparation done by the government, especially after witnessing the havoc it wreaked in the Philippines. Likewise, Haiyan also didn't linger and quickly moved to China, where it eventually dissipated into a tropical depression.

Figure 44 Super Typhoon Haiyan's Timeline

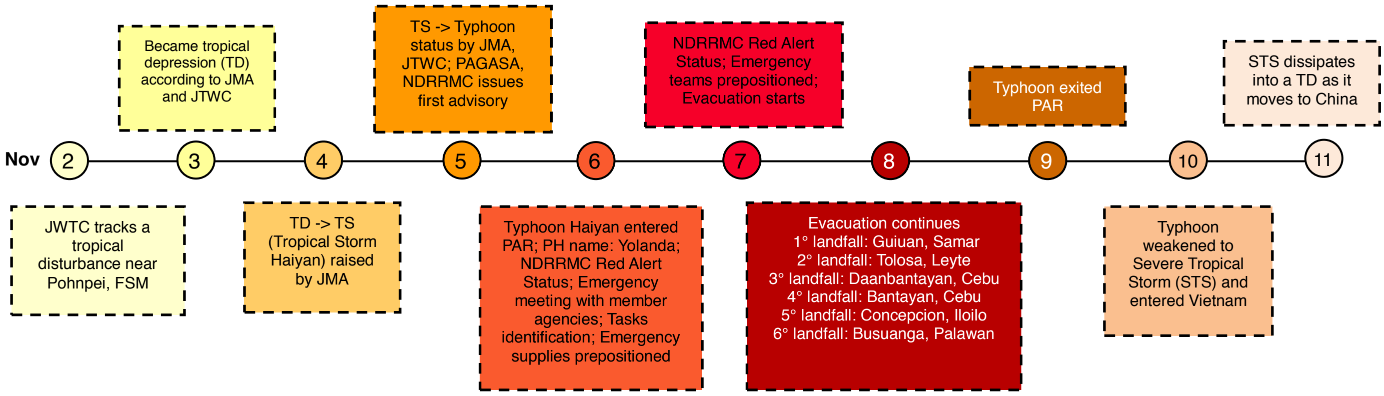
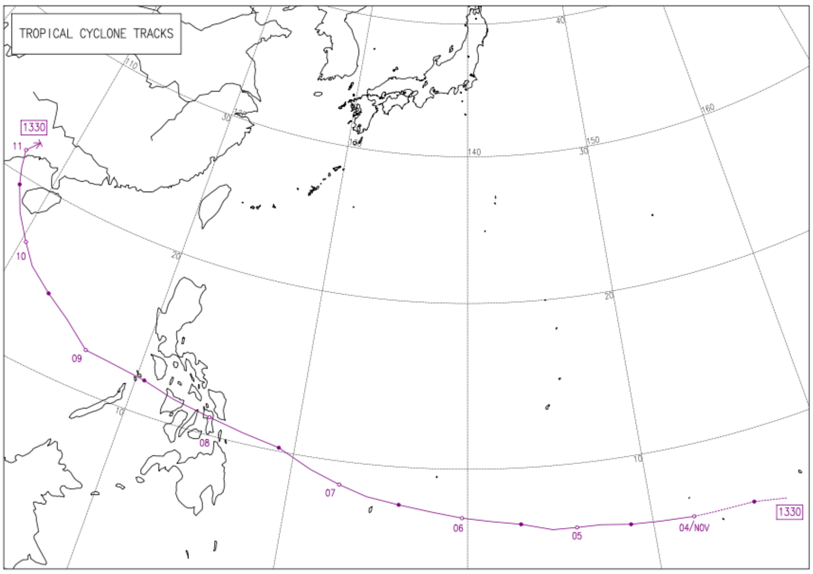


Figure 45 Super Typhoon Haiyan's Actual Path



Source: JMA, 2013

A more detailed account of the disaster in the Philippines is presented in the succeeding section. On the contrary to some reports and opinion that no or little preparations were made, a lot of effort and resources were spent to gear up for the monstrous event. Whether the actions and decisions made were appropriate are outside of the study's coverage. Thus, the focus will only be on recounting how the Philippines reacted and managed the calamity.

4.2.1.2 Haiyan's Chronology in PH

On the 6th of November, NDRRMC called for an emergency meeting to discuss the tasks and responsibilities of the various member agencies. Emergency supplies and equipment were prepositioned and personnel were deployed for the anticipated peri- and post-typhoon relief and response activities.

By the noon of the 7th of November, the intensity of Typhoon Haiyan grew faster and stronger. Thus, the storm warning signals for Visayas and Mindanao were elevated to PSWS No. 3, with winds of more than a hundred (100) to a hundred eighty-five (185) kph. Throughout the rest of the affected areas, the storm warning signals were also raised by a level(National Disaster Risk Reduction and Management Council, 2013). Residents in low lying and mountain areas under PSWS Nos. 3, 2 and 1 were alerted against possible flash floods and landslides, while those living in coastal areas under PSWS Nos. 3 and 2 were alerted against storm surges with a potential wave height of 7 metres (National Disaster Risk Reduction and Management Council, 2013).

Shortly after, the public storm warning signals reached the scale's highest, PSWS No. 4, which was only issued for typhoons with wind speeds of more than 185 kph. As such, the preparation phase immediately turned into an emergency management phase. The scope was widened and preparation activities still ensued.(National Disaster Risk Reduction and Management Council, 2013). More action had been done by the Department of Public Works and Highways (DPWH) by prepositioning their heavy equipment in strategic areas for possible clearing operations. They also monitored national roads and bridges and deployed teams to strategic locations particularly identified sections prone to landslides and flooding. The Department of Health (DOH)also activated more operation centres on a 24-hour basis, prepositioned assorted drugs and medicines in the province. The Armed Forces of the Philippines (AFP) provided logistical and manpower support to haul and preposition relief items around, and placed all lower units on heightened alert. Likewise, the Philippine Red Cross (PRC)prepositioned rescue supplies and equipment and activated its response teams and volunteers.

On the 5th of November 2013, the Philippine National Disaster Risk Reduction and Management Council (NDRRMC) issued the first typhoon warning (Lopez, 2013). The country's weather bureau, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), issued a weather alert declaring Public Storm Warning Signal (PSWS) No. 1, the lowest of four levels, for typhoons with thirty (30) to sixty (60) kilometres per hour (kph) winds. This was declared for much of the Visayas and Mindanao, central and southern parts of the country respectively. Along with this, the NDRRMC had also issued a list of cities that will be affected as the typhoon enters the Philippine Area of Responsibility (PAR). It had asked the following areas: Metro Manila and the regions IV-A (CALABARZON), IV-B (MIMAROPA), V (Bicol), VI (Western Visayas), VII (Central Visayas), VII (Eastern Visayas), XIII (CARAGA) and X (Northern Mindanao) to make the necessary preparations before the typhoon hits the country. Disaster coordinating councils (DCC) and local government units (LGU) were instructed to carry out pre-emptive evacuation of residents and to prepare emergency food and shelter (National Disaster Risk Reduction and Management Council, 2013). This announcement was also followed by a storm surge warning coming from the Department of Science and Technology's (DOST) Nationwide Operational Assessment of Hazards Project (Project NOAH). It had stated that the surges can go as high as five (5) metres or sixteen and a half (16.5) feet. They have also released a list naming potentially affected areas for precautionary measures (Ranada, 2013). These alerts, warnings and updates were disseminated through various communication channels such as print, television, radio and web-based media as well as social networking sites.

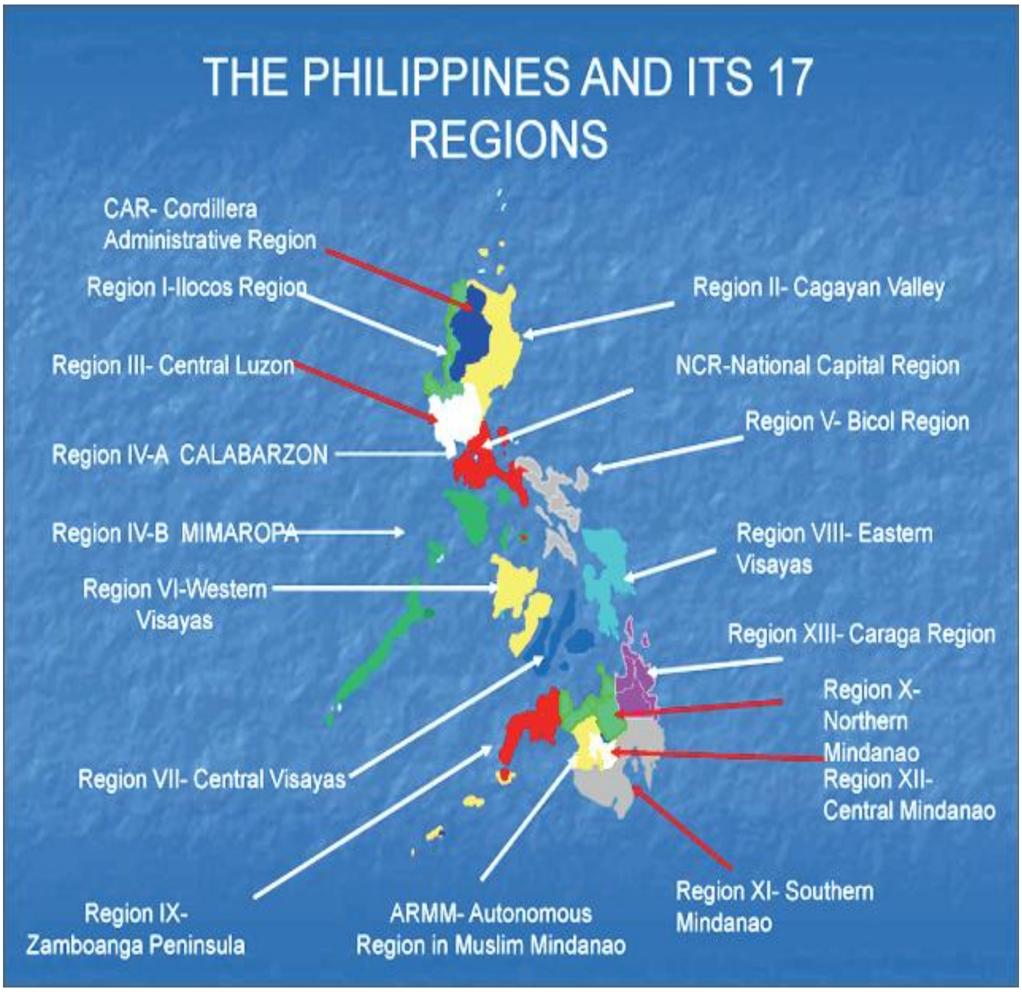
In the early morning of November 8, Haiyan made multiple landfalls in six different localities. The first landfall was in Guiuan, Samar followed by Tolosa, Leyte, afterwards Cebu's Daanbantayan and Bantayan, then Concepcion, Iloilo and finally, in Busuanga, Palawan. As the effects were overwhelming, the previous preparations did not suffice. Haiyan brought with it terrible winds and a huge storm surge. Major flooding occurred, and it submerged several regions and washed away towns. This was aggravated by strong winds with an approximate speed of 235 kph and a gustiness of 275 kph(National Disaster Risk Reduction and Management Council, 2013), that easily uprooted and blew away inadequate structures, natural and man-made alike. Major infrastructures and lifelines were damaged. Transportation became very difficult as major roads and waterfronts were blocked by debris, and airports had been badly damaged. Transmission lines for electricity and communications were also hugely affected, causing power interruptions, loss of communication and area isolation. Local government buildings, medical facilities and even some evacuation centres were inundated(ABS-CBN News, 2013). To make things worse, prepositioned emergency supplies were washed out(Balita, 2013), and emergency responders on standby were not spared, too. Some of those who stayed and manned their respective posts were also swept away(Yap, 2013). In the end, though preparations were made, it clearly wasn't enough to withstand Haiyan's unprecedented strength, whose quick sweep left a colossal mess of wiped out towns and cities looking like wastelands.

4.2.2 Poverty and Resilience: The Tale of Haiyan, Region VIII and Tacloban

4.2.2.1 Aftermath in Region VIII: Eastern Visayas

Nine (9) of the seventeen (17) Philippine administrative regions were affected by Haiyan. They are: IV-A (CALABARZON), IV-B (MIMAROPA), V (Bicol), VI (Western Visayas), VII (Central Visayas), VIII (Eastern Visayas), X (Northern Minadanao), XI (Davao) and XIII (CARAGA). These regions are composed of fourty-four (44) provinces, fifty-nine (59) cities, five hundred eighty-seven (587) municipalities and a total of twelve thousand one hundred thirty-nine (12,139) barangays[1](Department of Social Welfare and Development, 2013). Unfortunately, these are some of the poorest regions in the country. In comparison to the rest of the country, it can be observed that these regions have higher incidences of poverty and subsistence. The pre-disaster figures shown in the table below is expected to worsen after Haiyan

Figure 46 The Philippines and its 17 Administrative Regions



Source:MLIT, 2013

[1]Barangay is the smallest political unit in the Philippines

[2]In the Philippines, Highly Urbanised Cities (HUC) are cities with a minimum population of two hundred thousand (200,000) inhabitants, and with an annual income of at least Fifty Million Pesos (PhP50,000,000.00).

Table 8 Regional Poverty Incidence and Subsistence Among Families in PH, 2006-2012

Regions		1st Semester Poverty Incidence among Families (%)			1st Semester Subsistence Incidence among Families		
		2006	2009	2012	2006	2009	2012
Philippines		23.4	22.9	22.3	10.8	10	10
NCR	Metro Manila	2.8	3.7	3.8	0.5	0.7	1.1
CAR	Cordillera	25.6	22.7	22.6	13.8	12.6	12.3
I	Ilocos	23.3	18.5	16.7	8.8	6.1	6.2
II	Cagayan Valley	22	22.3	19.8	8.1	7.3	6.9
III	Central Luzon	13	12.5	12.2	4.5	4.3	3.8
IV-A	CALABARZON	10.1	10.8	11.2	2.9	3.2	3.9
IV-B	MIMAROPA	**34.1**	**30.6**	28.4	**16.1**	12.6	12.8
V	Bicol	**36.2**	**36.5**	**34.1**	**17.3**	**16.5**	14.1
VI	Western Visayas	27.5	26.7	24.7	12.3	11.1	9.4
VII	Central Visayas	**35**	**31.6**	28.8	**19.9**	**15.2**	14.9
VIII	Eastern Visayas	**33.3**	**36.2**	**37.2**	**16**	**16.9**	**17.3**
IX	Zamboanga	**41**	**41.5**	**36.9**	**24.6**	**24.3**	**20.1**
X	Northern Mindanao	**35.1**	**35.4**	**35.6**	**18.6**	**18.8**	**19.5**
XI	Davao Region	26.9	27.3	28.6	12.2	13.1	13.2
XII	SOCCSKSARGEN	**34.7**	**31.1**	**37.5**	**17.7**	13.9	**20.7**
XIII	CARAGA	**43.3**	**43.3**	**34.1**	**24**	**24.5**	**16.9**
ARMM	Muslim Mindanao	**43**	**42**	**46.9**	**16.8**	**15.1**	**20.4**

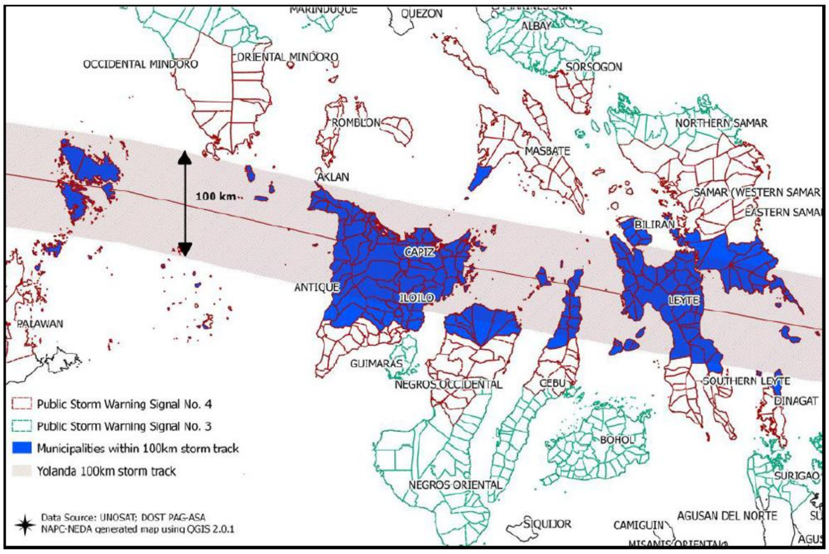
Legend:

(shaded)	Haiyan affected region
ABC	Poverty incidence above 30%; Subsistence above 15.0

Source: NSCB

Massive destruction was brought about by the combination of the storm surge and the forceful winds. The coastal towns of Samar and Leyte suffered tremendous losses due to the storm surge, while its inland areas including some parts of the provinces of Aklan, Capiz, Cebu, Iloilo, and Palawan experienced severe stress from the forceful winds. The destruction from the winds was less serious, but it had a wider coverage that reached areas beyond the 100-kilometre typhoon track (Government of the Philippines, 2013).

Figure 47 Map of Haiyan's Track and Affected Areas



Source: Gov.PH, 2013

Table 9Haiyan's Total Affected Population per Region

Regions	Affected Population					
	Province	Cities	Municipalities	Barangays	Families	Persons
IVA	5	6	33	168	5,935	27,076
IVB	5	2	62	793	101,437	467,050
V	6	7	92	1,229	150,889	692,020
VI	6	16	117	3,176	810,715	3,744,904
VII	4	14	84	2,136	1,299,436	**5,909,955**
VIII	6	7	137	4,387	1,006,988	**5,017,402**
X	4	3	7	26	4,253	19,592
XI	3	1	11	19	1,000	5,000
CARAGA	5	3	44	205	14,799	69,956
Total	**44**	**59**	**587**	**12,139**	**3,395,452**	**15,952,955**

Source: DSWD Report, 2013

Table 10 Total Number of Damages Houses by Haiyan

Regions	Number of Damaged Houses		
	Total	Totally Damaged	Partially Damaged
IVA	840	34	806
IVB	33,813	11,611	22,202
V	12,412	2,088	10,324
VI	498,040	241,738	**256,302**
VII	110,787	62,828	47,959
VIII	**511,828**	**260,687**	251,141
X	20	2	18
XI	19	11	8
CARAGA	6,704	466	6,238
Total	**1,174,463**	**579,465**	**594,998**

Source: DSWD Report, 2013

Table 11Haiyan's Casualty Count

Region / City	Dead	Injured	Missing
PH Total	6,300	28,689	1,061
Region IV - A	3	4	-
Region IV - B	19	61	24
Region V	6	21	-
Region VI	294	2,068	27
Region VII	74	348	5
Region VIII	5,902	26,186	1,005
Region IX*	1	1	-
Region X	-	-	-
Region XI	-	-	-
CARAGA	1	-	-

Source: NDRRMC, 2013

*Region IX not officially listed under the affected region

In terms of affected population, Regions VII and VIII have the highest count. However, more people have become displaced in Region VIII, which makes Eastern Visayas as Haiyan's top affected region.

Recovery will come as a great challenge, as coincidentally, it also has the poorest standing in the country in terms of productivity and GDP share. Its GRDP rate has slipped to a -6.2 from a 2.1 as recorded in the 2012 country statistics. Only the Cordillera and Eastern Visayas had a reverse growth among the country's regions.

Table 12Gross Regional Domestic Product (GRDP), 2011-2012

Regions		2010-11	2011-12
Philippines		3.6	6.8
NCR	Metro Manila	3.1	7.3
CAR	Cordillera	1.3	1
I	Ilocos	2.4	5.2
II	Cagayan Valley	5.6	8.2
III	Central Luzon	7.1	6.3
IV-A	CALABARZON	1.7	7
IV-B	MIMAROPA	3.1	4.2
V	Bicol	1.9	7.1
VI	Western Visayas	6.2	7.5
VII	Central Visayas	6.8	9.3
VIII	Eastern Visayas	2.1	-6.2
IX	Zamboanga Peninsula	0.1	12.4
X	Northern Mindanao	5.8	7.4
XI	Davao Region	3.7	7.4
XII	SOCCSKSARGEN	5.3	8.1
XIII	CARAGA	8.5	10.6
ARMM	Muslim Mindanao	-0.3	1.2

*Highlighted regions are Haiyan affected areas Source: NSCB, 2013

4.2.2.2 Region VIII: The Country's Gateway

The region belongs to the central part of the Philippines along with Western and Central Visayas. It is composed of 3 major islands: Samar, Leyte, Biliran, along with some minor ones, and makes up about 7 percent of the country with its total land area of 2,156,285 hectares. The area is mostly steep with 61 percent having a rolling to mountainous slopes of 18-50%, and 39 percent with level to rolling slopes of 0-18%. Mountainous slopes are often considered as forest lands, and are, ideally, for protection, but some timber production may also be allowed. On the other hand, those with level slopes are considered as alienable or disposable lands, and may be used for habitation, agriculture and other purposes (Department of Agriculture - Region 8, 2012).

Given its strategic geography, it serves as the gateway to the northern and southern parts of the country, namely Luzon and Mindanao. It connects the two through the National Maharlika Highway that crosses the region. However, it does not share land borders with other regions as it is bounded and separated by various water bodies from the rest of the archipelago. It is bordered by the San Bernardino Strait and Bicol Peninsula on the north; by the Surigao Channel and Mindanao on the south; by the Maqueda Bay, Camotes, Visayan Seas, Cebu and Bohol on the west; and by the Leyte Gulf, the Philippine Sea and the Pacific Ocean on the east (NEDA Regional Office 8, 2011).

Table 13 Land Classification of Region VIII: Eastern Visayas

Province	Alienable and Disposable (in '000 has)		Forest Lands (in '000 has)		TOTAL (in '000 has)	
	Area	%	Area	%	Area	%
Biliran	18	2.14	37	2.81	**55**	**2.55**
Leyte	293	34.84	278	21.14	**571**	**26.48**
So. Leyte	42	4.99	131	9.96	**173**	**8.02**
Samar	173	20.57	274	20.84	**447**	**20.73**
E. Samar	170	20.21	389	29.58	**559**	**25.93**
N. Samar	145	17.24	206	15.67	**351**	**16.28**
Total	**841**	**100**	**1315**	**100**	**2156**	**100**

Source: DA

Table 14 Land Uses in Region VIII

Land Use	Biliran	Leyte	So. Leyte	Samar	E. Samar	N. Samar	Subtotal	% Share
A. Agricultural Areas	**27230**	**332018**	**90673**	**154906**	**170995**	**200563**	**976385**	**45.3**
Rice	6408	84277	8891	24660	26737	34988	185961	
Corn	239	6950	75	2186	542	148	10140	
Rootcrops	473	2284	88	1042	1710	348	5945	
Vegetables		325	12	38	85	188	648	
Fruit Trees/Banana	615	1765	1043	16	679	135	4253	
Sugarcane		19722	140				19862	
Coconut	18729	203017	71766	118858	140212	132882	685464	
Pastureland	613	3563	119	40	260	580	5175	
Fishpond	153	6203	161	3550	75	812	10954	
Abaca		3912	8378	4516	695	30482	479	
B. Forest Area	**5427**	**59450**	**26275**	**263559**	**143096**	**111518**	**609325**	**28.3**
C. Grasslands	**22235**	**165555**	**52562**	**137767**	**128872**	**34435**	**541426**	**25.1**
D. Miscellaneous	**658**	**14257**	**3970**	**2868**	**4112**	**3284**	**29149**	**1.4**
TOTAL	**55550**	**571280**	**173480**	**559100**	**447075**	**349800**	**2156285**	**100**

Source: DA / BSWM

Majority of Eastern Visayas' area is agricultural. 45 percent of its total land area is devoted to farming, while the rest is broken down into 28 percentforest lands, 25 percent grasslands, and the remaining for other purposes. Leyte and Northern Samar have the largest agricultural land in the region (ibid). However, the success of its agriculture industry does not lie with the land alone. Its regional climate also helps in its agricultural production. The region's climate can be classified as Types II and IV, having no dry season and with evenly distributed rainfall respectively. Therefore, the region is no stranger to rain and typhoons as it is often frequented by these. It had also experienced major disasters in the past such as flash floods and landslides. According to its rapid geohazards assessment, the most common hazards in the region are: earthquakes, earthquake-related hazards, floods, landslides, liquefaction, tsunamis, coastal erosions, carbonate sinkholes, subsidence, and volcanic eruptions(NEDA Regional Office 8, 2011).

Unfortunately, the region was incredibly distressed by the recent super typhoon. It had severely damaged its agricultural industry and worsened its already adverse economy and growth slump. Thus, the region must rely on external assistance and its other resources in order to recover from the harsh conditions brought by the super typhoon.

According to the latest report on the Haiyan / Yolanda relief and response, Region VIII (Eastern Visayas) has the highest amount of casualties and damage, and it has also received the highest amount of combined assistance. It is home to 6 provinces and 7 cities, which is composed of 4,387 barangays, the highest count among the affected regions.

Table 15 Total Cost of Assistance Received / Region

Regions	Cost of Assistance in Philippine Pesos (PhP)			
	Total	DSWD	LGUs	NGOs/Other GO
IVA	106,001.00	25,000.00	81,001.00	0
IVB	17,810,502.13	6,731,128.00	9,416,418.03	1,662,956.10
V*	21,712,267.28	5,884,469.00	15,815,684.28	12,114.00
VI	229,036,184.42	147,338,020.72	74,801,153.70	6,897,010.00
VII	81,982,240.09	26,671,551.00	8,826,070.40	46,484,618.69
VIII**	592,405,122.30	585,569,568.00	4,963,804.30	1,871,750.00
X	1,196,550.00	1,125,000.00	71,550.00	0
XI	133,685.00	96,000.00	37,685.00	0
CARAGA	4,674,689.41	1,321,152.72	3,353,536.69	0
Total	949,057,241.63	774,761,889.44	117,366,903.40	56,928,448.79

Source: DSWD

*Includes cost of assistance for strandees in Region V
** for validation with DSWD-Field Office VIII

With these combined factors of a lethargic economy, a large population living under poverty, and a hazard-prone geography, the area appears to be in a more vulnerable condition than the rest of the affected regions. This serves as a good motivation to look at the area's situation in a much deeper fashion. However, as the limited time does not permit to cover the whole region, the study will only focus on its centre, Tacloban City.

4.2.2.3 Tacloban: From a Humble Settlement to a Highly Urbanised City

Tacloban City belongs to the Eastern Visayas region. It is both Region VIII and the Province of Leyte's capital (NEDA Regional Office 8, 2011). It is located on the northeastern portion of Leyte and has a total land area of 20,172 hectares. It is composed of 138 barangays with a total population of 221,474 as of the 2010 statistics survey. It has an annual growth rate of 2.16% and an average household size of 4.8, which shows a decrease from the previous statistical surveys (National Statistical Coordination Board Regional Division VIII, 2013).

Table 16 Population in Region VIII by Cities / Municipalities

CITIES	TOTAL POPULATION		AVG HH SIZE		DENSITY		POPULATION GROWTH (%)		POVERTY INCIDENCE	
	2007	2010	2007	2010	2007	2010	2007	2010	2003	2009
Tacloban (Leyte)	217,199	221,774	5.1	4.8	1,077	1,096	2.72	2.16	16.56	20.5
Ormoc (Leyte)	177,524	191,200	4.7	4.5	289	312	1.95	2.17	31.29	28.3
Calbayog (W. Samar)	8,827	172,778	5.1	4.9	186	196	1.47	1.62	66.48	38.7
Borongan (E. Samar)	59,354	64,457	4.7	4.7	125	136	1.02	1.57	20.87	37.6
Catbaloga n (W. Samar)	92,454	94,317	5.4	5.1	337	344	1.3	1.14	51.69	33.6
Maasin (S. Leyte)	79,737	81,250	4.7	4.4	377	384	1.58	1.33	26.59	31.4
Baybay (Leyte)	102,526	102,841	4.6	4.4	223	224	0.96	0.73	29.55	31

Source: RSET, NSCB

Table 17 Updated Poverty Incidence among population, 2003-2009

Region / Province	2003	2006	2009
Region VIII	*37.6*	*39*	*41.4*
Biliran	38.2	33.8	34.9
Eastern Samar	36.4	47.8	54
Leyte	37.2	34.9	34.3
Northern Samar	44.6	53.8	51.2
Southern Leyte	37.7	30.2	43.3
Samar	33.9	38.1	45

Source: NEDA / NSCB Region VIII

Its bustling economy earned it the first class city status. It also became the first highly urbanised city (HUC)[2] in the Eastern Visayas (ibid). Due to this, it has attracted a huge population which gives it a density of 1,096 persons per square kilometre. This makes it the densest areas in the region, and also creates an overcrowding issue. Despite this, it still has the lowest poverty incidence among the cities in the province and the region. In the 2009 statistical survey, its poverty incidence rose to 20.5% from the previous 16.56%, but still appears to be the lowest among the region's top cities. It roughly translates to 1 out of 5 persons being considered as 'poor.'

In contrast to the highly agricultural character of the region, Tacloban relies on its business and trading industries. The city has adequate critical infrastructures and business support facilities that continues to attract investments and businesses. It is well-connected through a major air transport node, the Daniel Z. Romualdez (DZR) Airport, which serves the region as well as its neighbouring areas. Most goods enter here and get distributed through complementary terrestrial and maritime transport links, such as the San Juanico Bridge, the country's longest bridge and several ports that allow movement to other disjointed islands. In addition to transport, industrial and administrative facilities, there is also access to social facilities such as health and recreation centres. It hosts the San Juanico Golf and Country Club, which is the only sports facility in the region (Tacloban City Government, 2013).

Apart from being the region and province's administrative and economic powerhouse, Tacloban also holds an important place in the Philippine history as it once held the seat of government at the end of the Second World War, while Manila was still under siege (Tacloban City Government, 2013). In addition to being a historical point of interest, it is also a cultural centre for the preservation of ethnic traditions and customs that existed even during pre-colonial times.

[2] In the Philippines, Highly Urbanised Cities (HUC) are cities with a minimum population of two hundred thousand (200,000) inhabitants, and with an annual income of at least Fifty Million Pesos (PhP50,000,000.00).

Definitely, Tacloban has come a long way from being a component city to becoming a highly urbanised city. The concentration of facilities, infrastructures and businesses signifies its huge role in the provincial and regional economy and development. Its locational advantage makes it the ideal trading hub and the perfect gateway to the northern and southern parts of the country.

On the other hand, its location also exposes it to a lot of natural disasters like typhoons and storm surges. Apart from hydrometeorological incidents, it is also prone to earthquakes, landslides, floods, liquefaction, and volcanic eruptions. These hazards were identified and plotted during its geohazards assessment and mapping activities (Tacloban City Government, 2013).

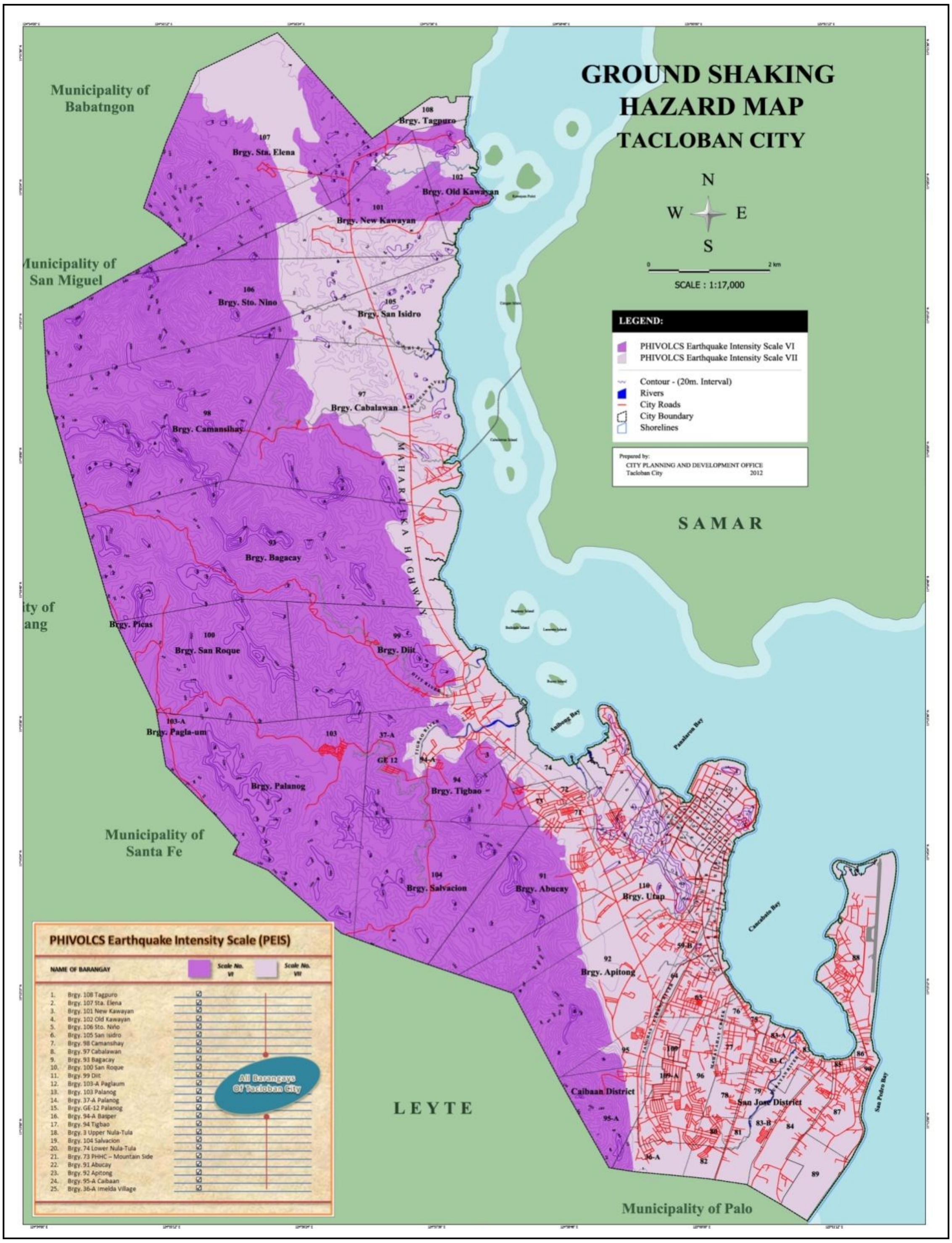
Figure 48 Tacloban City's Fault Line Map

Source: Tacloban City Government

Figure 49 Tacloban City’s Earthquake Induced Landslide Hazard Map

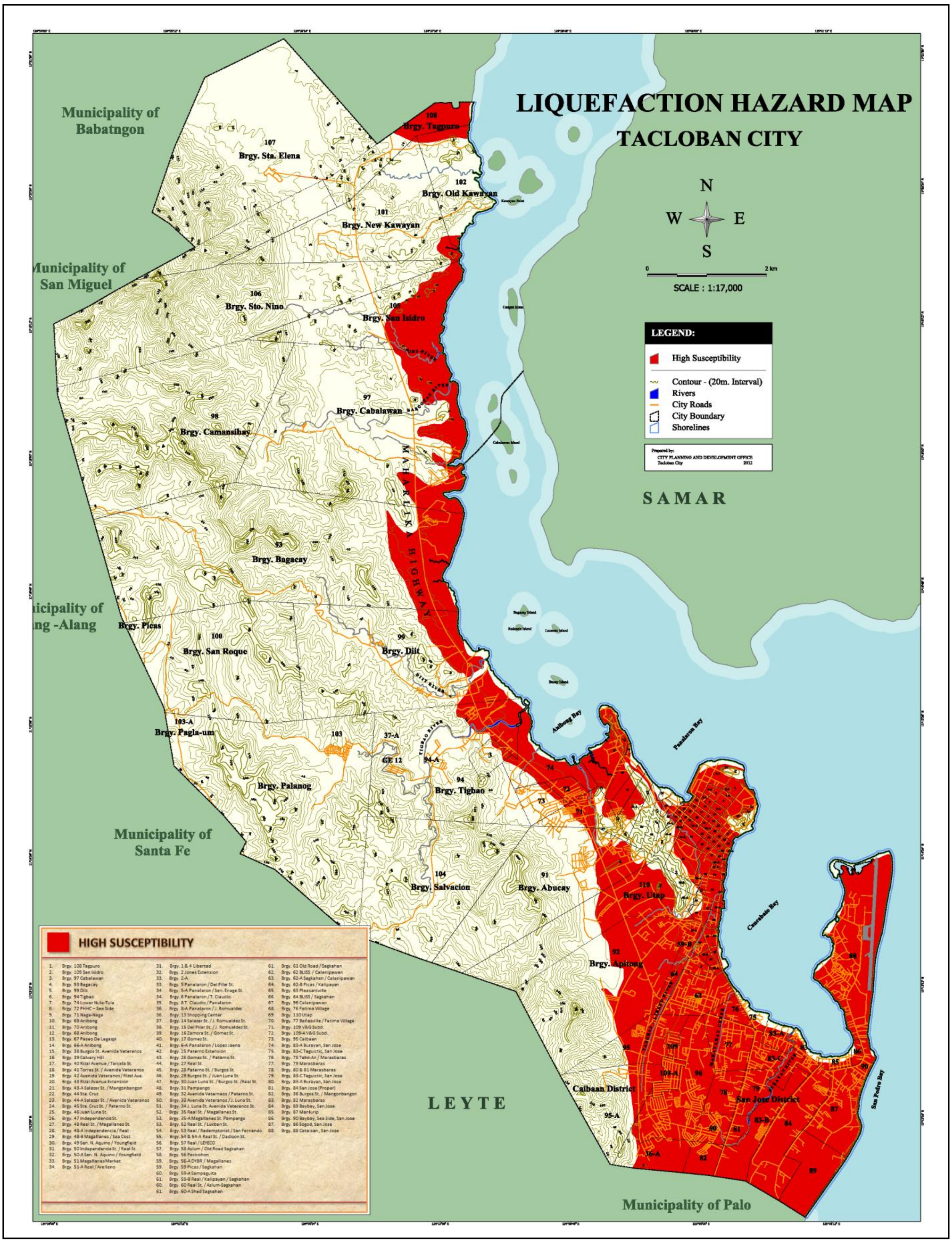
Source: Tacloban City Government

Figure 50 Tacloban City's Ground Shaking Hazard Map



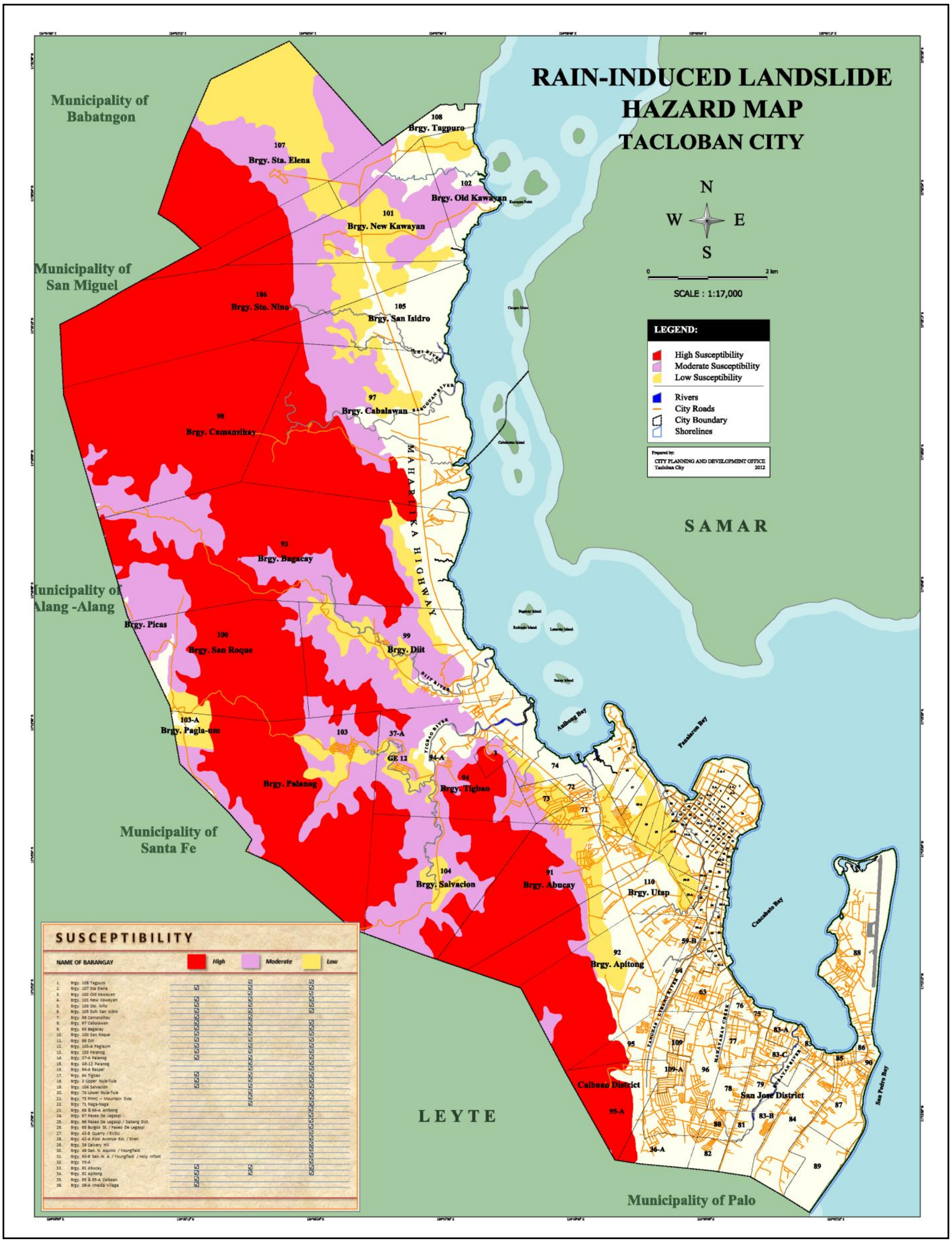
Source: Tacloban City Government

Figure 51Tacloban City's Liquefaction Hazard Map



Source: Tacloban City Government

Figure 52Tacloban City's Rain-Induced Landslide Hazard Map



Source: Tacloban City Government

Figure 53Tacloban's Flood Hazard Map

Source: Tacloban City Government

Figure 54Tacloban City's Storm Surge Hazard Map

Source: Tacloban City Government

Figure 55Tacloban City's Tsunami Hazard Map

Source: Tacloban City Government

As illustrated on the various hazard maps, Tacloban is a multi-hazard and disaster prone area, but these hazards are differentiated based on the area's topographic character. Inland areas would suffer more from earthquake and rain induced landslides, whereas coastal areas are likely to experience liquefaction and flooding from storm surges.

Since Tacloban City is located close to the Philippine Fault Zone (PFZ), which is considered a major earthquake generator, it is familiar to quakes and tremors. The PFZ cuts through the island of Leyte, and is often noted as the cause of earthquakes that have occurred in Tacloban's history. Apart from the PFZ, there is also another earthquake generator, the Philippine Trench (PT), which is also located at the eastern coast of Samar but quite far from Tacloban. The earthquakes that the PT generates are often with a lesser degree in comparison to the PFZ's.

Low-lying areas, such as the eastern and southeastern portions, and those that are close to the sea are prone to flooding, tsunamis and storm surges, while in the inland parts of the city, eighteen (18) fault lines and six (6) fault dipping zones have been identified. Due to this, the northwestern and southwestern parts with steep slopes are likely to suffer from earthquake-induced landslides. Majority of the city appear to be sheer. On the west side lies the Naga-Naga mountain range with 40% slopes and a highest elevation of 305 metres above sea level (ASL) , while on the north there is a much steeper slope of 60.5% along the Sta. Elena mountains, whose highest elevation measures 575 metres ASL.

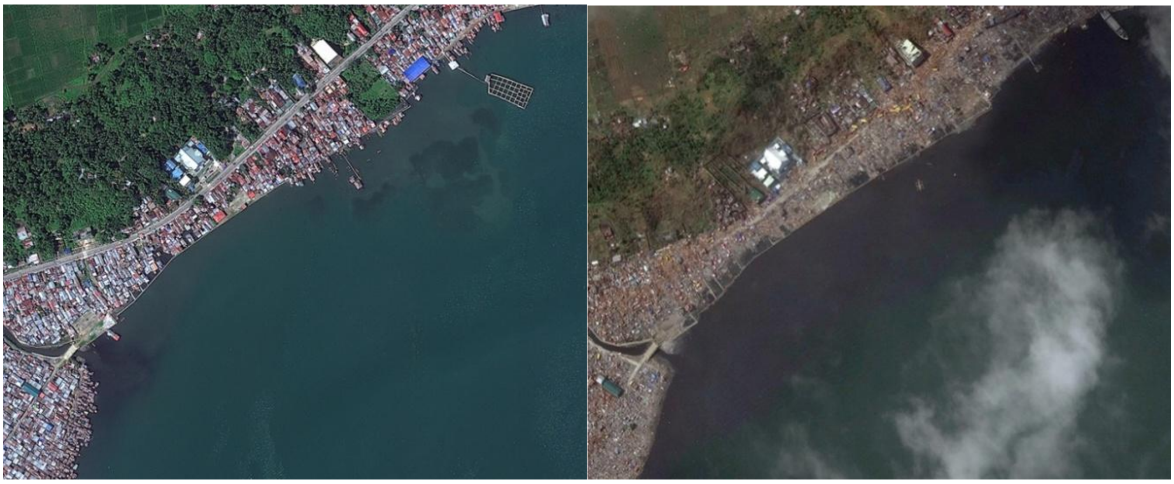
In the eastern portion of the city, coastal areas are highly susceptible to liquefaction. This is further aggravated by the danger of abundant hydrometeorological incidents as it lies along the frequented storm path. The city's climate pattern of Types II and IV, no dry season and with an evenly distributed rainfall, also add up to it. As a result, the recurrent storms and rains may bring about erosion as well.

Extraordinarily though, the periods of 2009-2011 have been peaceful for the city. Tropical disturbances and typhoons seemed to have evaded it. Regrettably, this unusual calm, which may be attributed to climate change, was broken as Super Typhoon Haiyan heavily trampled the city. Below are some images of Tacloban before and after its devastation.

Figure 56 Tacloban before (left) and after (right) Super Typhoon Haiyan

Source: Digital Globe

Figure 57 Tacloban before (left) and after (right) Super Typhoon Haiyan



Source: Digital Globe

Figure 58 Tacloban before (left) and after (right) Super Typhoon Haiyan

Source: Digital Globe

4.2.2.4 Tacloban after Haiyan

As evident in the images, the city has experienced grave losses and destruction. Instantaneously, millions of people became widowed, orphaned and homeless as thousands of lives were lost and tens of thousands of structures and livelihoods were destroyed. The total affected population reached an approximate count of sixteen (16) million persons, roughly equivalent to four (4) million families (Department of Social Welfare and Development, 2013)(Department of Social Welfare and Development, 2013). To date, twenty eight thousand and six hundred eighty-nine persons are listed as injured (28,689) and six thousand three hundred (6,300) persons are officially pronounced dead, while a thousand and sixty-one (1,061) persons are still unaccounted for (National Disaster Risk Reduction and Management Council, 2014).

Table 18 Total Cost of Damages per sector in Philippine Pesos and US Dollar

Sector	Amount (PhP)	Amount (US$)
Infrastructure	9,584,596,305.69	219,478,150.03
Productive	21,833,622,975.09	499,969,224.19
Social	55,110,825,740.69	1,261,985,554.18
Cross-Sectoral	3,069,023,613.41	70,277,725.17
Total	89,598,068,634.88	2,051,710,653.57

Source: NDRRMC / PDNA Report April 2014

Table 19 Total Number of Casualties: PH, Region VIII and Tacloban

Region / City	Dead	Injured	Missing
PH	6,300	28,689	1,061
Region VIII	5,895	26,186	1,005
Region VIII Share (%)	93.57	91.28	94.72
Tacloban	2,678	-	701
Tacloban Share (%)	45.43	0.00	69.75

Source: NDRRMC, 2014

In Tacloban alone, the number of houses totally damaged houses have reached 40,192, while those partially damaged had a lot of people displaced were counted at 15,066. These figures aren't complete though. Twenty-six barangays are still to be surveyed and confirmed. Therefore, these numbers are still expected to rise.

Table 20 Number of Damaged Houses in Region VIII vs. Tacloban

Region / City	Number of Damaged Houses		
	Total	Totally Damaged	Partially Damaged
VIII	511,828	260,687	251,141
Tacloban*	40,192	25,126	15,066
% Share	7.85	9.64	6.00

Source: DSWD, Shelter Cluster*

Given the household average of 4.8, the estimated affected population in Tacloban would reach an estimated 193,000 persons. Sadly, this would represent eighty-seven (87) percent of its total population. In the casualty count alone, about 90 percent belonged to Region VIII, while Tacloban accounts for most of the regional figures.

As some of these areas are disjointed islands without shared land borders, it resulted to being cut off from the rest of the country. Accessibility to and from the area was greatly influenced and limited by its geographical character, which was worsened by the presence of excessive debris that rendered alternative routes, such as port areas and airstrips, also impassable and unfit for use. The DZR airport was completely blown away while port areas are filled with rubbish and ruins. This gravely pushed back the delivery of the essential relief goods and services that caused more suffering to the victims and survivors.

4.3 Modern Day S.O.S

Most of the pre-emptive measures have been compromised. Some of the intended rescue teams fell victim to the typhoon, and emergency equipment and supplies have also been carried away by the storm surge. With critical infrastructures and lifelines heavily damaged, it prevented any effective coordination among and between the affected communities and the responders, rescuers and aid workers. Having an almost non-existent communication provided no hope and no sign that immediate help was to be received. Thus, survivors tended to themselves. With the survival instinct kicking in, they scavenged for whatever food and drink they could find. Items in establishments that withstood the rage of the storm were ravaged, be it food or non-food, and aggressive acts to take advantage of the relief good were also reported. This phenomenon, however, aggravated the situation as it created peace and security concerns (Felden, 2013).

As the public authorities and local media arrived in the area, news slowly trickled and a much clearer picture started to unfold. The international community was also quick to respond. International entities, such as governments, non-government / non-profit organisations and media arrived in the country just a few days after the disaster. Even individuals expressed their support by volunteering their services be it on-site or remotely. Most relief and support came in traditional forms like cash, food and other relief goods. However, in these modern times, we also see an increase in the unconventional support through technological means. The latest advancements in ICT definitely made it easier and more convenient for people to contribute and participate. This is especially true for the technologically empowered general public whose participation has increased during the recent disaster events.

For Super Typhoon Haiyan, this was apparent during the disaster's peak. Even as the central region of the Philippines was being battered and was temporarily isolated, news and updates regarding the typhoon and the devastated areas continued pouring in and circulating through various media outlets, such as the television, the radio, print media, and the web, which also includes social media networks. Information was being shared through tweets, blogs and status messages, and even aid and rescue requests were being communicated using the same media channels. Perhaps, this was one of the most interesting things about Haiyan. We are witnessing the continuous evolution of emergency management communication as digital technology utilisation rises through these new and alternative communication channels, and people eagerly participating, using it, and formally incorporating it. Eventually, these people who provided and disseminated crucial information related to the events and response activities have become beacons, regardless of the fact whether they did it unknowingly or intentionally. Moreover, people did not just share information, they also took action by organising themselves to contribute to the on-going relief and response.

As expected, immediate responses mostly came from concerned families, relatives, friends and colleagues, but another fascinating fact though was how quickly these communities, local and global alike, had coordinated amongst themselves to assist to the typhoon victims. Most of these organising were also carried out using social media and the web. Such digital tools can be powerful and useful when properly managed as it allows us to transcend the physical bounds of the concerned areas. Nevertheless, it is also worth mentioning that the national government and its agencies were also instrumental in the heightened responses when they partnered with the microblogging site, Twitter, and promoted unified hashtags for easier tracking and monitoring of essential disaster information(GMA News, 2013). They did this as early as the preparatory phase and during Haiyan's peak, which could have also fairly contributed to the greater response during the catastrophe.

Apart from the use of social media for preparatory measures, NDRRMC, the national disaster management agency, also turned to web-based tools or online platforms to disseminate and gather information and coordinate responses and actions during the disaster. Situation reports containing essential information, such as the context and crisis data, were being posted on their website all throughout the pre-disaster, disaster and post-disaster periods. It became a good avenue for the greater public to get official updates.

Figure 59 Unified Hashtags and Contact Details for Typhoon Haiyan Rescue and Relief Efforts

Both images were circulated through Twitter and other social networking sites. Images taken from http://twitter.com/typhoonhaiyan.

Figure 60 Screenshot of the tweet from the Presidential Communications Development and Strategic Planning Office's (PCDSPO) Official Twitter Account promoting unified hashtags

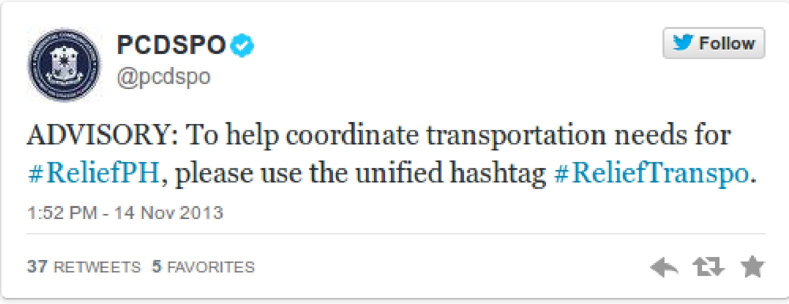
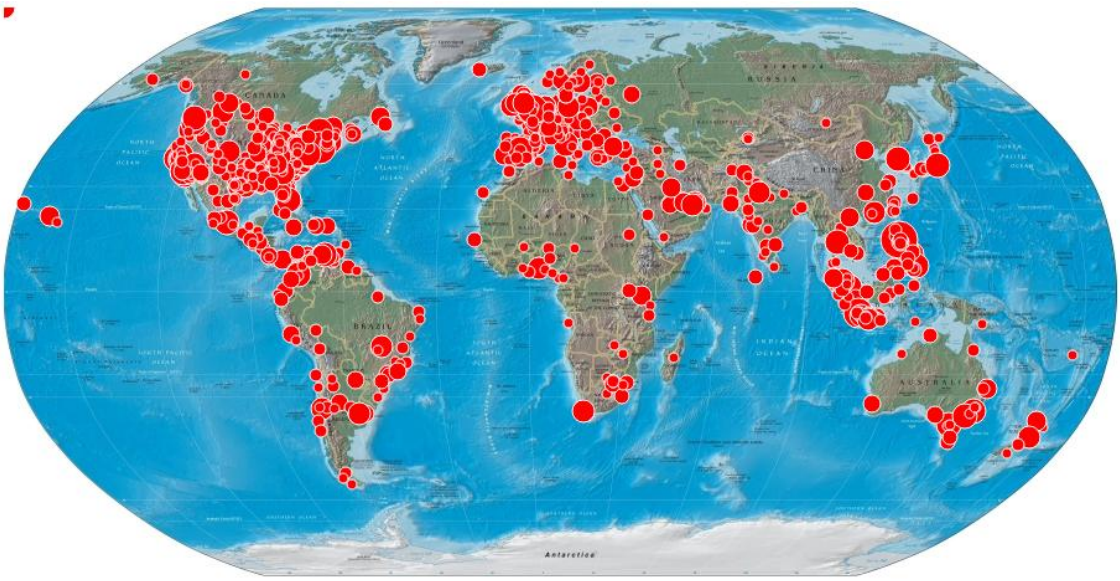


Figure 61NDRRMC's web page containing weather bulletins and situational reports for Super Typhoon Haiyan

However, the use of social media during the advent and actual disasters and emergencies is not an entirely new concept for the Philippines. Earlier, the national government and its agencies have already recognised the value of ICT and explicitly expressed their beliefs that web-based tools and social media are now playing an important role in information and communication flows (Valdez, 2011). In fact, there were already precedents such as typhoons Ketsana (PH name: Ondoy) and Bopha (PH name: Pablo) in 2009 and 2012, respectively. Haiyan wasn't the first time that civilians were involved and crowdsourcing was used to aid the emergency response and relief activities. Awards were even given previously to honour the digital heroes and recognise their efforts and contributions (Calvin, 2012).

Nevertheless, Super Typhoon Haiyan is unique because of its unusual meteorological nature, and massive destruction, and moreover, in terms of emergency management communication and information flows during and after the catastrophe. As evident during this misfortune, intensive use of web-based tools, social media and crowdsourcing reached new heights. There was wider adoption and use not just by the public, but also by authorities, various personalities and organisations. The Philippine government even attempted better integration with its emergency management process through 'formalised' social media usage guidelines. Specific hashtags were officially promoted to facilitate easier communication and information flow as early as the preparations and throughout the calamity (PCDSPO, 2013). As a result, there was an amplified use of social media to communicate updates and important information ranging from weather advisories to rescue requests, and a significant boost in the general public's participation in the emergency management activities and interaction with authorities. On the other hand, this was made possible by the current technological advancements, which made involvement and information widely accessible and convenient to almost everyone. In addition, hundreds of reports have been (Yonetani & Yuen, 2014) and will continue to be generated regarding the post-disaster response and recovery activities. These also contribute to Haiyan's pool of emergency data. In this light, Super Typhoon Haiyan and the Philippines make a good case for studying the influence and use of ICT to reduce and mitigate hazards, vulnerabilities and risks on an emerging economy, especially with sizeable responses elicited around the globe(Levine, 2013).

Figure 62Super Typhoon Haiyan related tweets distribution. Image taken from Market Wired Blog



With the immense amount of open data and tools generated during the mishap, be it official or unofficial, traditional or innovative (crowdsourced / crowd-generated data / volunteer geographic information), as well as internal or external, it provides a vast supply of information resources to evaluate the usefulness of open digital crisis data in post-disaster recovery and redevelopment activities for planning future responses to further reduce disaster risks or even eliminate them if possible within the context of emerging economies. This will be the focus of the study and it will be elaborated in further in the next sections and chapters.

4.4 Haiyan's Open Data and Its Explosion

As described and elaborated in the previous section of Emergency Data, we can loosely group the kinds of information that were generated and found during catastrophes into (1) the context data and (2) the crisis data. This is also true and applicable in Haiyan's case. Most of these data are classified as open, regardless of its ownership and production. With respect to the data that have been gathered, both are abundant. However, more information regarding the disaster's consequences and effects have been disclosed and made publicly available. The data collected ranges from imagery to textual narratives. They were gathered from various sources including reputable organisations and volunteered information from concerned individuals, unaffiliated experts and the general public. These data will be the subject of the study and analysis in order to understand how useful these data can be for future risk mitigation. Specifically, the study seeks to understand whether it may be reused them in post-disaster recovery and redevelopment as spatial planning inputs and if this will be reliable and acceptable to the public authorities.

With the magnitude of Haiyan, this increased public participation from the local and international community was a big welcome. It has caused more information to be generated and disseminated. However, it also posed a huge challenge in terms of processing the large chunks of data it spawned. In fact, there was too much information that the United Nations had to request a group of IT enthusiasts to help them filter messages received over social media networks such as Twitter (Meier, iRevolution, 2013).

Information is valuable, but too much generated and volunteered information also tests the abilities of the receivers to sort, process and prioritise these big data. In this case, crowdsourcing became very useful, especially for microtasking. Volunteers were asked to help tag received and collected tweets so that they can be sorted prior to data validation and processing. Conversely, this also creates another issue regarding the information reliability and task distribution and coordination. As information are being fed and processed often by non-professionals and non-experts, issues regarding the data validity and accuracy arise.

However, these issues will not be dealt with as it is outside the scope of the study. The study shall mainly focus on the potential reuse of volunteered information generated during catastrophes, and its sorting and/or processing into a format suitable for use in post-disaster recovery, redevelopment activities such as spatial planning / land use planning that seeks mitigate future hazards and risks.

4.5 OpenStreetMap in Typhoon Haiyan, Philippines

New revolution of crisis mapping is not only limited to using social media, but also it can be used to map affected area in a disaster in order to provide a better platform for emergency managers to coordinate their relief and recovery efforts. Open-source mapping tools by providing much needed low-cost high-tech opportunity, fills the gap of lack of l information in aftermath of a disaster.

After the devastating typhoon Haiyan hit Philippines in 2013, the need for accessing localized high-resolution information of the affected area for guiding communities' recovery and reconstruction was clear. Therefore, to respond to this challenge, over 1,000 volunteers had activated by the Humanitarian OpenStreetMap Team (HOT) to create baseline geographic data in the area affected by typhoon, which can be freely used by the Philippine government, donors and partner organizations such as United Nation Office for the Coordination of Humanitarian Affairs (UNOCHA) and American Red Cross (ARC) to support all phases of disaster recovery.

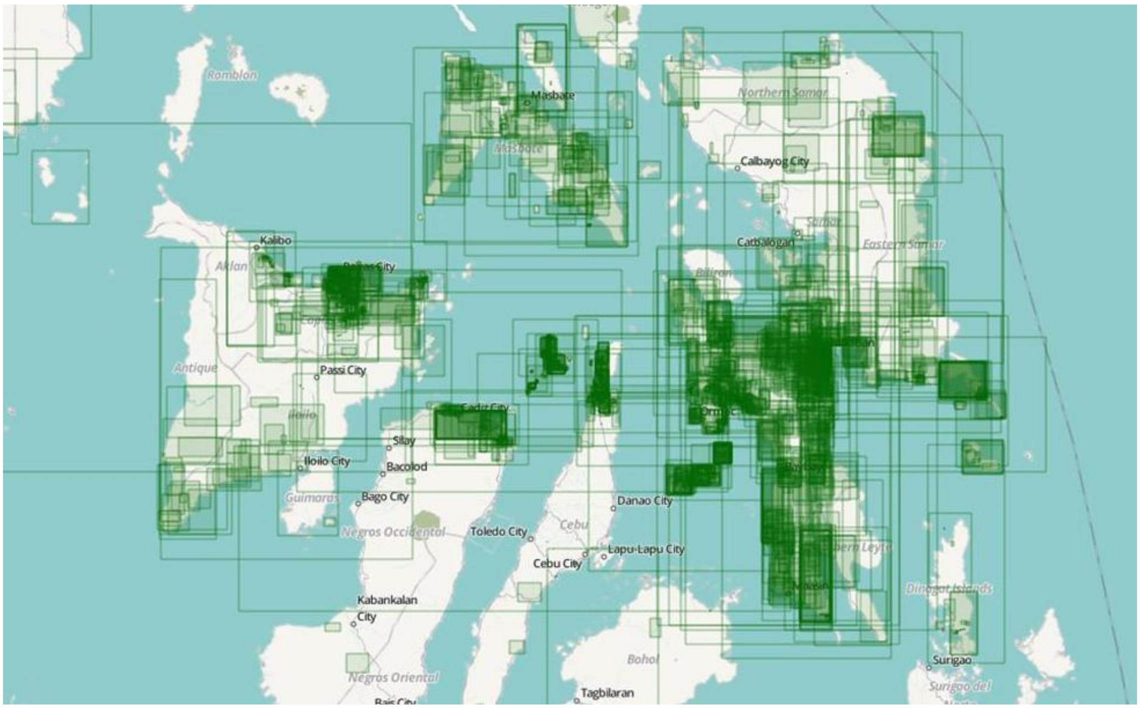


Figure 63 Work in progress - Digitizing images for the Philippines through OpenStreetMap

Soon after OpenstreetMap started to determined collapsed building and roads damaged by using post-disaster satellite imagery from geospatial companies who agreed to provide freely and rapidly satellite imagery in support of emergencies, disasters and humanitarian efforts to UN agencies and some humanitarian organizations. Due to extend and the intensity of the event the use of volunteers to speed up the process was negligible. Volunteers by using task manager via Internet, had contributed 2.2 million changes on the crowdmaps of damaged building and infrastructure(Beland, 2013).
Since the data are open, agencies responding to needs in the aftermath of Typhoon Haiyan have been able to use it in many different ways: They printed it out as maps; downloaded it to response teams' SatNav units; used it to locate population centres such as villages; and analyzed it to understand patterns of disease outbreak. In addition, this rapidly updated map data can also be used by journalists with a bit of geo-data know-how; for example, to provide geo-located contextual information for data coming in from other sources such as tweets, to help validate claims about the relative impacts on different areas, or to produce info-graphics of the impact and spread of a disaster(Stowell, 2013-2014).

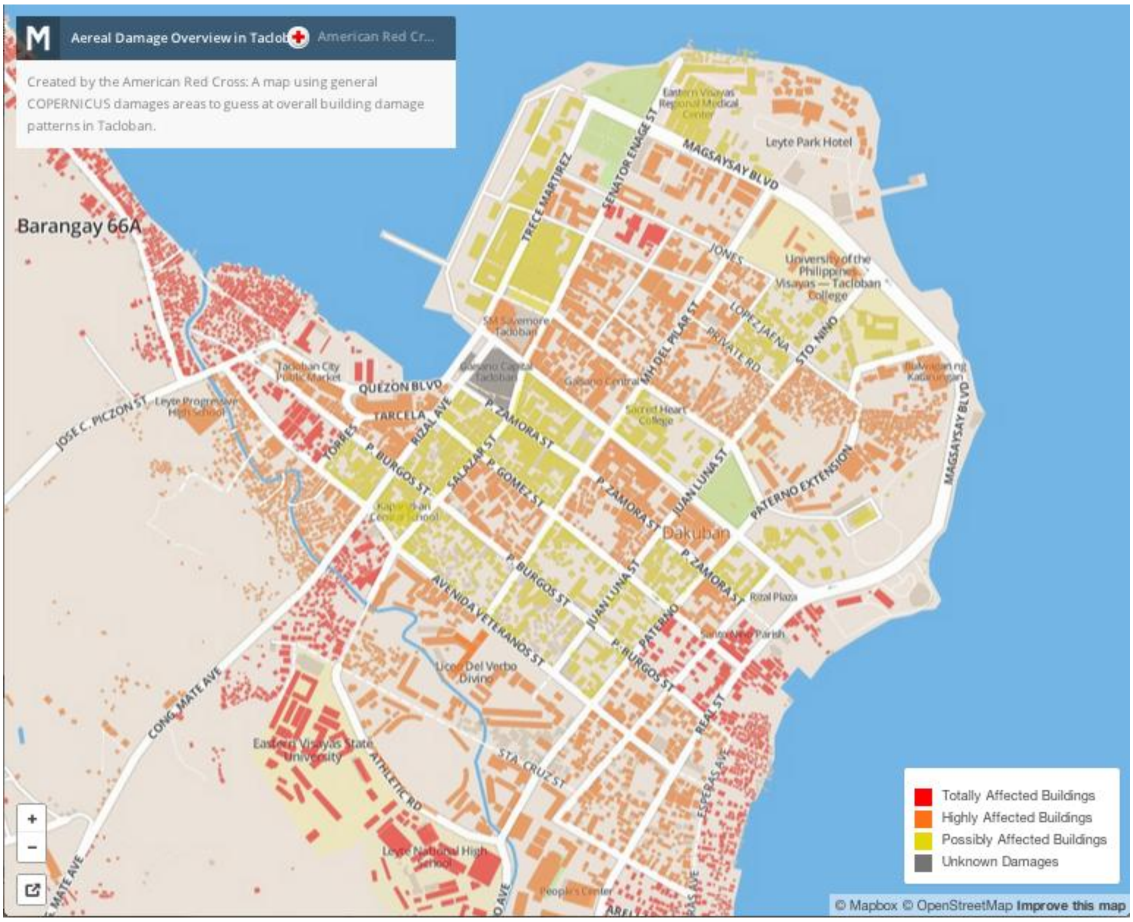


Figure 64 Mapping impact on houses in Tacloban

This project demonstrated that volunteers could do more than simply map information drawn from social media, as on the Haiti Crisis Map. While this project provided a proof of concept, namely that volunteers using new technologies such as the OSM Tasking manager platform can also support humanitarian organizations by rapidly analyzing satellite imagery.

Finally, the role of crowdsourcing and crisis mapping is increasingly significant in emergency management cycle. It is becoming quite clear that open government data and open data initiatives, combined with or leveraged by crisis mapping and crowd sourcing, can enhance aid efficiency, transparency and humanitarian operations in response and recovery.

5 Application

5.1 Results of Reusing VDDs

5.1.1 Pre-selection of VDDs

Plenty of data were gathered, but only a few were chosen to be analysed. Before any of the data was used, a classification was necessary in order to pick the best data suited to the study's objective. Several questions were asked to aid the data organisation. These questions also coincide with how the taxonomy and the ontology were devised. They are as follows:

(1) What is the nature of the gathered data?
(2) What kind of data does it contain?
(3) How is the information presented? (Data format /file type)
(4) How was the data produced? Where was the data taken from (source)?
(5) Does it have open access or are there restrictions?

After all the data were regrouped, it was then filtered according to the study's main purpose, which was to reuse VDDs as spatial planning inputs to support to post-disaster recovery and redevelopment. This entailed familiarization of the required datasets needed for spatial planning. These specific datasets were presented in Tables 1 and 4.

With all these, including the overall aim of improving the integration between disaster risk reduction and management and development planning, taken into consideration, the data analysis was carried out. The analysis puts an emphasis on the latent benefits of reusing VDDs to support planning decisions. Along the way, several observations were also made. The details of the analysis and other observations will be further discussed in the following sections.

5.1.2 Selection of VDDs

Exploring the information highway revealed tremendous amounts of crisis-generated open data were available to be mined. Depending on how one will do the search, at least thousands of results will come up. Results often cover both closed and open data.

During the course of gathering data specific to Super Typhoon Haiyan, a single search yielded approximately six (6) million results. This, of course, is overwhelming, and it would be impractical to go through all these matches. Thus, several methods were used in order to trim down these results such as employing more specific keywords, monitoring news and updates through RSS feeds, and visiting specific relevant organisation and government websites. Even so, tons of data were still uncovered and gathered.

Data came in all forms. There were different types such texts, photographs, satellite images and maps. There were also some in other forms like scripts, which provides annotations for imagery and/or for processing raw data.

For easier curation and collation of the data, a taxonomy and an ontology were devised. This was applied to the gathered VDDs. The VDDs were initially broken down according to the nature of information that it provided. A simple question was asked to determine its nature: "does it contain information regarding exposure, resource or hazard?" This was then followed up with the questions that lead to the making of the ontology: "did it contain context or consequence information?" After finishing the primary classification, it was observed that there were distinctions between the two types in terms of generation methods and sources. Context data were more likely to be produced in a 'traditional' sense, which means majority of the source were authorities, reputable organisations, and experts in the field. On the other hand, collaborative and voluntary efforts were more evident in the production of consequence data. However, it was also observed that most of these collected VDDs build upon traditional or official data while adding more information and aggregating both for quicker interpretation.

Even after the separation of the data into the context and crisis categories, it appeared that it wasn't enough. Subsequently, the data in each category were regrouped into sub-categories that referred to the nature of its content, which is either image or text-based, and for better understanding, the ontology terms for each was expanded. The expansion of the terms helped sift the data in a much more detailed manner. It also highlighted the detailed information that each data form contained. Through this, several selections were identified to be used and tested in order to understand how open data, specifically voluntary generated information may be used as inputs for recovery activities and risk reduction or resilience-building tools such as spatial planning.

Data were chosen on the basis of its production method or source, the data accessibility and restriction, data type, the nature of the information that it provided, and its potential usefulness in spatial planning, as guided by the required data sets for spatial planning in the Philippines and by the Provention Consortium's Hazard Information and Data Requirements Chart.

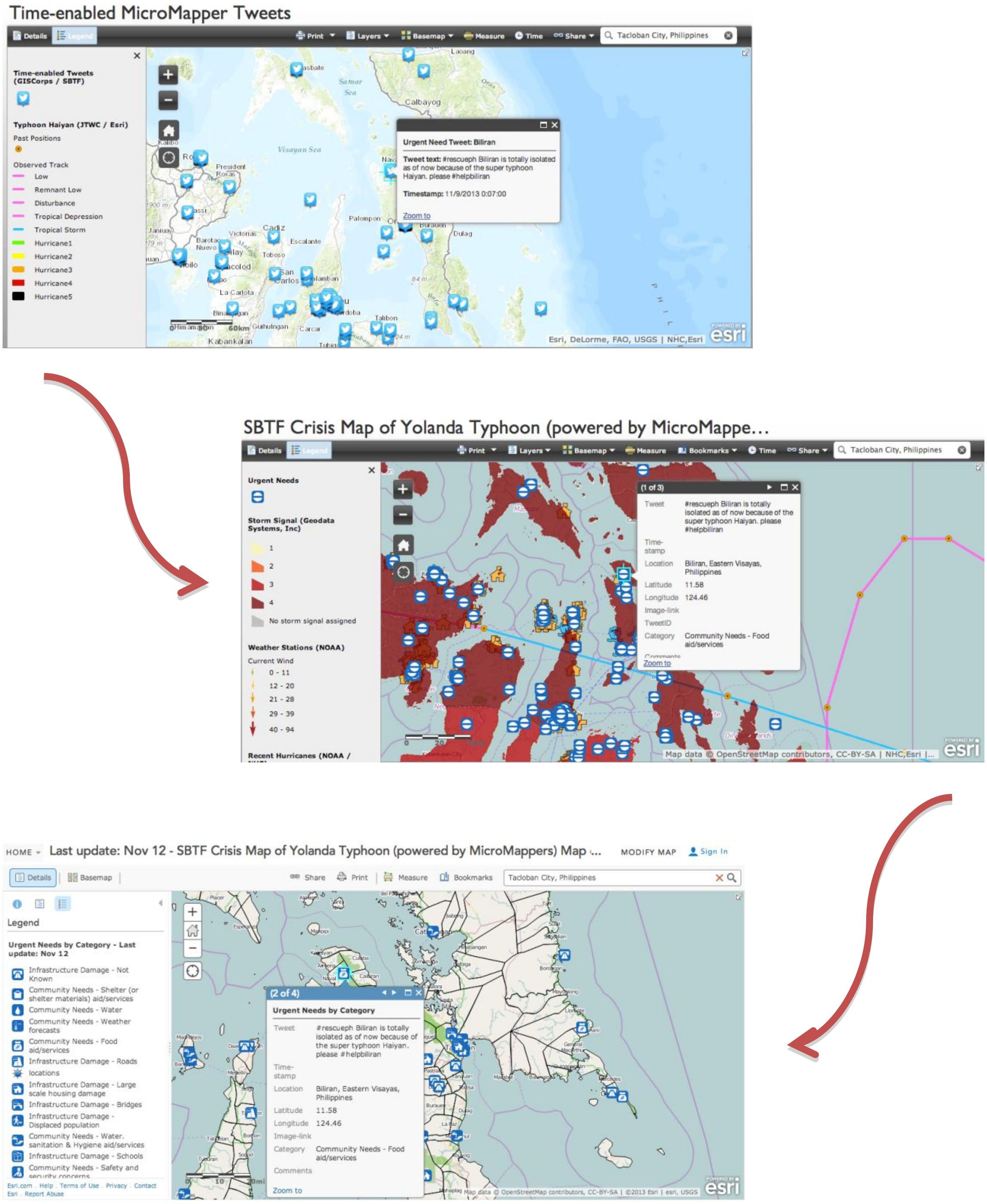
To better understand the procedure that was carried out to sort the gathered data, the VDD sorting table is presented below. It presents several entries of the gathered data such as the Crisis Map of Typhoon Yolanda, which is powered by MicroMappers and developed by GIS Corps and ESRI. The MicroMappers and the SBTF collected and sorted VDDs, including live feeds from social media networks, according to their content. Tweets gathered and sorted usually contained the following information: (a) community needs such as food, WASH, shelter, safety and security concerns, (b) direct damage and loss to population like displaced persons, casualties and missing persons, (c) damages to infrastructures such as bridge, road and large scale housing damage, (d) and other relevant information like weather forecasts, flood reports, etc. These information were later plotted by the GISCorps and ESRI on the crisis map.

Apart from the aforesaid information, the map also contains information on the current location, forecasted position and probable path of the tropical storm, the potentially affected areas of the storm surge and monitored weather updates from official sources like DOST's Project NOAH, the National Hurricane Center and the Joint Typhoon Warning Center.

Table 21 VDD Sorting Table

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
									Context		Crisis		
				Crowdsourced	Traditional	Hazard	Exposure	Resource	Resource	Exposure	Hazard	Disaster Consequence	
Story Map	Geographic Reference Picture Map	Philippines	SBTF/ GISCrops/ ESRI/ OSM/MicroMappres	x			All Categories					Depicts Yolanda's Devestation	This map was produced using a selection of photos from Twitter, Facebook, news articles, and other websites curated using the MicroMapper platform.
Hospital & School	Geographic Reference Map	Philippines		x			Critical Facility - Hospital /Clinic Critical Facility - School /University			Location Location			
Yolanda Perspective Map (1) Typhoon Haiyan/Yolanda	Geographic Reference Map	Philippines & Southest Asia		x		Natural-Hydrologic-Storm surge Natural-Atmospheric-Hurricane					Location-Intensity-Storm Signal Incident-Location-Stregth-Movement Data		
Yolanda Perspective Map (2) Storm Surge in Tacloban City				x			Critical Facility - Hospital /Clinic Critical Facility - School /University			Location Location			Urgent need Tweets/ This map shows schools and hospitals in the area as well as damage reports from social media and UNOSAT.
Yolanda Perspective Map (3) Recent Earthquake in Bohol				x		Natural-Seismic-Ground Shaking Natural-Atmospheric-Hurricane					Location Location-Stregth-Movement Data		Urgent need Tweets/ The Bohol region was struck by a magnitude 8.5 earthquake on October 14th. As a result, many citizens were already living in temporary housing when the typhoon hit. This map shows the Shakemap report from the earthquake as well as damage reports from social media.
Yolanda Perspective Map (4) Bantayan Island				x		Natural-Atmospheric-Hurricane	Structures				Incident-Location-Stregth-Movement Data	Direct Damage	
Crisis Map	Geographic Reference Map	Philippines		x		Natural-Hurricane, Typhoon, Storm surge, Earthquake	Infrastructure Building Population Critical Facility	Shelter Vital line Supply Human Resource	Community needs Community needs Community needs		Forecast Position, Track path, weather forecast, Location, Intensity	Direct Damage Direct Damage Direct Damage/ Loss Direct Damage	Urgent need Tweets by Category
Google Crisis & Relief Map	Geographic Reference Map	Philippines		x		Natural-Atmospheric-Typhoon Natural-Other Geologic/Hydrologic-Landslide/Flood	Critical Facility-Hospital/Command Center/Police Town Infrastructure-Vital line/sea & airport	Evacuation Center Relief Goods Drop off Center / Donation	Location Location	Location Location	Incident-Location/Path Monitoring-Susceptibility-Location	Affected area-Damage	Crowdsourced map of evacuation centers, crisis areas and relief drop zone areas in relation to Typhoon Haiyan/Yolanda.
Globe 2G Cell Network Restoration	Geographic Reference Map	Philippines		x			Infrastructure- Communication Network					Direct Damage-Functional	Dynamic Map - The map shows the Globe 2G network restoration by municipality for areas affected by Typhoon Yolanda (from Nov. 15 to Nov. 29, 2013)
SBTF Crisis Map- Tweets heat map	Geographic Reference Map	Philippines		x		Natural-Atmospheric-Typhoon					Incident-Location-Stregth-Movement Data		Urgent need Tweets
Incident Map Catalog	Geographic Reference Map	Philippines		x		Natural-Atmospheric-Typhoon Natural-Hydrologic-Storm surge	Population Infrastructure- Communication Network	Resource	Crisis and relief points	Communicaton Assessment (smart-Not Smart)	Incident-Location-Stregth-Movement Data Incident-Location-Intensity	Affected population Distribution Damage Assessment	Urgent need Tweets
Disaster Information Map	Geographic Reference Map	Philippines	Rappler	x		Natural-Hydrologic-Storm surge/Flash Flood	All Categories				Tweet reports	Tweet Report	Reports on Flood, Damage or Rescue call out by public

Figure 65 VDDs map building procedure



The complete data sorting table may be checked in the Appendix. It contains the comprehensive categories that were identified through the ontology.

Despite the table's obvious efficacy in sifting and organising the collected VDDs, and its provision of practical ontology classes and terms, the table was unable to show the link between the various EM phases and spatial planning, in terms of informational requirements. It also offered a limited insight on the availability and potential utility of the gathered data. Due to this, the developed table was refined once more.

Though the initial sorting table was imperfect, it had already identified the characteristics of the various data that were collected. This allowed the refinement to take place at a faster pace. The refined sorting table is shown below.

It can be noticed that the refined table has a more practical presentation that allows quicker access to data by providing content overviews without having to read each field, and filtering opportunities to arrange the data according to the different headings or categories for use with specific aims. This may also prevent errors and duplication as it may highlight those while sorting or filtering the data.

The table presents some of the useful VDDs to be included in the practical application. These data fit the requirements that were listed and elaborated in Tables 1, 2, and 4. Among these listed data, the GIS Corps' Crisis map, Google's Crisis and Relief map and World Map's Philippines Typhoon Haiyan (Yolanda) Map are the selected sources for VDDs. These maps will be elaborated in the next section.

Table 22 Data Sorting Table based on the EM Data Ontology

Document Name	Document Type					Area of Interest (Location of Incident or Event)	Source / Origin (Name of generator, producer, owner)	OD Prod.		EM Data Ontology																	Remarks / Other Details	Link to Document Location (if any)
										Context										Crisis								
										Exposure				Resource						Hazard			Disaster Consequence					
	Text	Image	Static Map	Georeferenced Map	Others (State file type)			Volunteered Data	Traditional	Population	Building	Critical Facility	Infrastructure	Human	Monetary	Vehicle	Vital Line	Shelter	Equipment	Monitoring	Alerts	Incidents	Direct Loss	Direct Damage	Indirect Loss	Indirect Damage		
Post disaster rapid needs assessment	x					Iloilo	ADRA		x	x							x	x					x	x		x	Shelter, Water, Livelihood, Food	
HEARS PLUS Report	x		x			PH	DOH		x	x				x	x				x				x	x		x	Health	
Updated DOH Report on Typhoon Yolanda	x					PH	DOH		x																	x	Health	
Groundtruthing OpenStreetMap Damage Assessment Review	x		x			PH	ACTED/ REACH/ American Red Cross		x															x			Accuracy check: Not reliable enough to utilize for damage analysis and recovery planning	http://americanredcross.github.io/OSM-Assessment/
Landslide & Flood Susceptibility			x			PH	MGB		x				x							x							Official map for validation use / Scale 1:50,000	
Storm Surge & Medical Facilities			x			PH	MapAction/OCHA		x			x									x	x					Scale 1: 50,000 (at A3)	http://www.mapaction.org/map-catalogue/maps.html?deployment_filter=224
Population Density & Medical Facilities			x			PH	MapAction/OCHA		x	x		x										x					Scale 1: 50,000 (at A3)	http://www.mapaction.org/map-catalogue/maps.html?deployment_filter=224
Crisis Map				x		PH	GISCorps	x														x	x	x			Urgent need Tweets/ Info about needed resources not available resources.	http://giscorps.maps.arcgis.com
Google Crisis and relief Map				x		PH	GISCorps	x				x	x		x		x	x		x		x						
Disaster Information Map				x		PH	Rappler	x														x	x	x	x	x	Reports on Flood, Damage or Rescue call out by public	http://www.rappler.com/
Tacloban damage assessment			x		Vector Files	PH	Copernicus		x															x			Scale 1:12,500	http://emergency.copernicus.eu/mapping/list-of-components/EMSR058
Land Use Maps			x			Tacloban	Tacloban City Government		x		x		x														Scale 1:25,000	
Flood Susceptibility			x			Tacloban	MGB		x				x							x							Official map for validation use / Scale 1:50,000	
Storm Surge Hazard Map			x			Tacloban	Tacloban LGU		x											x							Official map for validation use / Scale 1:17,000	
Landslide Hazard Map			x			Tacloban	Tacloban LGU		x											x							Official map for validation use / Scale 1:17,000	
Comprehensive land use plan	x	x	x	x	Table/Graph	Tacloban	Tacloban LGU		x	x	x	x	x							x								
Tacloban Infrastructure			x			Tacloban/ PH	Tacloban LGU		x				x															
Philippines Typhoon Haiyan/ Yolanda Map (Aggregated)				x			Harvard / World Map	x	x													x		x				http://worldmap.harvard.edu/maps/typhoon_haiyan

The data sorting and selection processes provided a deep insight into the emergency management data and highlighted the link between the information requirements of the emergency management and spatial planning. This strengthens the proposal of the study to reuse VDDs as planning decision support.

As depicted in Tables Table 1 Common Spatial Planning Data Requirements for Integrating Disaster RisksTable 3 Necessary Hazard Information for PlanningTable 4, spatial planning requirements cover a wide range of urban components such as physical (including hazards), social, economic and environmental sectors. When an incident happens, all of these components may be affected. Coincidentally, most of these components have also been highlighted in emergency management. For instance, population information such as demographic data and density distribution, social clustering and health situation are considered in both fields of emergency management and spatial planning. In the developed ontology for E.M. Data, the classes have been coloured to reflect their relevance in spatial planning. The classes are marked in three ways, most relevant, which is represented by the colour green, partially relevant in purple, and least relevant in blue. An example is shown in figure 66, but the complete set is placed in the Annex.

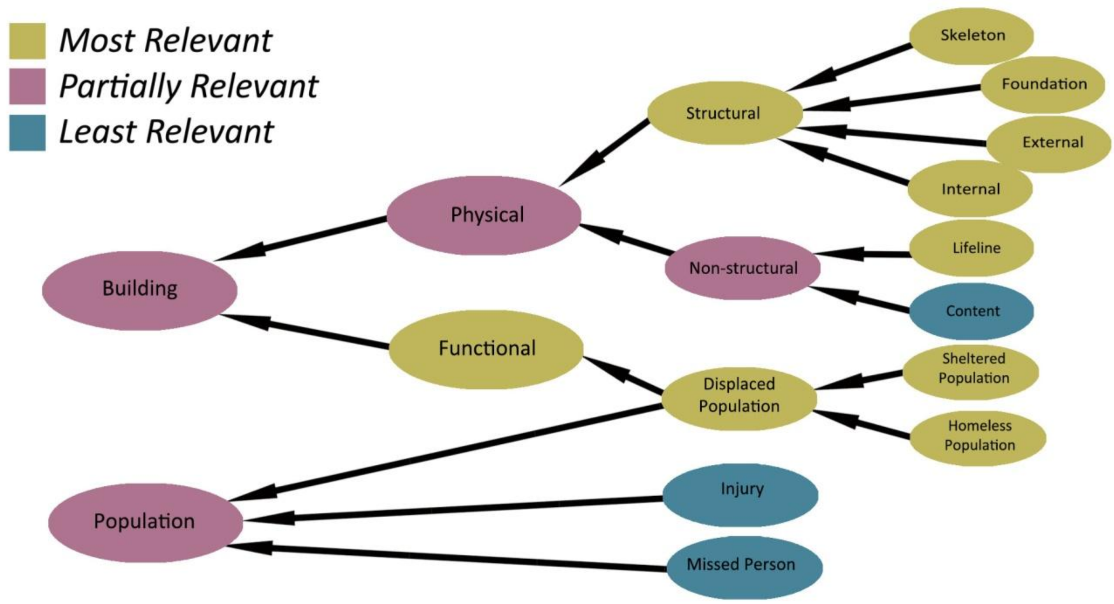


Figure 66 Section of coloured ontology of direct consequence data

As it can be understood from the coloured ontology, most of the classes are relevant. Moreover, in the disaster consequence data, most of the ontology classes have been marked as relevant to SP. This illustrates that both information overlap with one another. This has also been argued in the case for mainstreaming disaster risk management into development planning as spatial planning techniques and decisions directly affect the mitigation or magnification of disaster risks depending on the land use policies taken and enforced by the planning authorities. This also serves as another proof of the latent potential of VDDs in spatial planning.

Following this affirmation, another chart has been created to illustrate how VDDs can be used for spatial planning to support post-disaster recovery and redevelopment. The chart was drafted using the coloured ontology and the spatial planning requirements that were earlier shown. It can be easily adopted and adapted as it is generic. It uses the general categories and important characteristics of the selected relevant data, which may be tailored depending on the information need or purpose of use. The table also highlights the link between the information needs of the two fields. It illustrates the reciprocal nature involving resilience and development, which reflects the relationship between emergency management and spatial planning. From the new table, it can be easily seen that most of the VDDs may be considered as inputs to the spatial planning process. Furthermore, it also displays data requirements for the various phases of emergency management: prevention and mitigation, preparedness, response and recovery, along with spatial planning.

Table 23 Charting the Overlapping of EM and SP based on EM Data Ontology

EM Data Ontology			EM Cycle Phase Use				Spatial Planning Use	Remarks
			M/P	P	R	R		
Context								
Exposure	Population		x	x	x		x	
	Building		x	x	x		x	Proper location and condition may be identified during redevelopment planning
	Critical Facility (CF)		x	x	x		x	Redevelopment planning requires knowledge of characteristic and condition of critical facility
	Infrastructure		x	x	x		x	Characteristics of communication or road networks are essential for a good spatial planning
Resource	Human		x	x	x		x	
	Monetary		x	x	x		x	
	Vehicle			x	x			
	Vital Lines			x	x			
	Shelter		x	x	x		x	Proper locations may be identified during planning
	Equipment		x	x	x		x	Specific equipment are considered in SP
Crisis								
Hazard	Monitoring		x	x	x	x	x	Regular monitoring including historical data is useful for SP
	Alerts			x	x			May be useful in recovery phase with secondary effects
	Incidents		x		x		x	Past incidents can be used as basis for future mitigation through SP
Consequences	Direct	Loss	x	x	x	x	x	May be used as references in M/P, P, R to cut down future losses
		Damage	x	x	x	x	x	Consequence damages are important features to consider in post-disaster redevelopment plan
	Indirect	Loss	x	x		x	x	Better redevelopment plan may reduce the indirect losses and Damages
		Damage	x	x		x	x	

Table 24 Charting the Overlapping EM and SP based on Spatial Planning Data Requirements

Spatial Planning Data Requirements			EM Phase Use				Remarks/ Examples
			M/P	P	R	R	
Population and Social Services							
1		Population Size	x	x	x		It is necessary for estimating the needed shelter's capacity
2		Age- Sex Distribution	x	x	x		Necessary for considering special attention group during emergency planning
3		Household	x	x	x		Necessary for evacuation plans
4		Population growth /projection/doubling time	x	x			Needed for resource allocation and emergency preparations
5		Population Distribution / Urbanization	x	x	x		Predict most critical/ dense areas during crisis and planning for them during emergency plan
6		Social Clustering	x	x	x		Level of the knowledge of disaster requires different preparedness plan
7		Status of well-being of population	x	x	x		Providing facilities for poor population in evacuation plan
Economy							
1		Types		x		x	Reduce the effects of indirect damage in post disaster recovery
2		Level of Urbanization					
3		Structural Shift					
4		Linked Activities	x	x		x	Reduce systemic vulnerability in emergency plan/ prioritize recovery activities
5		Money Flow / Revenue		x		x	Necessary to consider for post disaster economic recovery plan
Physical and Spatial Base							
1		Land and Land Uses Inventory	x	x	x	x	Location of critical facilities and infrastructures in Emergency planning
2		Political Boundaries	x	x	x	x	Considering boundaries for the interested area in each phase of E.M.
3		Thematic Maps					
	1	Land Classification	x	x	x	x	Emergency plan/ response prioritization
	2	Slope	x	x	x	x	Use for hazard scenario development
	3	Elevation	x	x	x	x	Use for hazard scenario development
	4	Physical Constraints	x	x	x	x	Use for hazard scenario development
	5	Present Land Use	x	x	x	x	Emergency plan/ response prioritization
	6	Road Network / Infrastructure	x	x	x	x	Emergency plan/ response prioritization
	7	Protected Areas	x	x	x	x	Emergency plan/ response prioritization
	8	Area coverage	x	x	x	x	Emergency plan
4		Map overlay analysis	x	x		x	Useful for risk estimation
Environmental and Natural Resources							
1		Natural Resource Inventory	x	x		x	May consider in Mitigation and recovery plan
2		Environmental Assessment	x	x		x	May consider EM to better protect the environment
LGU Capacity for Planning and Management							
1		Organizational Structure	x	x	x	x	Coordination and cooperation structure during response phase and planning
2		LGU Planning Relationship	x	x	x	x	Indicate responsibilities in E.M. cycle
3		Fiscal	x	x	x	x	Availability of financial resources for EM-related activities
4		Development Orientation	x	x	x	x	Purpose to consider in all phases of EM mostly in mitigation and recovery
5		Public participation	x	x	x	x	Provide crisis information during emergency, improve disaster preparedness

5.1.3 Sample Reuse Application of VDDs

5.1.3.1 Map overlay analysis

Maps can either be static or georeferenced. Both are useful, but static maps require much more work before they can be reused. This is especially true when working with digital processing softwares. Regardless, they still make good instruments for information visualization and evaluation. Maps can be considered as tangible and manageable representations of space, and can be easily manipulated to highlight spatial changes and problems that are almost impossible to see at ground level or macroscopic views. Switching to a bird's-eye view makes it easier to identify such concerns and carry out initial assessments. This ability makes them ideal tools to support land use management and emergency response activities because it can quickly display the bigger picture.

Nevertheless, adopting and adapting crisis and response maps for uses other than its original intention would require careful consideration and thought because it has unique characteristics that differ from other maps. As its primary purpose is to enable quick responses and decisions to be made during emergencies, these maps have the tendency to give greater weight to well-timed responses and information dissemination over precision and accuracy. This is not to say that they are not useful for other purposes. In fact, during the data sorting, it was revealed to contain crucial context and consequence information that fit some of the required spatial planning datasets. Coincidentally, the spatial planning datasets are also necessary for the conduct of the different emergency management phases.

During the selection, several maps were chosen to be reused. However, in order to build the case of reusing VDDs, it was also necessary to use traditionally generated maps or official maps from authorities. The traditionally-produced maps will be used to provide an insight on the pre-disaster conditions. Thus, both traditional and VDD maps were used during the application process. The traditional maps were obtained from the local government and relevant national agencies, while the VDD maps were obtained from community-managed sites such as OSM, GISCorps and World Map. Other open data maps were also available, but most of them were from political agencies, which, despite their free access, still represent traditional methods of production.

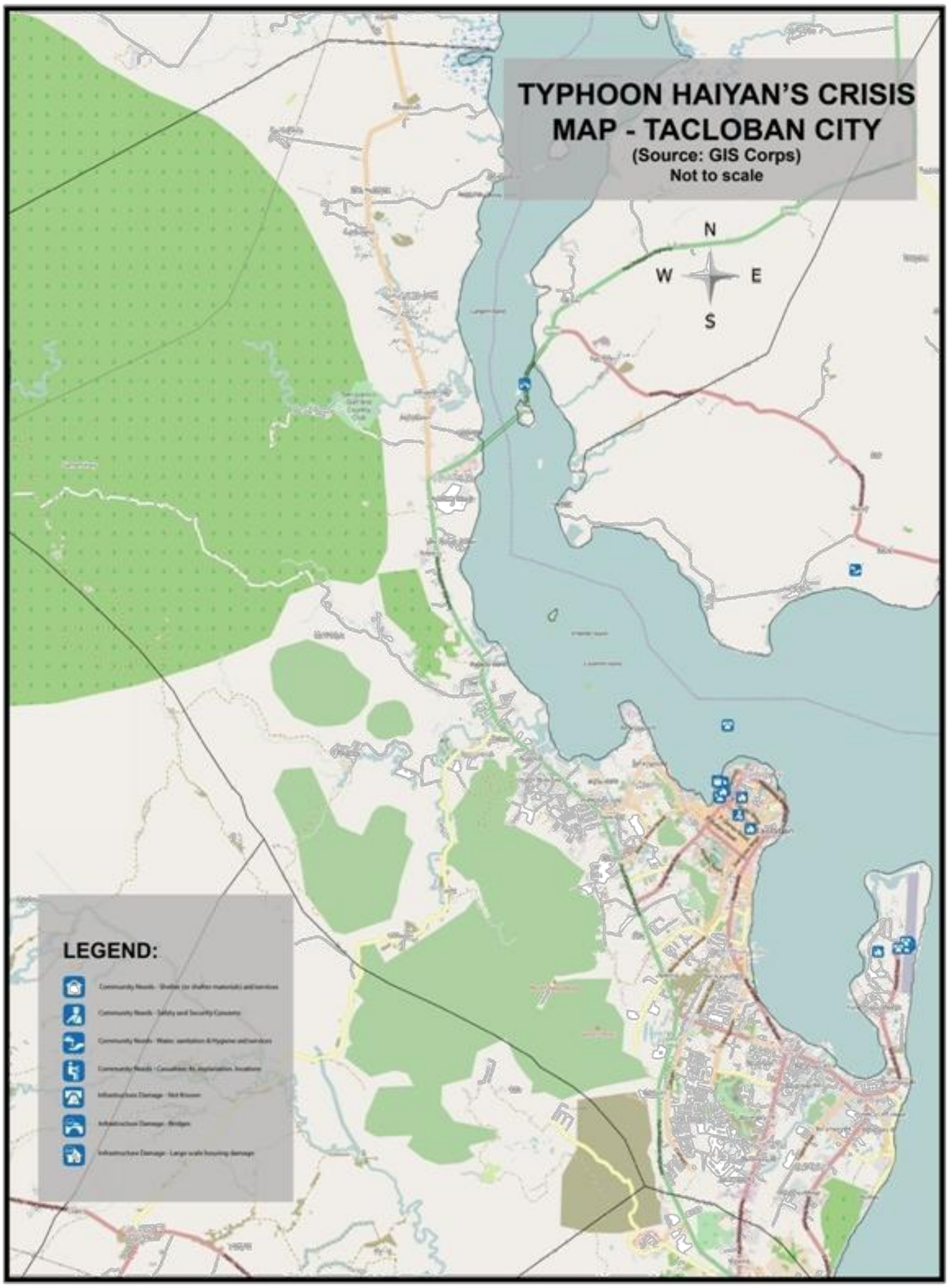
In the following images, both the traditional and VDD maps are presented. The traditional maps that were provided by the Tacloban City Government included various hazards and land uses. While, the VDD maps contained context and/or consequence data like storm surge modelling data, damage assessment and crisis information.

The first two images both represent VDDs that were gathered during the study. These maps were web-based but converted to a static image for the overlay analysis. The first map, Figure 67, only shows a single feature, while the second, Figure 68, has aggregated several features and overlaid them for viewing on its interactive interface. Both maps have an interactive interface that allows the user to customise the map, reveal or hide information, and add or edit the map and its contents.

Figure 67 Typhoon Haiyan's Crisis Map - Tacloban Cityis a crisis map prepared by the GISCorps. It contains various information regarding disaster consequences, such as infrastructure damage and community needs. While, Figure 68has joined several maps together to supply information on the storm surge, damage assessments, and emergency relief responses. Information on the storm surge was provided by a professional, while the emergency response information was provided by crowds, which represents both context and crisis categories. With the exception of OSM's damaged buildings assessment, most of the damage assessments were produced by various political agencies such as the ECHO and FEMA.

These two images are followed by Figure 69, Tacloban's Proposed Land Use Map that was supplied by the Tacloban City Government. The map shows the proposed land uses for the city. Previously, various hazard maps were introduced in Chapter 4. One of the hazard maps was for the storm surge hazard. This was also used in the analysis since this was one of the major causes of the disaster. The rest of the hazards will not be dealt with.

Figure 67 Typhoon Haiyan's Crisis Map - Tacloban City



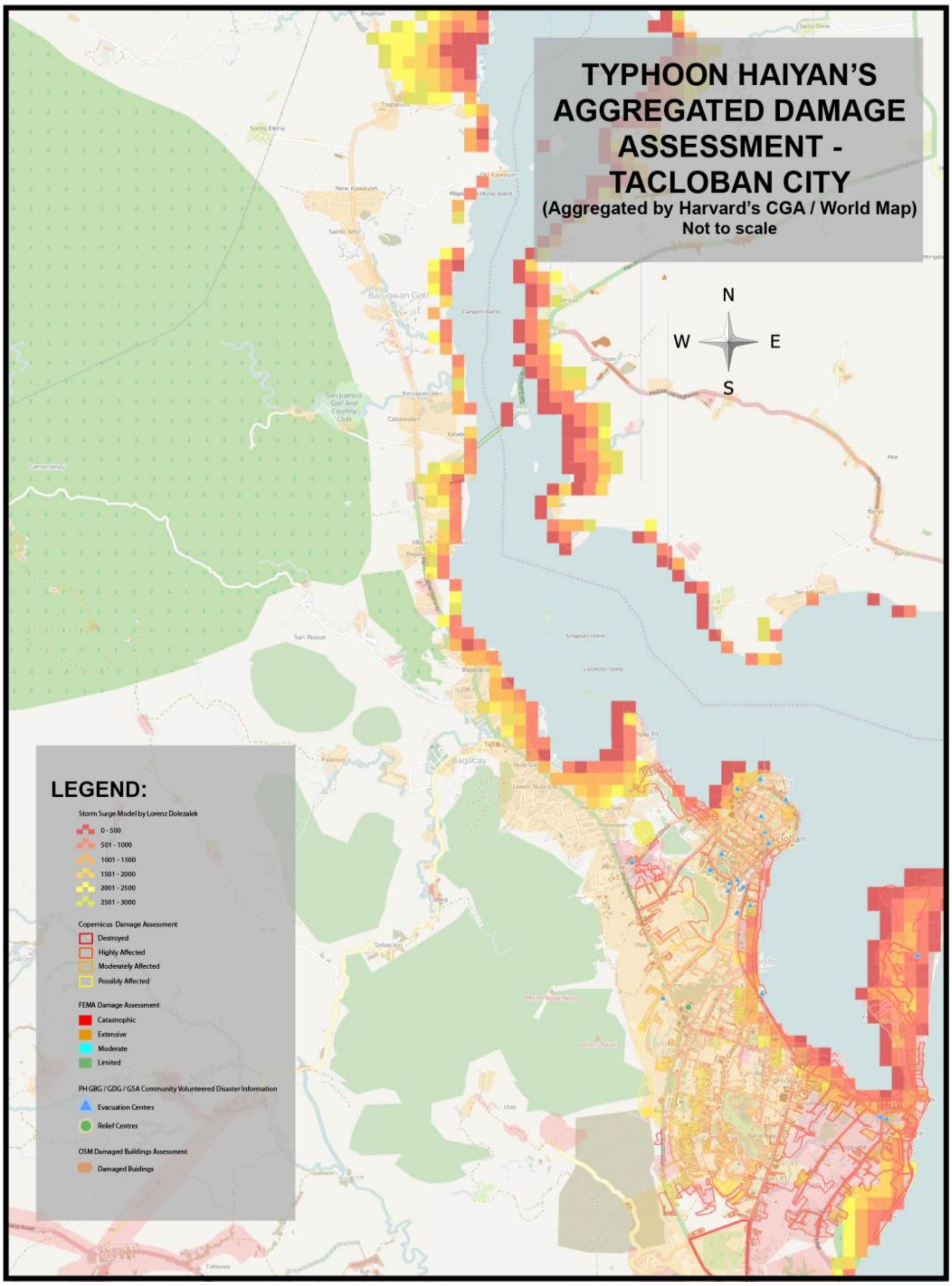


Figure 68 Typhoon Haiyan Aggregated Damage Assessment - Tacloban City

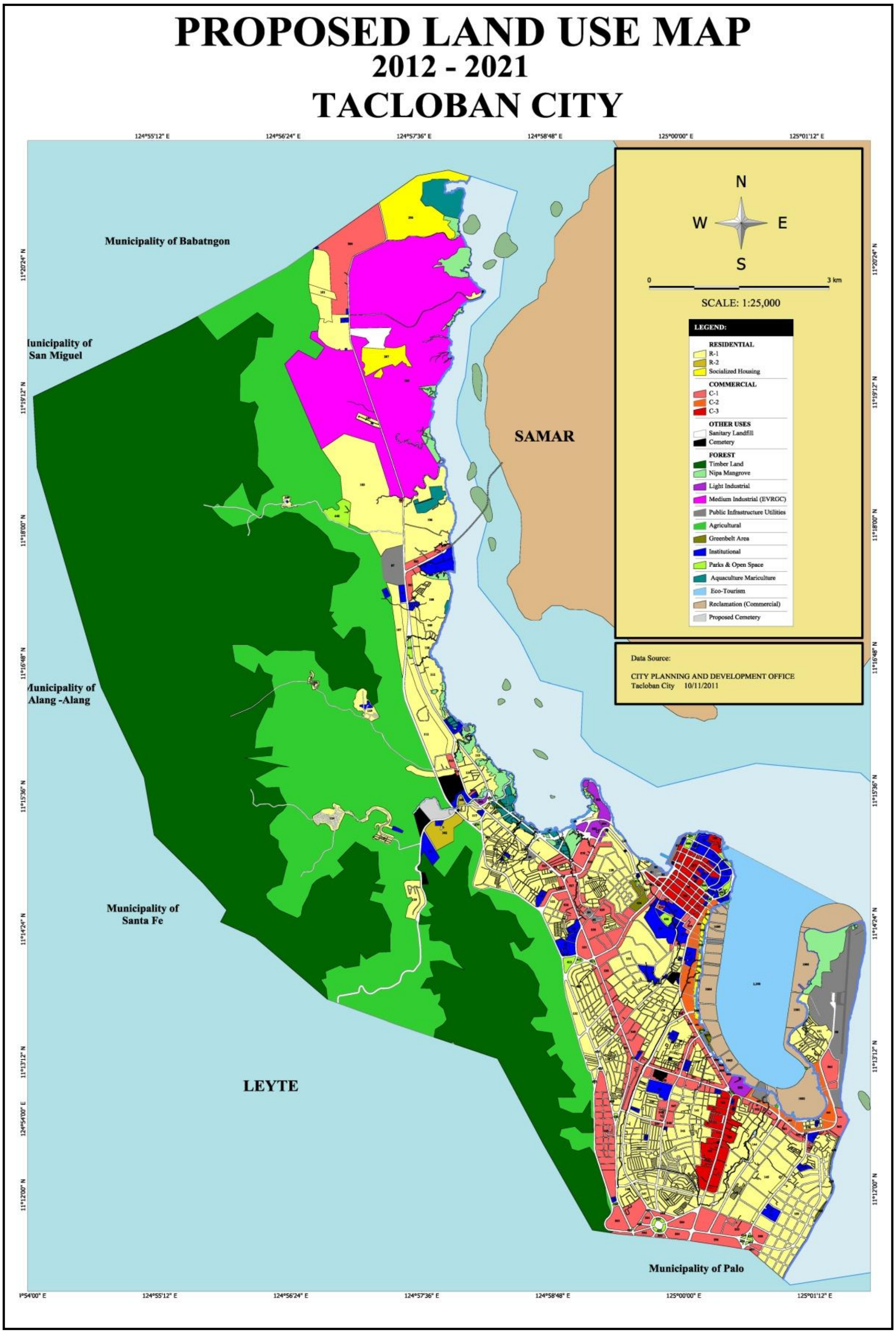


Figure 69 Proposed Land Use Plan of Tacloban City (Provided by the Tacloban City Government)

Combining the features of the various maps enabled several overlays to be produced. Map features were chosen also based on the identified criteria that were mentioned in Chapter 4 and at the beginning of this chapter. A combination of both traditional and volunteered geospatial data were used to compare the pre- and post-disaster situations. Maps were aggregated and layered to identify some critical areas and concerns. Recognized issues are expected to serve as useful inputs for the spatial planning process that supports the post-disaster recovery, redevelopment and future risk mitigation.

The first two overlays, Figure 70and Figure 71, show the GIS Corps Crisis Map and World Map's Aggregated Typhoon Haiyan-related Data in the Philippines overlaid with Tacloban's Administrative Boundaries, which was derived from the traditional maps. This was done to test the suitability of the proposal to do map overlays, and to anticipate issues that will be encountered in the whole process.

During the initial overlaying, the main issue that emerged was that of map scales. Map scales vary, and some corrections had to be done. Nevertheless, it isn't perfect as can be observed in the maps. Due to this, certain details and features, such as roads and boundaries do not exactly fit well together. In this light, most of the plotted location-specific information may also lose their precision or accuracy. Nonetheless, it still gives you a fair approximation of the various areas and how to navigate through them as well as a good overview of the area's condition. It also highlighted the fact that even when done crudely, it will still provide useful information.

Following this, other layers were made. In the next two images,Figure 72&Figure 73, another layer has been added to the overlay to reflect the storm surge hazard assessment that was done by the local government and relevant agencies. The storm surge hazard map showed the extent of the areas that will be affected should a storm surge occur in the area. The assumed maximum surge height was 4 metres, which was way below Haiyan's reported surge height that ranges from 5-7 metres. The data from the 'official' storm surge hazard map may be compared with the information provided by the VDD maps such as the modelled storm surge, damage assessments and crisis information. From the overlain maps, we see that the there is a high correlation between the various data presented. However, the 'official' storm surge map fell short in predicting the worst possible scenario, which could have aided the both the planners in identifying unsafe habitation zones and authorities to mitigate the potential risks. This highlights the importance of having reliable information for spatial planning and disaster risk management to be effective.

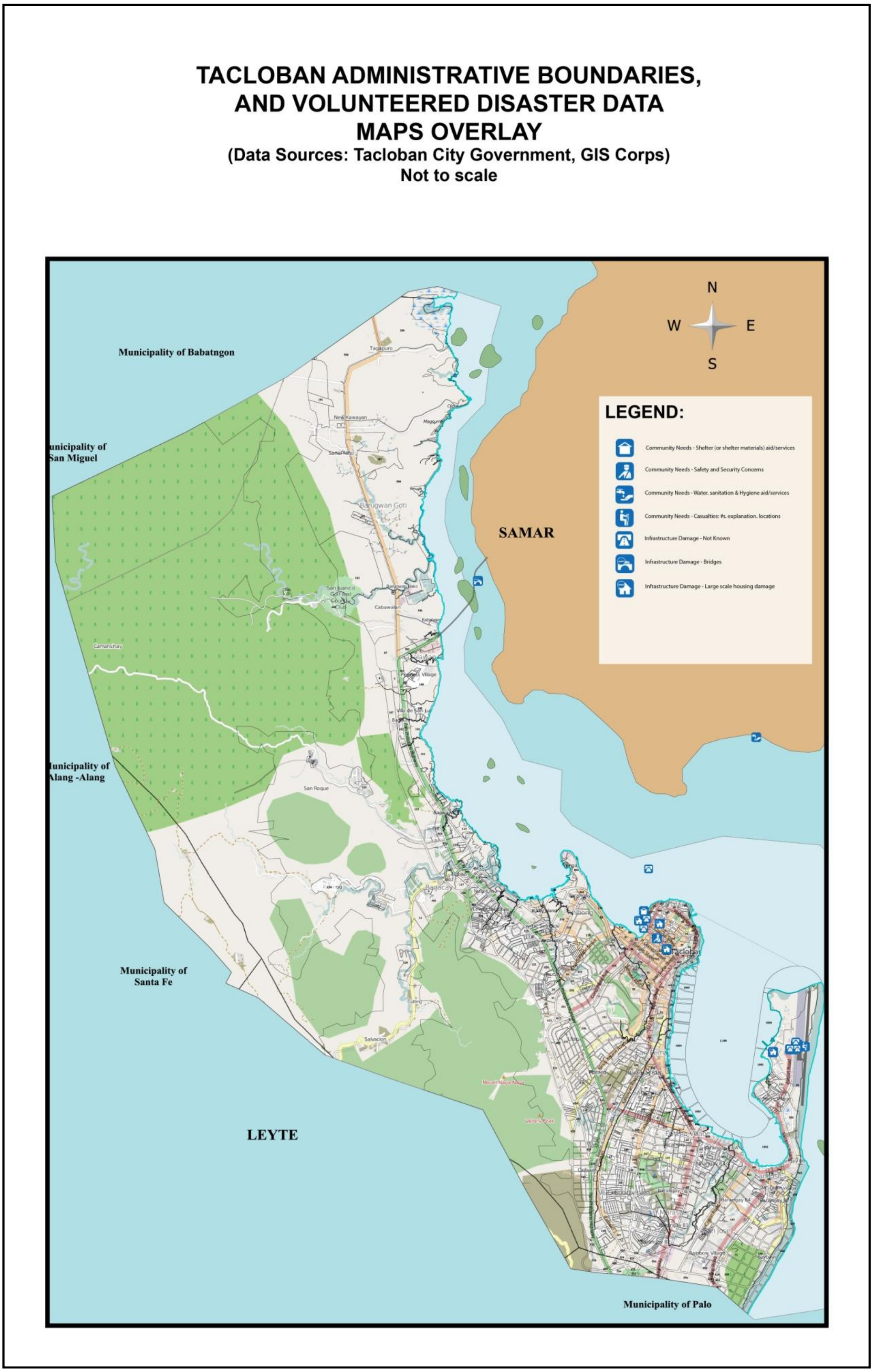


Figure 70 Tacloban Administrative Boundaries and GIS Corps Crisis Map Overlay

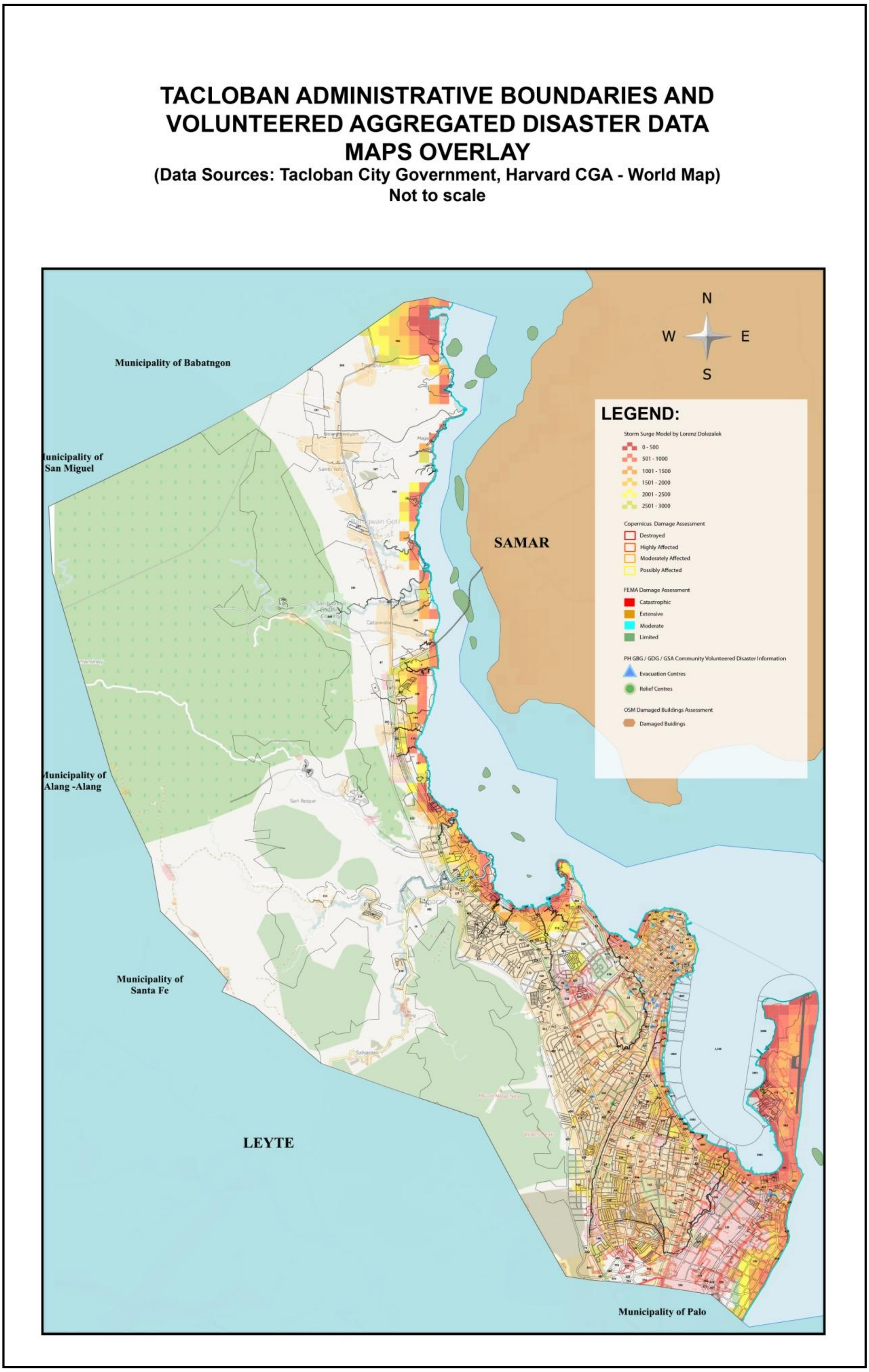


Figure 71 Tacloban Administrative Boundaries and World Map's Haiyan PH Map Overlay

Figure 72 Tacloban Admin. Boundaries with Storm Surge Hazard and GIS Corps' Crisis Map Overlay

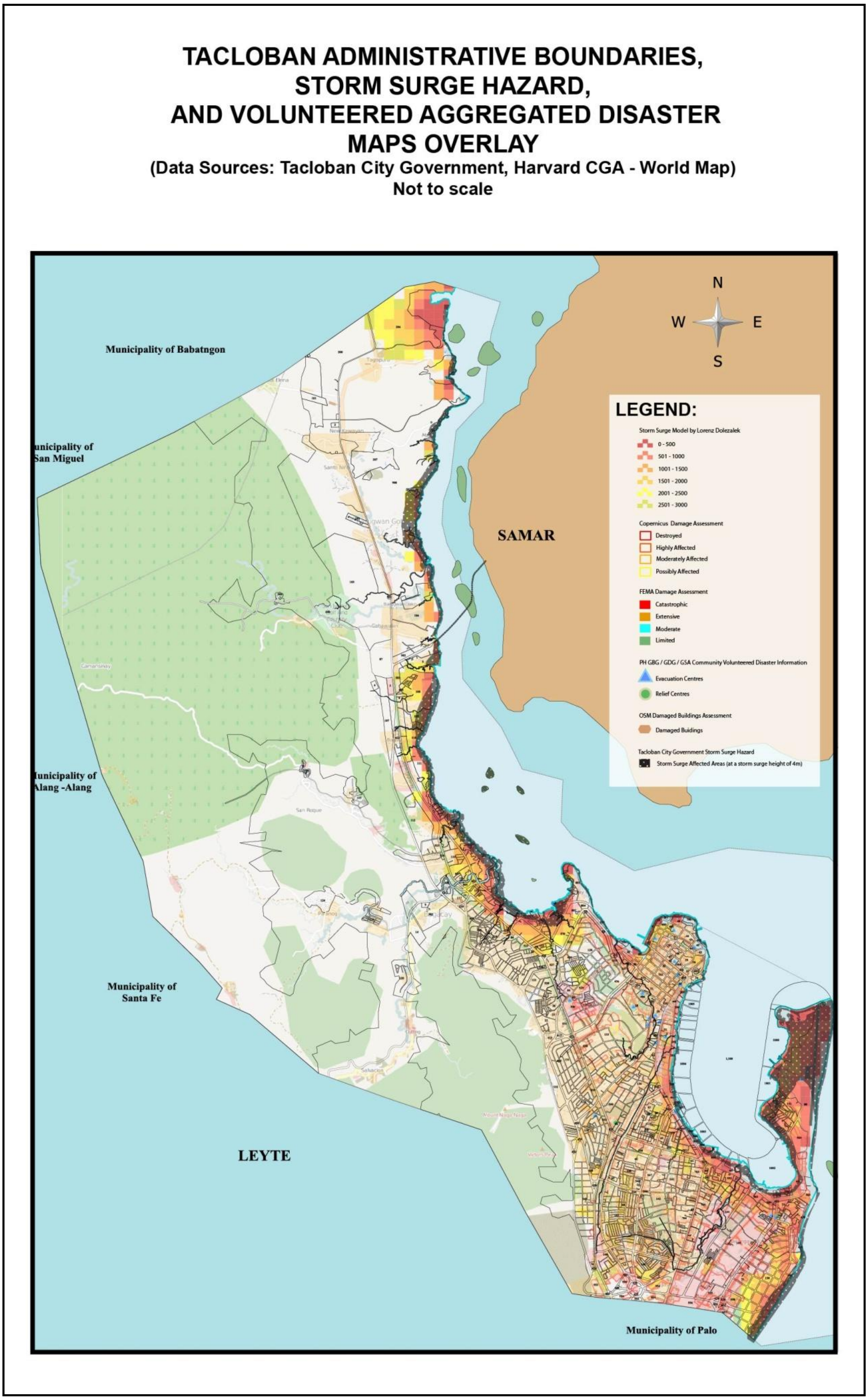


Figure 73 Tacloban Admin. Boundaries with Storm Surge and World Map's Haiyan PH Map Overlay

Another set of maps were overlain to produce another one with more features pertaining to land uses. This was done determine other issues more specific to spatial planning. The first one shows the location of the residential areas with differentiated densities, while other shows other proposed land uses such as commercial, industrial, institutional areas. These overlays create an image of the potential consequences to future infrastructures and settlements should another super typhoon and storm surge hit Tacloban again.

In Figure 74, the proposed residential areas are shown. Here, it can be pointed out that the intended social housing areas fall within the hazardous zones. In the Philippines, the social housing is intended for low-income communities. Should these vulnerable communities unfortunately experience another super typhoon, it will be very difficult for them to recover on their own with respect to their current status. Besides the social housing, other settlements that are planned along areas close to the coast should be reconsidered. In the proposed land use plan, a reclamation area was also marked, but the purpose was unclear. Based on the damage assessment, definitely, this area is also prone to devastation should another disaster happen. Unfortunately, this is also true for the other land uses such as commercial, industrial and institutional as shown in Figure 75. Critical infrastructures have also been wiped out during the disaster. Both the seaport and the airport suffered huge blows. It might be well worth it to think about relocating the airport on an area that is much safer, or put surge barriers to protect both infrastructures.

Overall, the challenge is to find a suitable place that presents acceptable and manageable risks. As Tacloban has a limited supply of alienable and disposable lands, it is forced to maximise its available buildable areas. However, maximisation must have priorities that are built on well-founded and reliable information.

An incident like Haiyan does not happen often, but it will happen again. In the past, Tacloban has already suffered a similar event. In January 1898, an Australian Newspaper reported that the Philippines was devastated by a typhoon and tidal wave which claimed about 7,000 lives(Broken Hill [N.S.W.]). However, this local knowledge must not have been passed on and buried in history. With this fact, the event can be estimated to have 100 year return period. On the contrary, due to the unpredictable weather patterns these days, it is difficult to bank on it, but combining this knowledge with the present, reliable information such as those provided by VDDs may offer a better perspective for better informed decisions and actions.

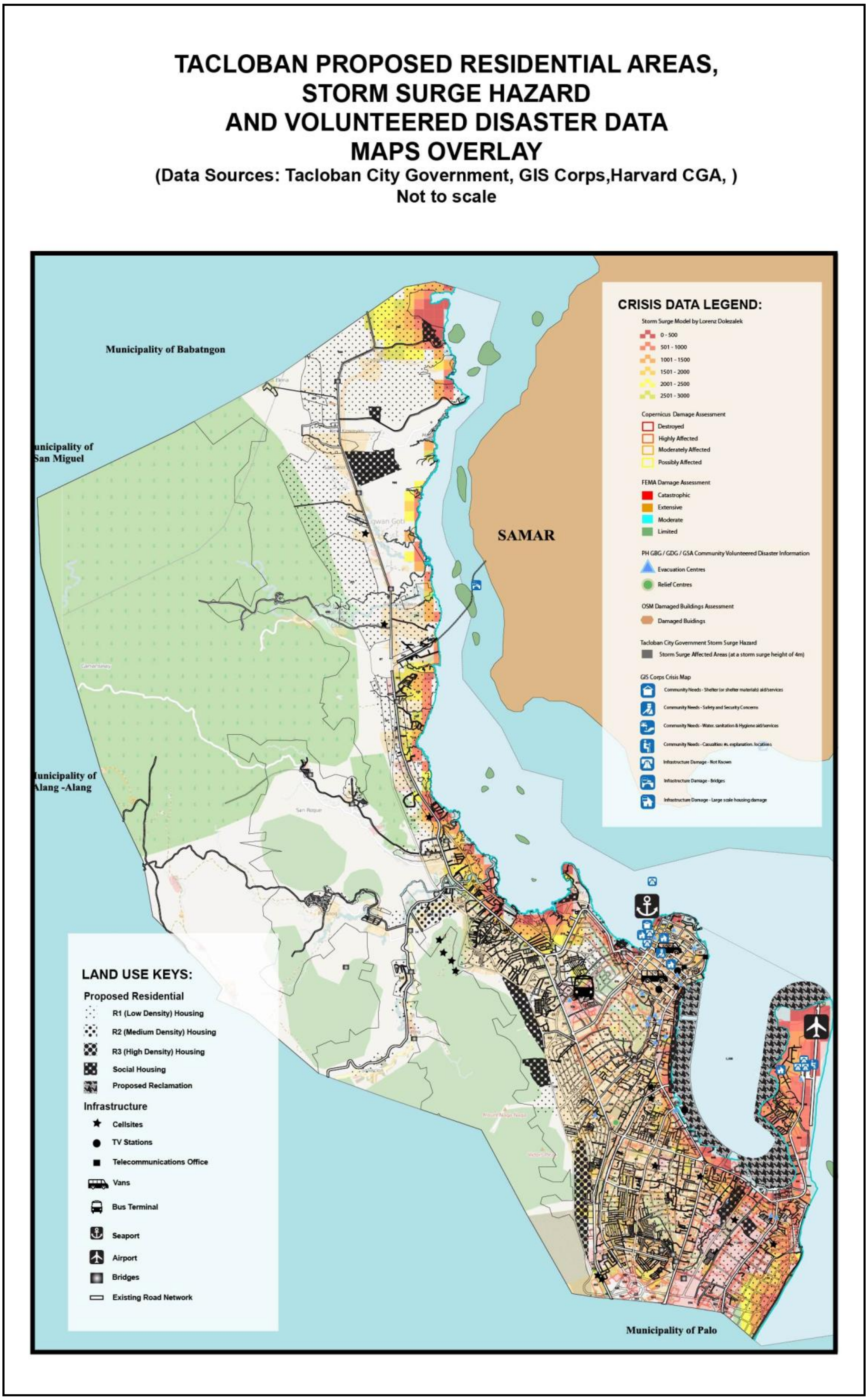


Figure 74Tacloban's Proposed Residential Areas with Storm Surge Hazard and GIS Corps' Crisis Map Overlay

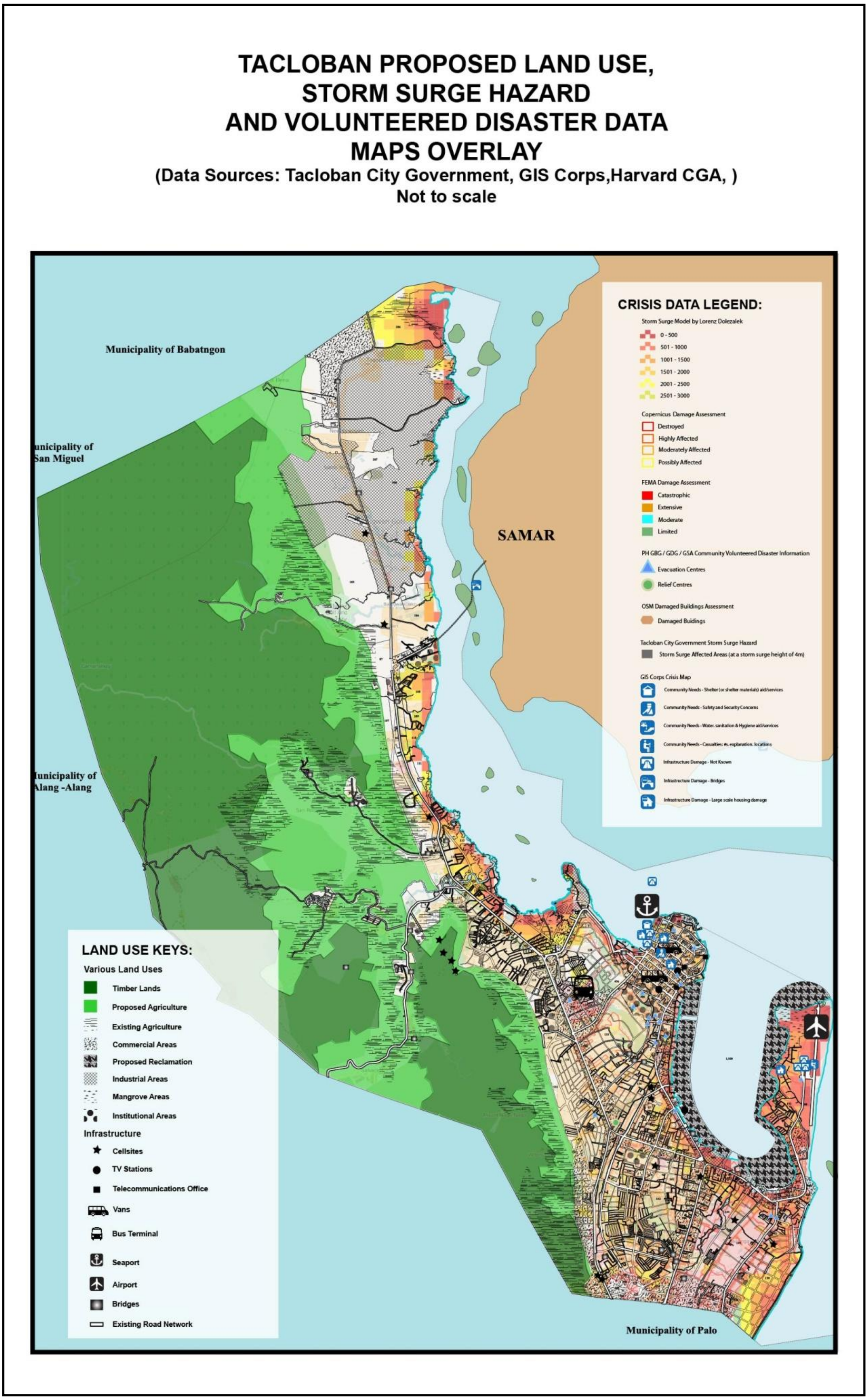


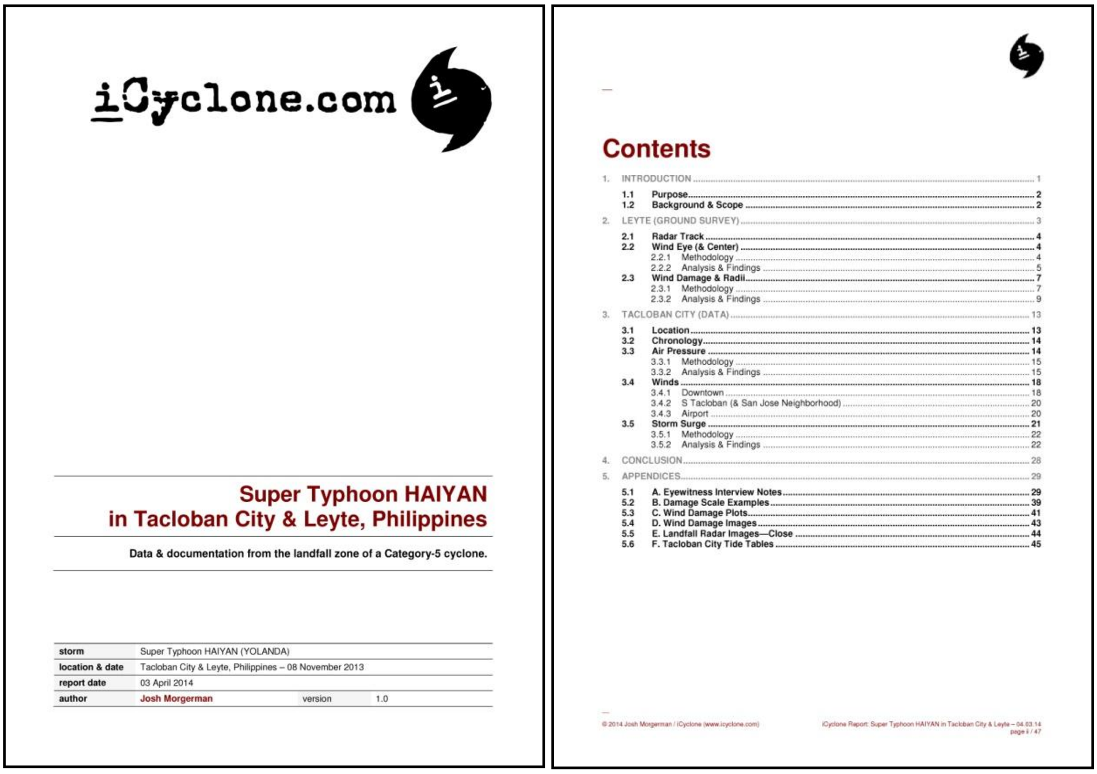
Figure 75Tacloban's Proposed Land Use with Storm Surge Hazard and GIS Corps' Crisis Map Overlay

5.1.3.2 Information Validation

Apart from the overlay analysis, VDDs may also serve as a practical validation tool. Not only does it add to the wealth of informational resources, but it may also indicate trends and discrepancies that either corroborate or negate information, and prompt further investigation.

A good example is the report made by iCyclone's Josh Morgerman, who was in Tacloban during the disaster. The report consists of primary information from personal observations with an elaborated methodology, and secondary information from interviews made.

Figure 76iCyclone Report for Super Typhoon Haiyan in Tacloban and Leyte



iCyclone.com

Super Typhoon HAIYAN
in Tacloban City & Leyte, Philippines

Data & documentation from the landfall zone of a Category-5 cyclone.

storm	Super Typhoon HAIYAN (YOLANDA)		
location & date	Tacloban City & Leyte, Philippines – 08 November 2013		
report date	03 April 2014		
author	Josh Morgerman	version	1.0

Contents

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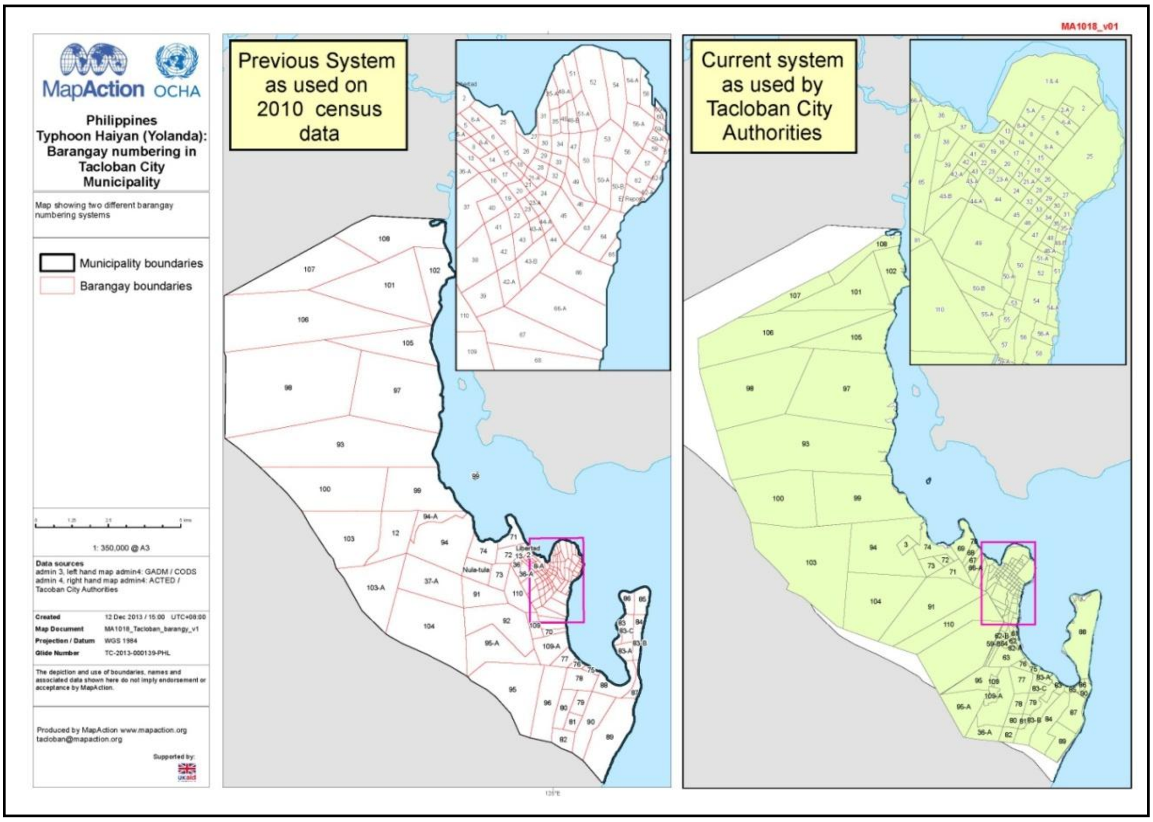
Another fine example, though not crowdsourced or crowdgenerated, is the Barangay Reference Map from Map Action, which highlights the updated administrative boundaries that Tacloban City has been using. As the last census was done in 2010, the national data has not been updated yet. This asserts that problem of outmoded information is another issue that can be addressed by VDDs.

Figure 77 Tacloban Barangay Boundaries Old and New



Source: MapAction

5.2 Towards a Better Integration of Emergency Management and Spatial Planning

5.2.1 Using VDDs to Support Spatial Planning in the Post-Disaster Context

Emergency management and spatial planning are civic activities that have heavily relied on traditional data in the past. However, currently, we see that emergency management has been quickly adapting to these changes by also incorporating the use of modern technology and exploiting collaborative efforts for common gains. Despite this, other fields have been slow to pick it up -- spatial planning being one of them.

In spatial planning, disaster risks are often integrated by including the risk assessment results. Nevertheless, most of these results are often based on estimations, models and past historical data. Few have actually integrated actual damage and losses into their plans. It can be assumed that this is such because data recording and collection were difficult and costly in the past. However, in these modern times, new sets of information are continuously generated and made available at a reasonable cost. This is happening every day, but this phenomenon peaks during the advent of large-scale events as more data are voluntarily created, used and shared. These generated volunteered disaster data (VDD) often contain various information regarding disaster consequences, damages and losses, which can be very useful to the emergency responders, governments and aid agencies during the response phase, but when this period is over, the VDD flows slow down or come to a halt. Often, these VDDs become a part of history, which will probably get pulled out from the archives for the use of scholars and experts. This is a shame because it usually contains more information than it gets credit for.

The charts and the maps that have been produced and assembled from the collected VDDs and combined with traditional data will provide a good basis for the conduct of a deeper analysis during risk assessments. Results of these assessments may serve as supplementary data inputs to improve for post-disaster recovery and reconstruction plans. It will also allow authorities, communities and organisations to work together and identify potentials for leveraging sustainable development commitments before revising the area's development goals and spatial strategies.

In the case of the Philippines, these new data forms can also be integrated in its disaster risk assessment (DRA). In its list of requirements, it had only stated the hazard maps, administrative boundary maps, population maps and the property values. Unfortunately, this hardly reflects and fosters the integration between spatial planning and EM. Another point to be raised is that the risk assessment is rather focused heavily on risk estimation and probabilistic analysis. The actual damages and losses were not part of the hazard analysis / assessment process.

As demonstrated by the practical application in this study, the existing DRA can be improved further by integrating these VDDs, which also provide crucial information on damage consequences and losses. This is especially useful during the post-disaster phase as the government will not have enough resources (money, time, and manpower) to conduct full-blown risk assessments. As most of the data are available in a georeferenced format, it is easier to intermix it with existing geospatial data sets that were produced traditionally. It is probable that some issues similar to what was encountered in the study will arise. However, just as the government have successfully partnered with the social media networks in the response phase, they may also do so during the recovery. They may try to exploit the available collaborative tools that they have at their disposal.

Another use for the VDDs, which is not exclusive to just the Philippines, is combining it with the area's identified development goals for aligning the post-disaster activities and ensuring that it 'builds back better.' To illustrate this, a simple chart has been adapted from the University of Colorado's Holistic Disaster Recovery. (Please refer to Table 25.) It is based on the principles of sustainability, which is also usually referred to use as the guiding principles for the identification of development goals. Countries who take part in the Millennium Development Goals (MDG) program of the UN are familiar with this. The table can be further tailored to reflect the specific goals of the area, and can be completed using the help of the aggregated VDDs and traditional data. It marries both the planning considerations and the disaster data that can be obtained through the VDDs. Not only is it useful for identifying of potential opportunities, but provides some guide to authorities and the various stakeholders to achieve an enhanced overall sustainability and resilience of the area.

Table 25 Matrix of Opportunities for Post-Disaster Recovery and Reconstruction Template

Disaster Damage Data / Development Goals	Damaged Transport			Damaged Public Facilities						Damaged Utilities				Damaged Housing			Economic Disruptions					Damage to Environment				Health and Safety Concerns				Others			
	Roads, bridges & related infrastructures	Railways and public transport	Others	Schools	City Centre	Public Spaces	Seaport, airport, etc.	Powerplants, etc.	Others	Power lines	Phone Lines	Water Treatment System	Others	For Repair	For Replacement	Others	Commercial Buildings Damaged / Destroyed	Disrupted Businesses	Loss of workforce	Unemployment	Others	Erosion	Soil, Air, Water Pollution	Habitat loss, tree loss	Others	Medical Facilities	Social and family servies	Traumatized victims	Others				
Maintain and Improve the Quality of Life																																	
Housing availability and affordability																																	
Health and other services																																	
Recreation																																	
Employment opportunities																																	
Education opportunities																																	
Mobility																																	
Safety and Order																																	
Others																																	
Ensure Social Justice and Equity																																	
Prevent disproportionate impacts																																	
Preserve social connections																																	
Natural, cultural resources preservation																																	
Encourage diversity																																	
Others																																	
Enhance and protect environmental quality																																	
Preserve/ conserve/ restore natural resources																																	
Protect open space																																	
Manage stormwater																																	
Prevent/ remediate pollution																																	
Others																																	
Enhance economic vitality																																	
Support area redevelopment / revitalization																																	
Attract / retain investments																																	
Attract / retain workforce																																	
Enhance economic vitality																																	
Develop sustainable tourism																																	
Others																																	
Strengthen resilience / disaster mitigation																																	
Damage-resistant buildings and infrastructures																																	
Controlled development																																	
Manage stormwater																																	
Protect natural areas																																	
Promote / obtain hazard insurance																																	
Others																																	
Participatory Approach																																	
Integrate particpatory approaches in all possible situations																																	

Adapted from: The University of Colorado, Boulder

5.3 Challenges in Reusing VDDs

5.3.1 Need for pre- and post-processing

5.3.1.1 Data filtering and sorting

One of the challenges of reusing VDDs is going through its massive volume. As a lot of VDDs are available to be mined, it was necessary to be as specific as possible during the search to avoid mining unnecessary information. However, being too specific also meant that some data might be left out, so a balance is required. Since the study did not employ automated processes, the search had to be done manually. However, many of the available technologies and systems now can aid in the search and collection process.

Apart from the tedious search, organising the unstructured and varying VDDs also presented a challenge. It was necessary to identify all possible characteristics that the data can contain in order to sort it appropriately. The taxonomy and ontology were very useful to achieve this goal, but their generation was a time-consuming process. It took too much time to build the table and extract the content that served as basis to build taxonomy and ontology.

Although the taxonomy and ontology has improved the presentation and structure of the collected data, the terminologies used may create some confusion or stir some discussion. It was necessary to develop a unique, but acceptable ontology and taxonomy that will be understood across all levels such as local, national and international ranks. This will enable all stakeholders to integrate and use it in their emergency management cycles. It will also allow a more systematic procedure in the knowledge creation from data generation to data reuse. The devised comprehensive ontology and taxonomy provides a good platform for the various stakeholders and interested entities to effectively gather data and sort them. It may also be applied in the various emergency phases, and not just in the response stage. The categories allow faster sorting and filtering of data, and it also prevents missing out necessary details as well as reducing potential errors and mistakes when it comes to data sorting or filing.

Moreover, in some cases the provided data appears vague. This presents some problem in identifying its potential value for use or reuse, which the ontology can easily sort out. This is not to point fingers at the data generator, owner or author as it may also be attributed to the different understanding of the potential user and curator. Since the data is freely accessible to everyone, it may also be used by non-emergency management professionals, whose comprehension of the terminologies and vocabularies may differ. Essentially, the ontology resolves this issue by providing common terminologies that reduce these kinds of problems and assist in making the data reuse more user-friendly.

5.3.1.2 Data interoperability

Most of the data that have been gathered appeared to have been converted from its original form to a portable document format for publication. Depending on the editing properties, it is more difficult to extract the data for aggregation with other data types / formats for post-processing. The situation reports crucial information about damages and other disaster consequences. These are presented in both textual and graphical formats. However, geographic information such as maps that were originally georeferenced were reduced to static images, that offer less information, and were less manipulable. In this case, data formats become a limitation. Nonetheless, there are also organizations that allow the raw data to be downloaded for easier post-processing.

5.3.2 Data reliability and perceived acceptability

5.3.2.1 Abstraction and variations

Another challenge was the use of web-based geospatial information, such as hosted crisis maps. Converting these maps from its dynamic state to a static one became difficult due to the scale factor. It was necessary to have a base map with a scale to follow prior to the extraction of maps containing VDDs. However, even with a reference scale, the generated output is still not 100% precise and accurate. This is evident in the map overlays. It can be observed that there are slight variations in the administrative boundaries and some other map details. Estimation and corrections were done prior to overlaying the maps for analysis.

Adding to the issue of scale variations is the use of differing base maps. The various VDDs, as well as the traditional maps, used different base maps, which resulted in obvious differences in the overlays.
The lack of further description was noticed in the storm surge model included in the aggregated VDD map provided a vague legend. The provided scale did not include any unit of measurement, and therefore, it was difficult to guess how to interpret the plotted data.

The presence of these irregularities and uncertainties may prevent a wider adoption of VDD maps. Nonetheless, as seen in the rest of the overlays, its reuse may still serve as a useful supplement to assessments. Factors influencing the irregularities and uncertainties like map scales and legends may later be worked out and corrected by professionals and experts to achieve better accuracy and precision.

5.3.2.2 Source reputation

An added issue linked to the irregularities would be the source of the data. The origin definitely affects the perceived acceptability of the data, which may promote or inhibit its later use.

Despite the mainstreaming of VDDs in the recent disasters, the tremendous amounts of data that it generated has yet to be harnessed and exploited for other purposes such as spatial planning decision support. Most people still rely on information generated traditionally, which may be attributed to the perception of VDDs and open data, in general.

However, with various efforts such as OSM, Google Communities, World Map and GIS Corps, crowdsourced and crowdgenerated information, such as some of the VDDs that were used, have already started paving the way for wider acceptance and use of alternative datastreams for civic purposes such as emergency management.

6 Conclusion and Recommendations

6.1 Disaster Data Gaps and the Promise of Open Data

The slipping disaster impact trends are a great feat of today's disaster risk management (DRM) systems. Unfortunately, it is a feat that is not enjoyed or shared by everyone. The general decrease is not representative of the small and middle-income nations that are still plagued by rising disaster consequences and losses. Despite increased concerns and intents, limited financial and technical resources prevent these emerging economies to fully commit to DRR and to establish an effective DRM (Velasquez, 2012).

In the context of emerging economies, two scenarios are prevalent: one is the utter lack of informational basis, while the other is the use of antiquated and unreliable information. Both are data gaps that hamper the full understanding of imminent disasters, which causes a chain effect to take place (Crowley, 2014). The absence of information is an outright acknowledged handicap. However, the use of outdated information results into the creation of substandard emergency and disaster management plans,whichmay create a false sense of security for the community. It may also lead to the further amplification of vulnerabilities and exposures instead of reducing them.

Super Typhoon Haiyan in the Philippines is a flagrant illustration of this. The fact that hazard information were already identified, mapped out, and integrated into the local land use plans were not enough to provide reliable information for the pre-emptive emergency actions. Some of the designated evacuation centres that were supposed to provide safe shelter to people were inundated, which worsened the casualty count (ABS-CBN News, 2013). The disaster couldn't have been averted, but its impact could have been stifled if only reliable information were available.

Nonetheless, in the recent disasters, we have seen an increase in the generation and sharing of information in the form of open data. This can be attributed to the recent technological advancements that have allowed improvised activities initiated by citizens during calamities (Palen & Liu, 2007), while also permitting the breaking down of traditional boundaries.

Open data is mainly characterised by unrestricted reuse, redistribution, and interoperability across various disciplines and varying datasets. Nonetheless, only open data from disaster events had been dealt with in the conduct of the work. To avoid confusion and to highlight the characteristics of the data, it has been distinguished as volunteered disaster data (VDD).

This study was undertaken to demonstrate the possibility of utilising these VDDs to support post-disaster recovery and redevelopment and future risk mitigation by augmenting identified data gaps, which is hoped to eventually improve DRM systems to respond better to catastrophes such as Haiyan.

6.2 Closing the Gap through Reusing Volunteered Disaster Data (VDD)

Haiyan-related VDDs were gathered for the conduct of the research. The collection was technologically-aided, but carried out manually. Several methods were employed such as the use of search engines, RSS feeds, social media monitoring, organisation and forum subscriptions, and website access. Due to huge volumes of VDDs available, data were gathered selectively. Initially, data collection included PH-wide disaster impacts and consequences, but with the overwhelming matches, it was limited to the most devastated area, Tacloban City. Due to time constraints and limited resources, the collection is not exhaustive.

Subsequently, official or traditional public data was also collected to supplement the VDDs and to assist in the analysis. In contrast to the VDD collection, obtaining traditional data was an arduous process. Nevertheless, this was necessary to have an image of the area's pre-disaster condition validate the research proposal and answer the research questions that were posed earlier on:

(1) Can volunteered disaster data be reused to support post-disaster recovery and redevelopment, and future risk mitigation?
(2) If so, how can it be reused?
(3) What are its advantages?
(4) What are its limitations?

Familiarisation with the traditional data also became instrumental in setting the framework for the VDD reuse. From the traditional documents, spatial planning data requirements were marked and compared with the derived characteristics of the VDDs from the developed taxonomy and ontology.

The taxonomies and ontologies provided considerable assistance to achieve a deeper understanding of the various VDD types and characteristics. It also provided a good visualisation of the available data and allowed its easy regrouping. During the data tabulation, a significant overlapping between the nature of the VDDs and the spatial planning information requirements was observed. This became a good indication of the VDDs potential to be reused as spatial planning inputs to support post-disaster recovery and redevelopment, and future risk mitigation action. These overlaps between the spatial planning dataset requirements and the VDD contents were noted and charted. The output was a generic chart that can be used as a practical guide for VDD sorting and selection.

The only caveat with the methods used was its time-consuming nature. Should time be a factor, this might be a letdown for others. Nevertheless, since a preliminary step was already done, others may build upon the existing taxonomies and ontologies to save time.

While the original intention for using taxonomies and ontologies was to assist the sorting, it had an unexpected result, which was the confirmation of the potential reuse of VDDs to support post-disaster recovery and redevelopment and future mitigation measures. It also provided additional insights and enhanced visualisation to better understand and appreciate the rationale behind mainstreaming DRM into development, and the development and resilience interlink.

6.3 Towards Better Resiliency and Sustainability with VDD Reuse: A Practical Example

Besides the time consuming collection and sorting processes, other difficulties prior to reusing VDDs were encountered, such as the need for pre- and post-processing. Indeed, VDDs can be easily obtained at a lower cost, but its reuse for purposes other than the original intention was a tad difficult, especially for an overlay analysis, which was the chosen application method. Nevertheless, once these processes were out of the way, the VDDs become more manageable and utilizable.

The overlay analysis was chosen as it is a common spatial analysis tool to identify decision zones and land use issues. It can also easily provide a general picture of changes in the area due to disasters or various social patterns and trends, which allow better informed decisions and actions to take place. It was also more practical to envisage the reuse of VDDs.

In the analysis, several VDD maps were overlaid with the proposed land use plan of Tacloban, the area of interest. Fitting the maps together became a chore due to the scale variations as well as base maps used. Nevertheless, it had been successfully carried out, and in the future, this may also be resolved to allow easier intermixing.

The overlays immediately exposed the damage consequences from the disaster. This information may be useful for authorities and other bodies that need to allocate resources and identify priority programs and activities. It also uncovered several issues that need to be addressed in the on-going post-disaster recovery and redevelopment, and future disaster mitigating measures. The overlay of the VDD maps with the storm surge hazard map uncovered huge discrepancies with the modelled extent of damage. Right before the onslaught of Haiyan, storm surge levels were predicted, but inundation models which could have aided the emergency preparations were unavailable. This, again, highlights the criticality of access to reliable information. The location of institutional buildings and potential evacuation centres could have been properly placed and decided during spatial planning if the necessary critical data were within the reach of local authorities. It could have also helped in the emergency management, especially in the design of pre-emptive courses of actions to preclude huge consequences and losses.

6.4 The Future of Resilience, Development and VDDs

In the process, the study had established that it is indeed possible to reuse VDDs to support post-disaster recovery and redevelopment through spatial planning techniques such as the map overlay analysis. In this case, geospatial VDDs have been very useful and showed a lot of potential. However, as VDDs have a diverse nature, other ways of using it maybe also be studied further.

The relationship between EM / DRM and spatial planning had been illustrated by the taxonomy and ontology, and allowed the study to chart the potential entry points for reusing various VDDs based on the informational requirements of spatial planning and the different phases of the emergency management cycle. This may be further refined to develop formal guidelines and even to support the tailoring of policies.

The reuse of VDDs holds some promise, but it isn't without challenges. Several concerns on data interoperability, reliability and acceptability arose.

Despite the ideal characteristics of open data to be interoperable and to be effortlessly intermixed with other data to satisfy a different purpose, VDDs still need pre- and post-processing prior to reuse. This was evident during the sample application. Thus, the challenge is to make the data friendlier to use, manage and manipulate. On the other hand, there is also the issue of data reliability, which impedes the full use / reuse of VDDs due to the need for an expert's opinion or interpretation. Data should be made as simple as possible and crucial information for correct interpretation should also be included. Finally, acceptability might also emerge as a huge concern if it were to be adopted into a critical decision-making process such as spatial planning. This concern is closely linked to data reliability

These noted issues are not impossible to resolve, but it requires attention if reuse were to be adopted on a wider scale. Later in the future, other researches may want to address these concerns along with other potential issues such as the need for policy support to guide the future direction of VDDs, or more broadly OD, such as its reuse and its role in advancing resilience and development.

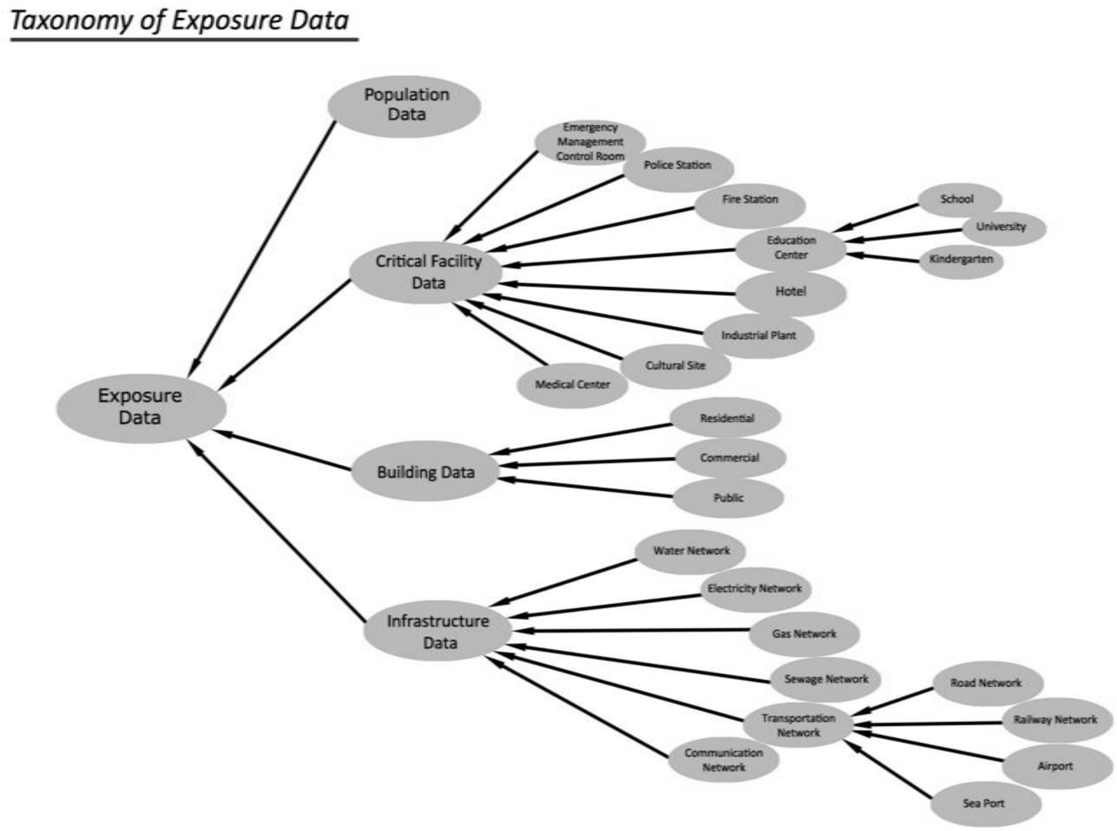
6.5 Further Considerations for the Future of Open Data and Research

As this work had greatly relied on ICT and on open data, several considerations regarding the future possibilities of the two subjects were also recognised. In the past, researches were carried out with a rigid set of criteria of acceptable sources. This reality has been slowly changing due to the availability of modern technologies and new sources of information. Together with spatial planning and emergency management, this trend was also observed.

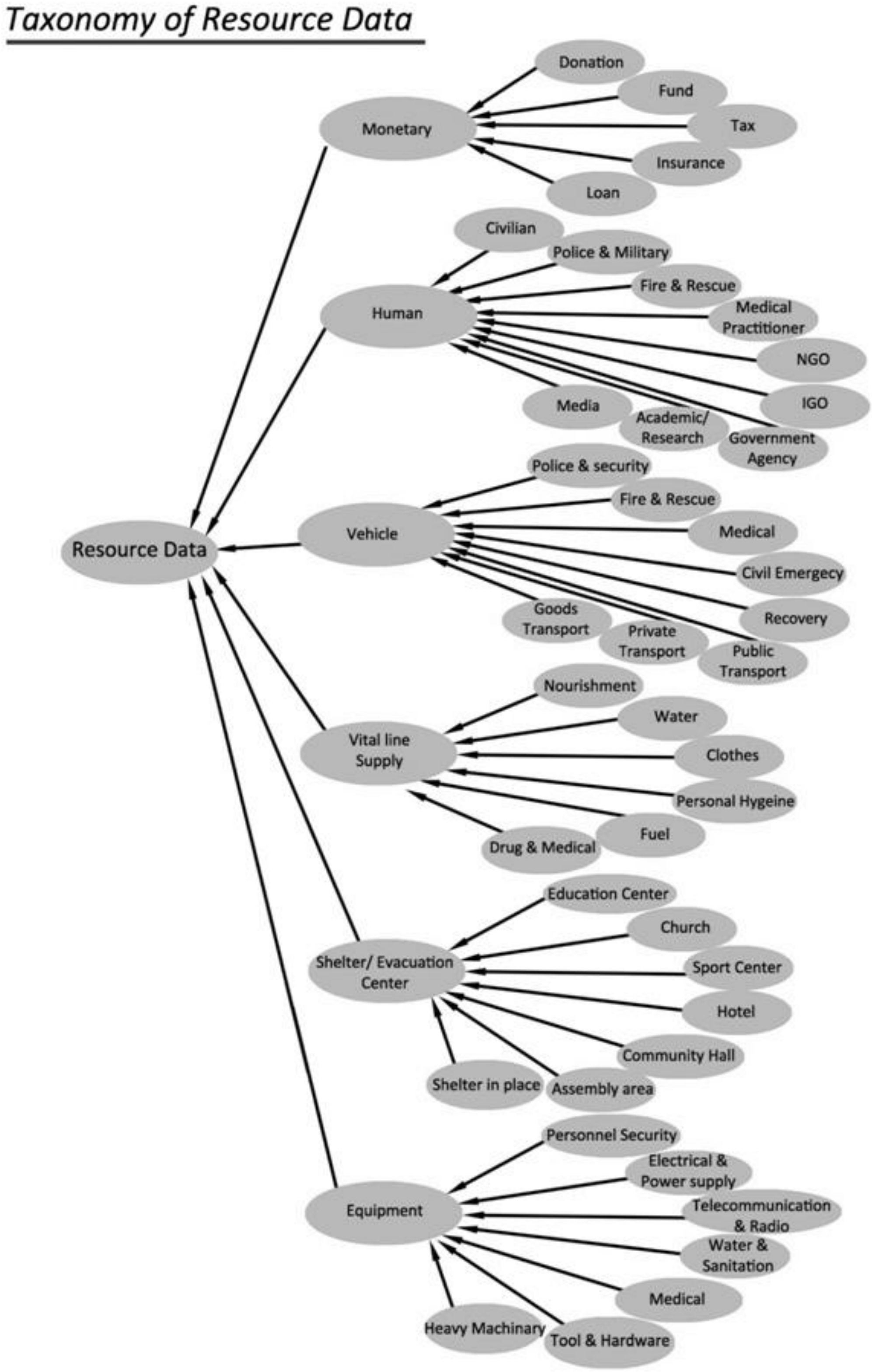
It cannot be denied that the academic community is greatly benefitting from technological advancements and the open data phenomenon as it extends the existing knowledge base at reasonable costs and virtually with no territorial limits. It also allows network building among other researchers who have common interests. This is evident in the 'research-geared' social networks such as academia.edu and researchgate.net. Nevertheless, it still has a long way to go, but it may be good to keep a watchful eye as things unfold rapidly. It might also require some agility from the academic community to keep up.

Appendix

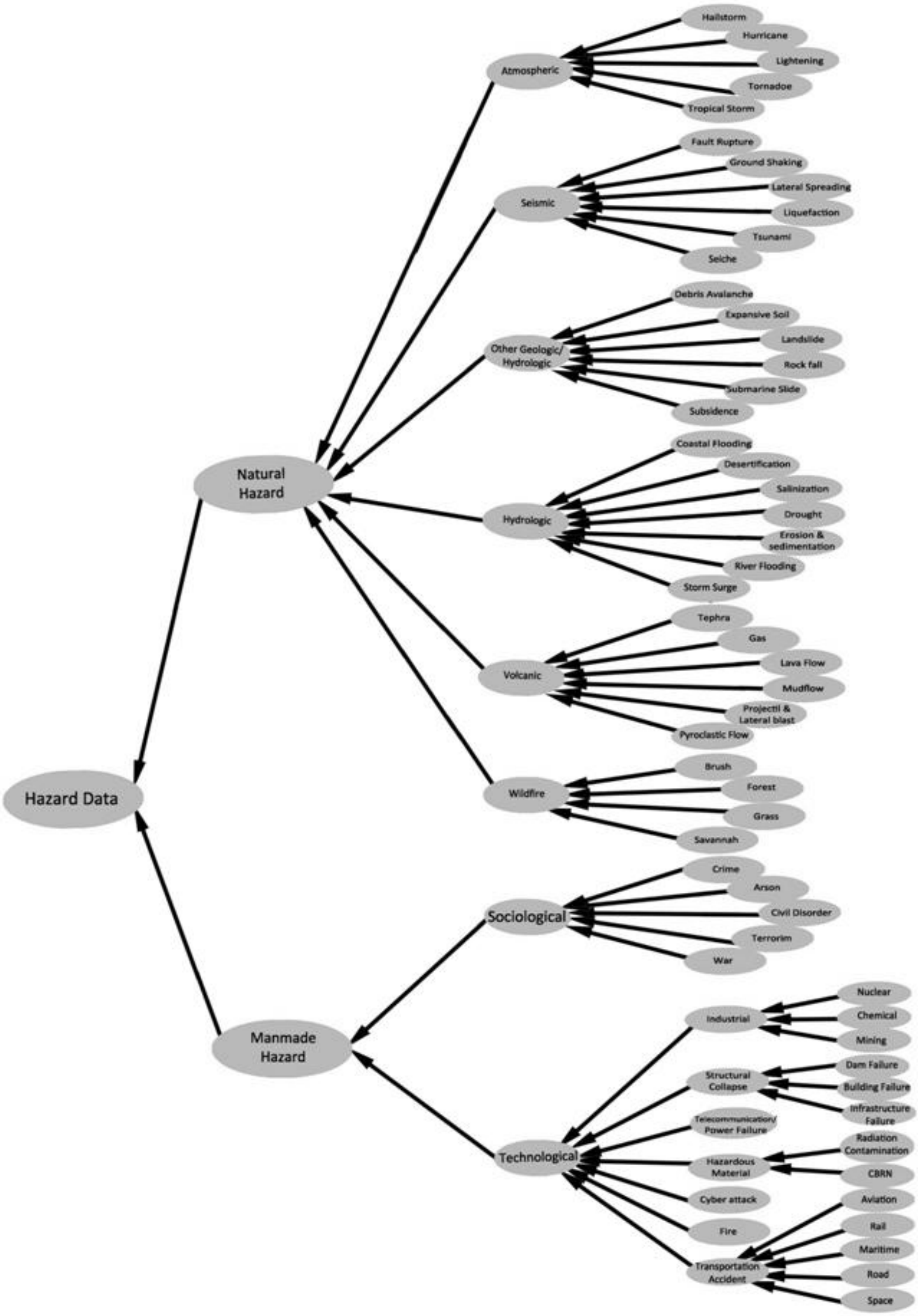
Appendix 1 Taxonomy of Exposure Data



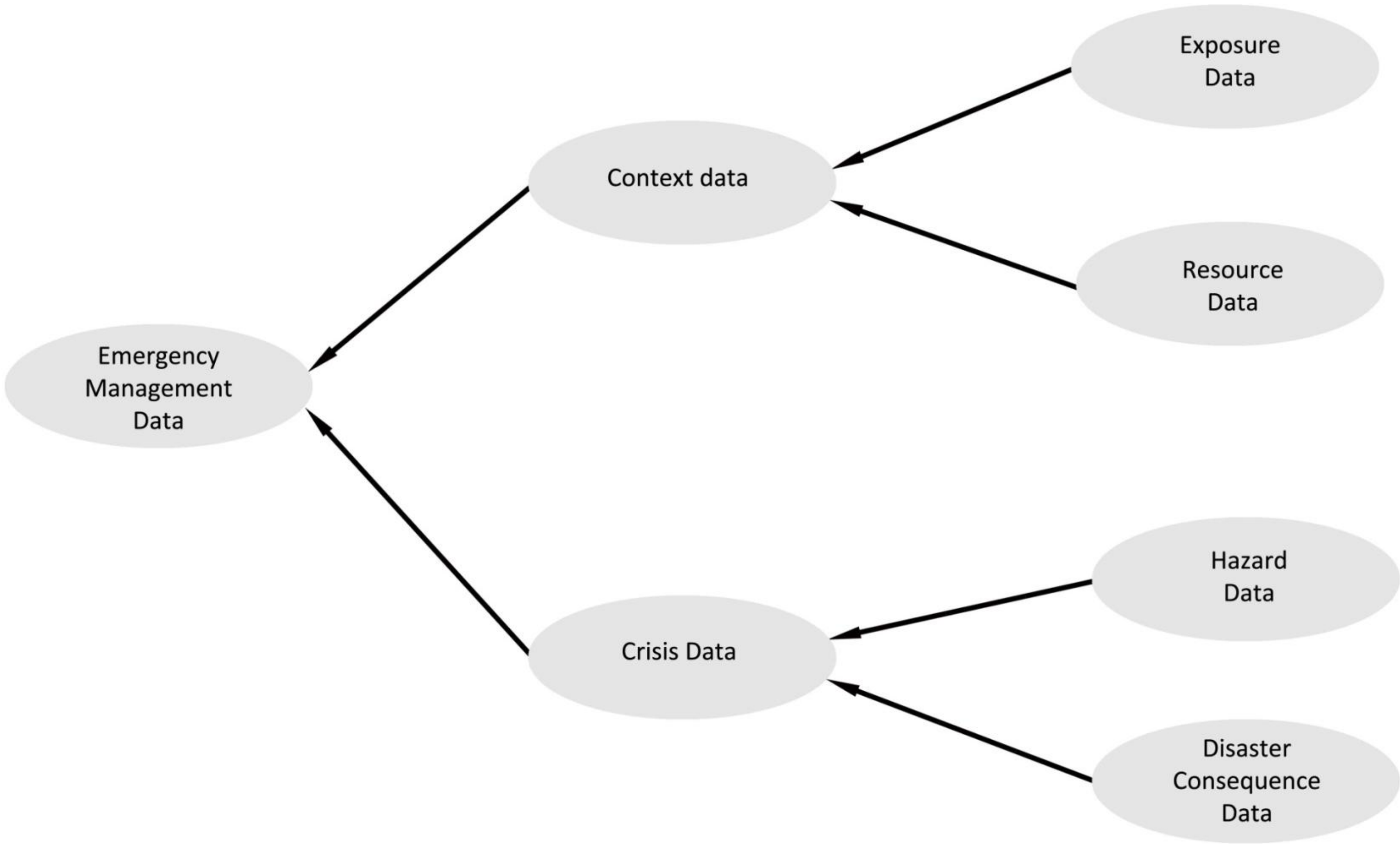
Appendix 2 Taxonomy of Resource Data

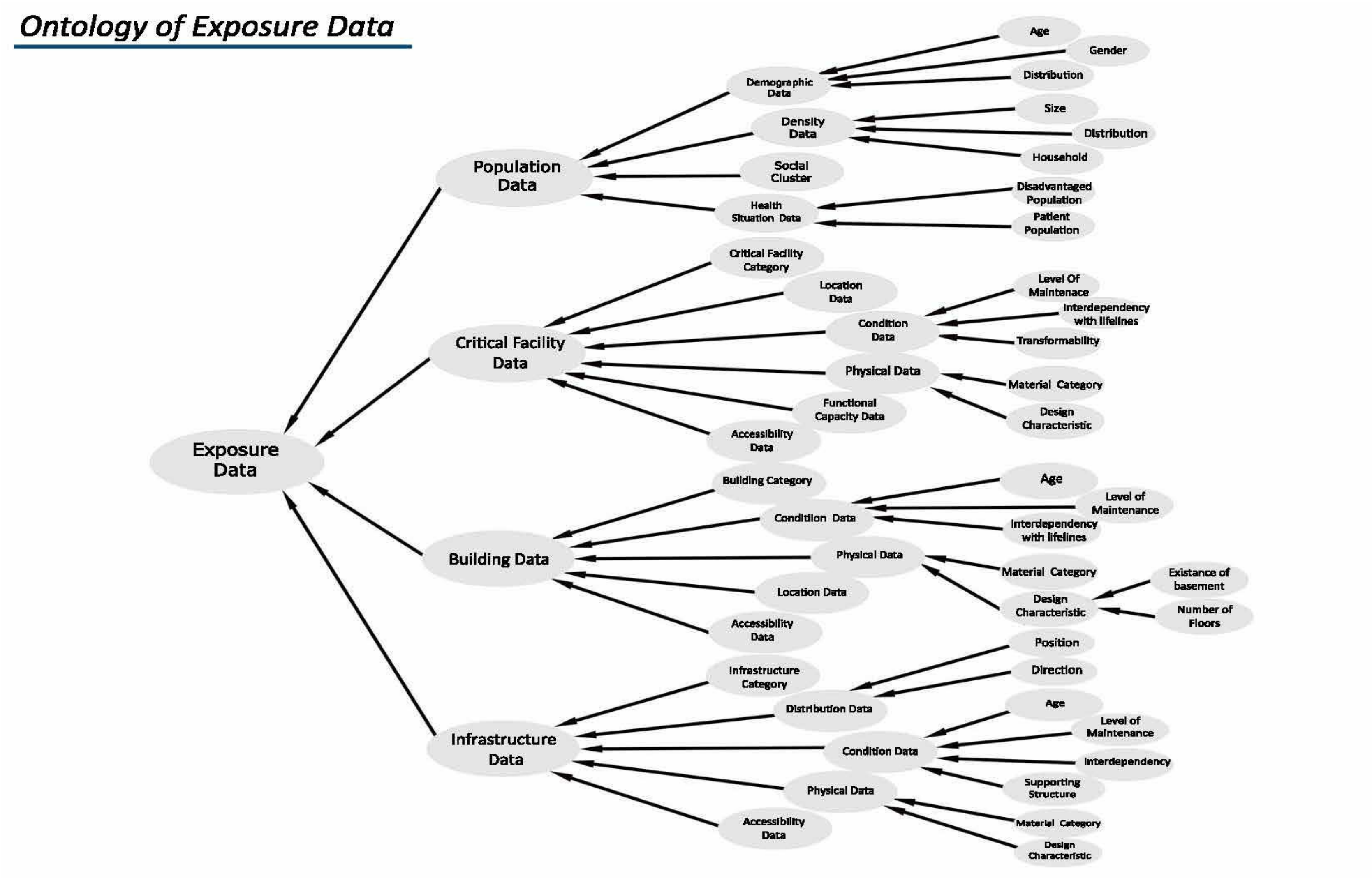


Appendix 3 Taxonomy of Hazard Data

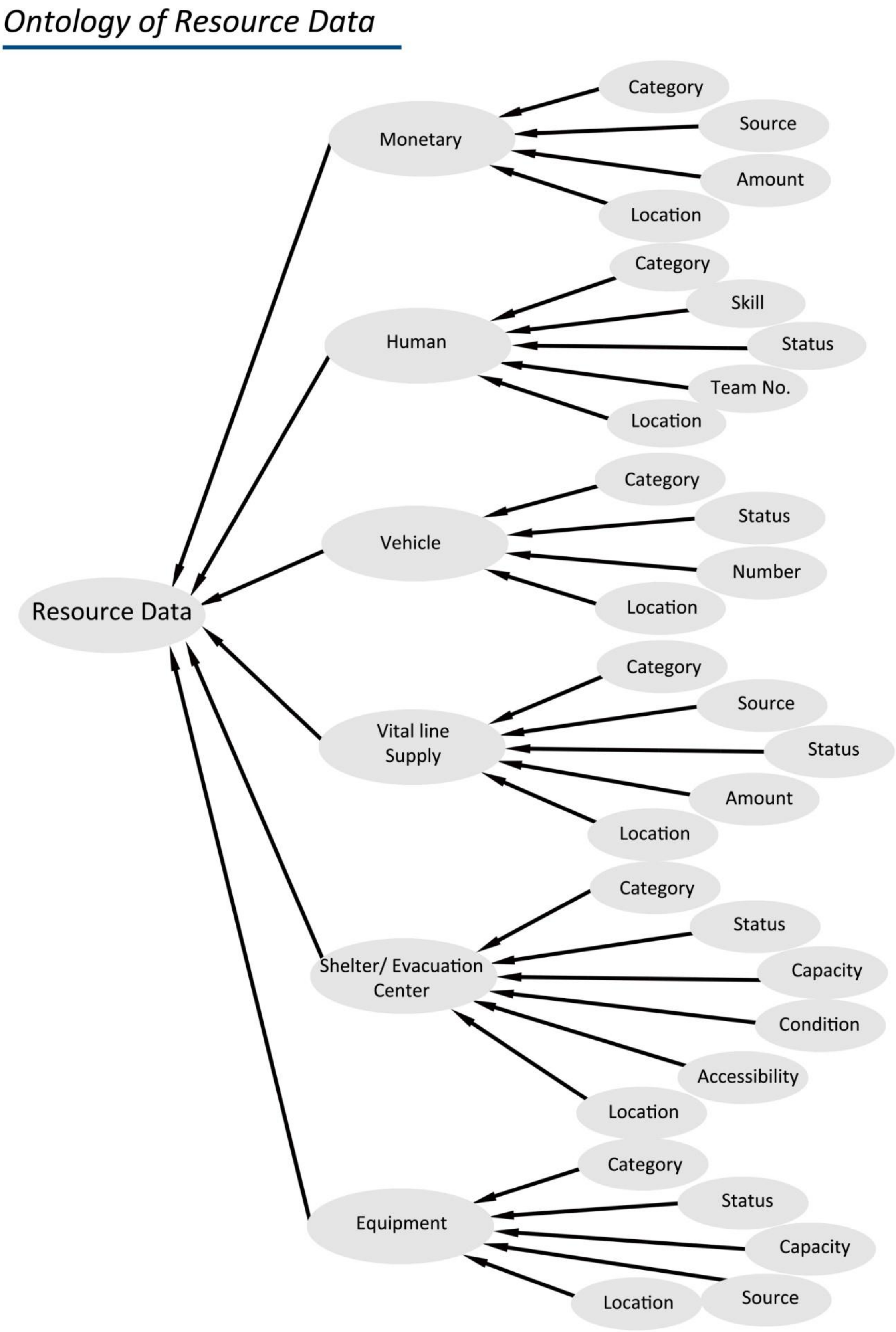


Appendix 4 Ontology of Emergency Management Data



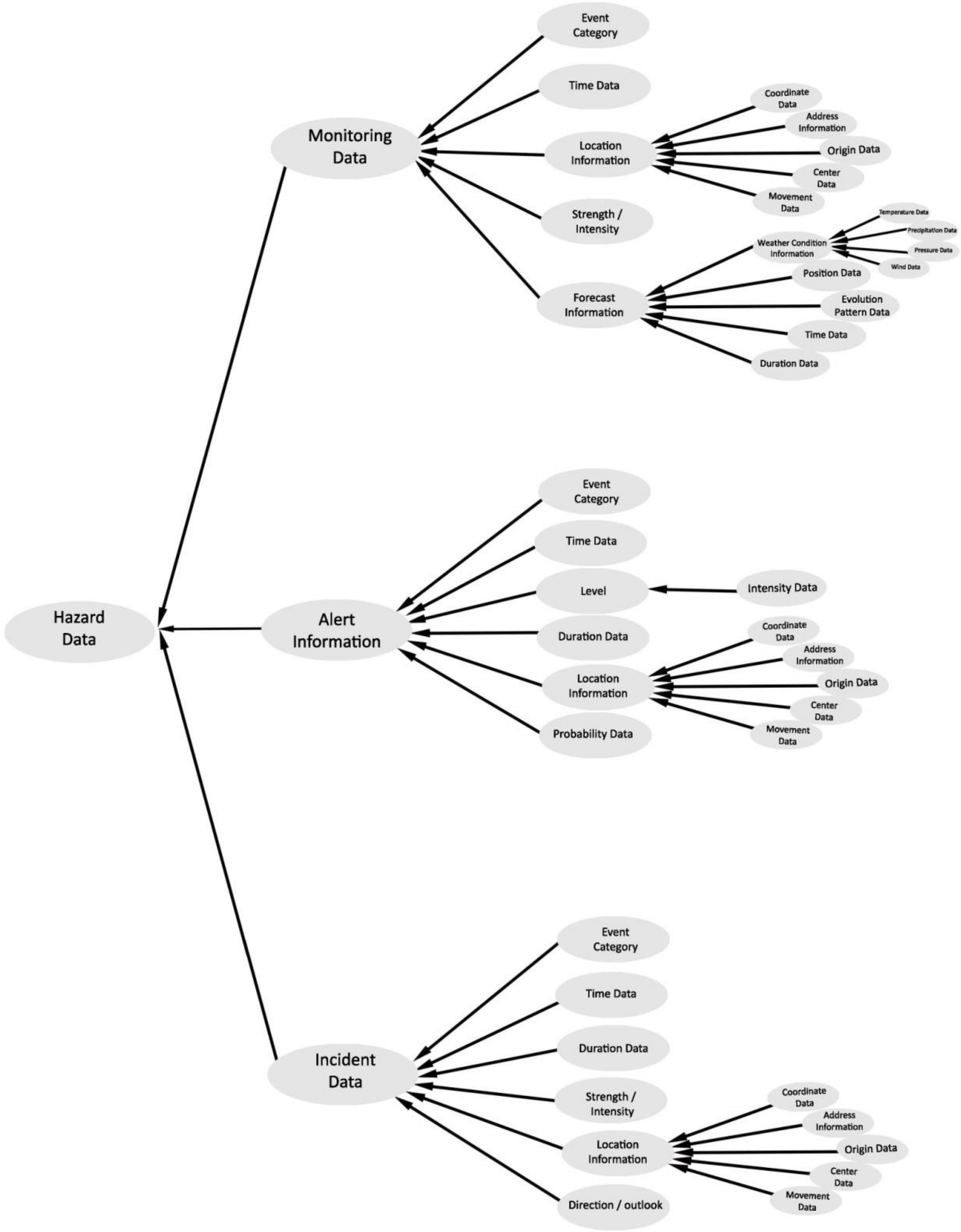


Appendix 5 Ontology of Exposure Data

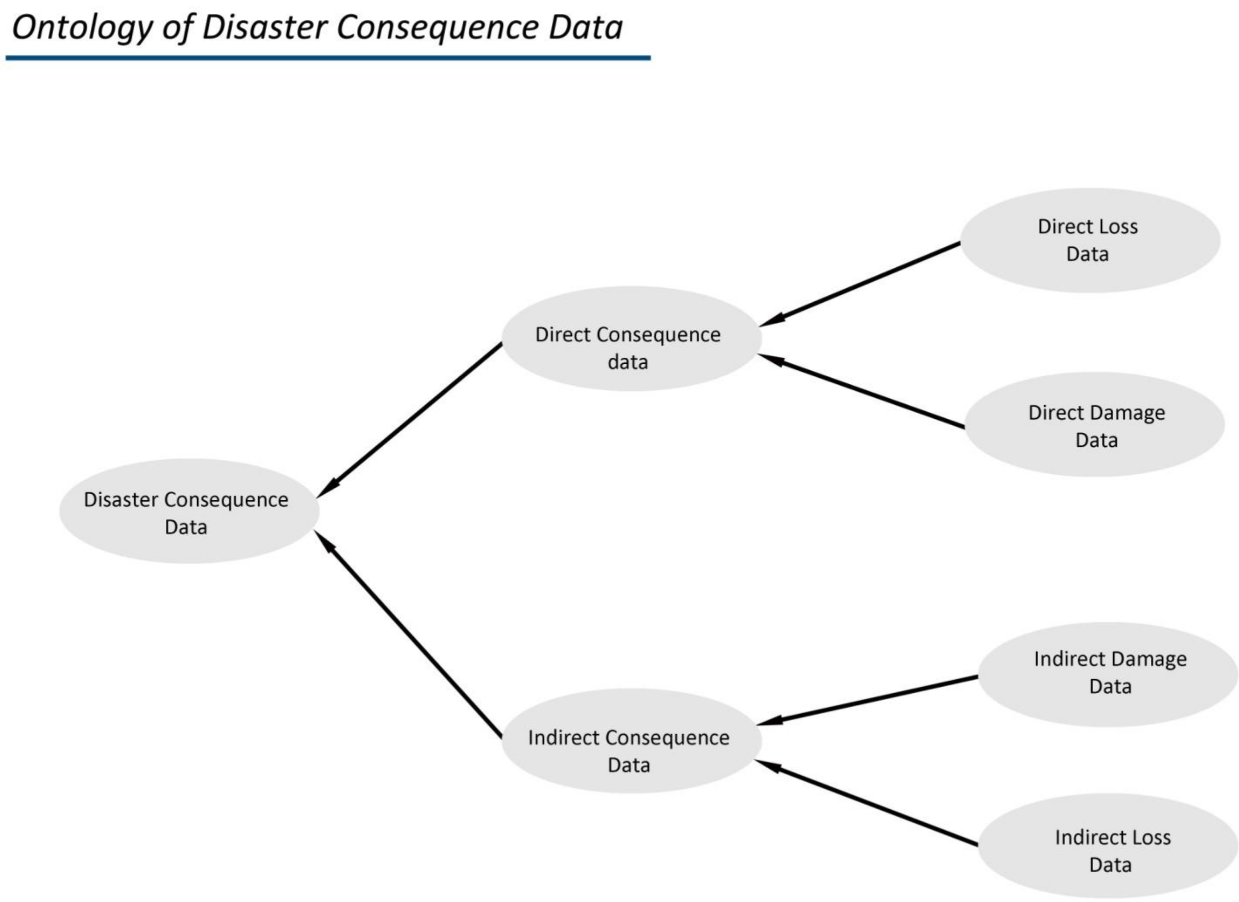


Appendix 6 Ontology of Resource Data

Ontology of Hazard Data

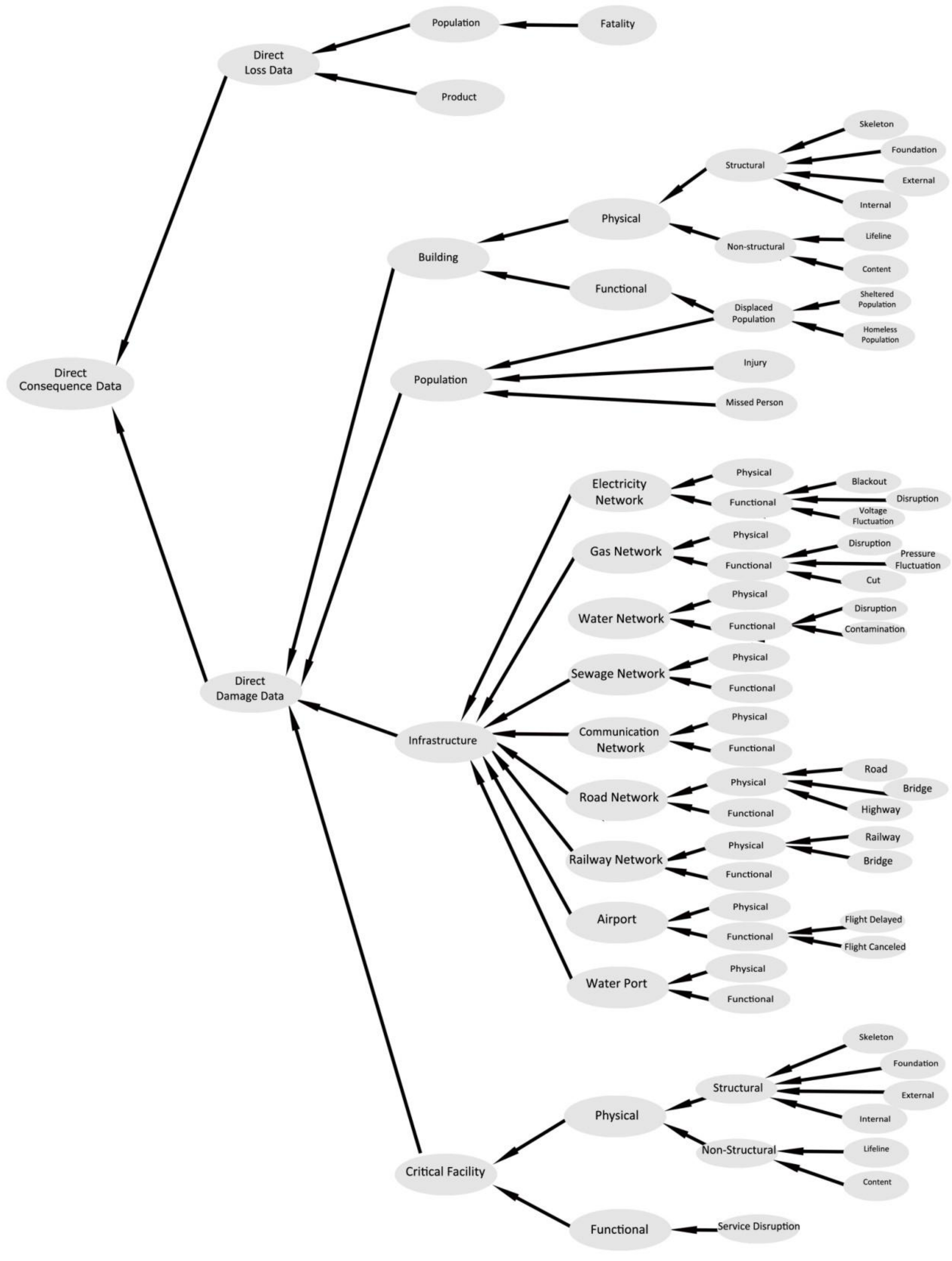


Appendix 7 Ontology of Hazard Data



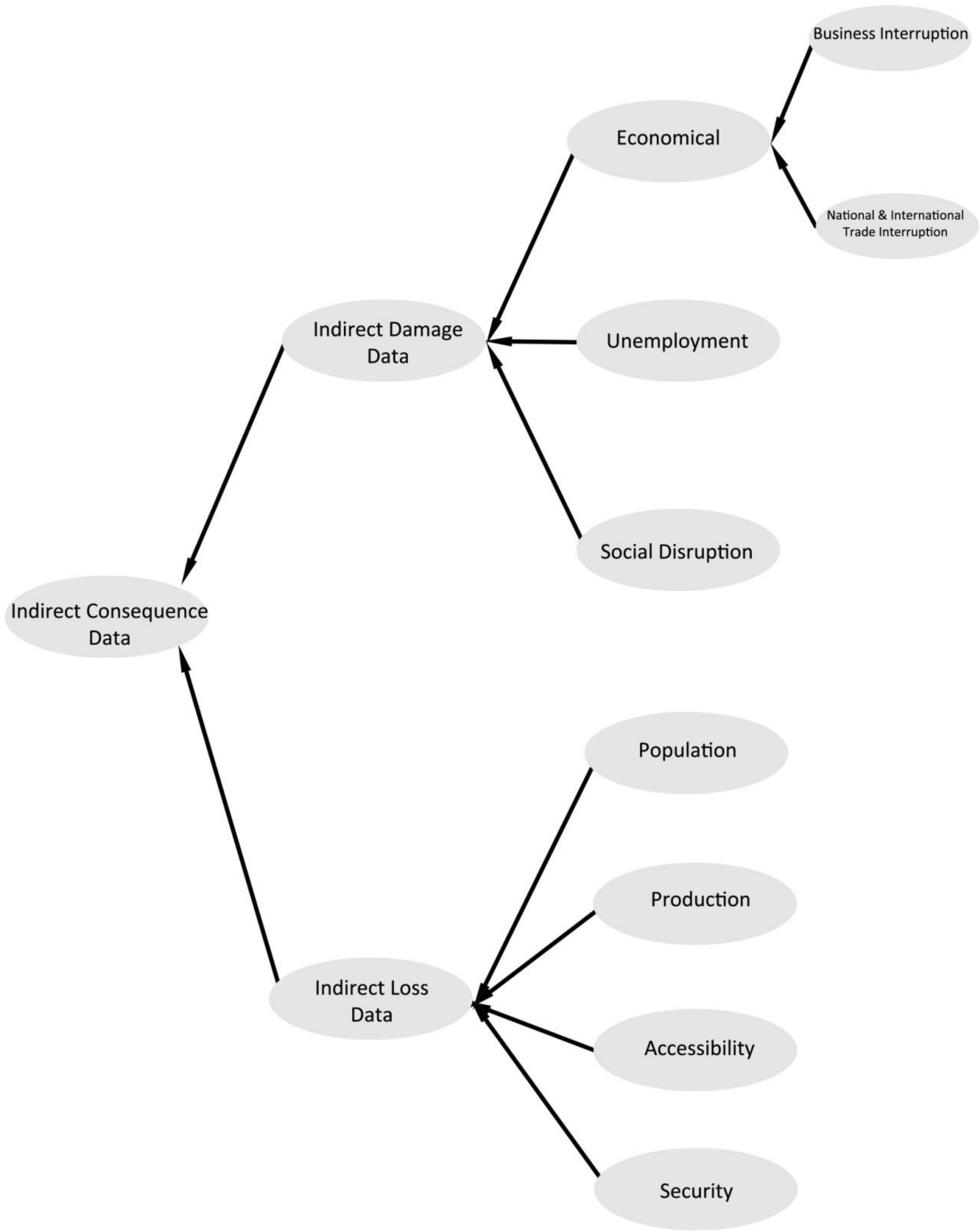
Appendix 8 Ontology of Disaster Consequence Data

Ontology of Direct Consequence Data

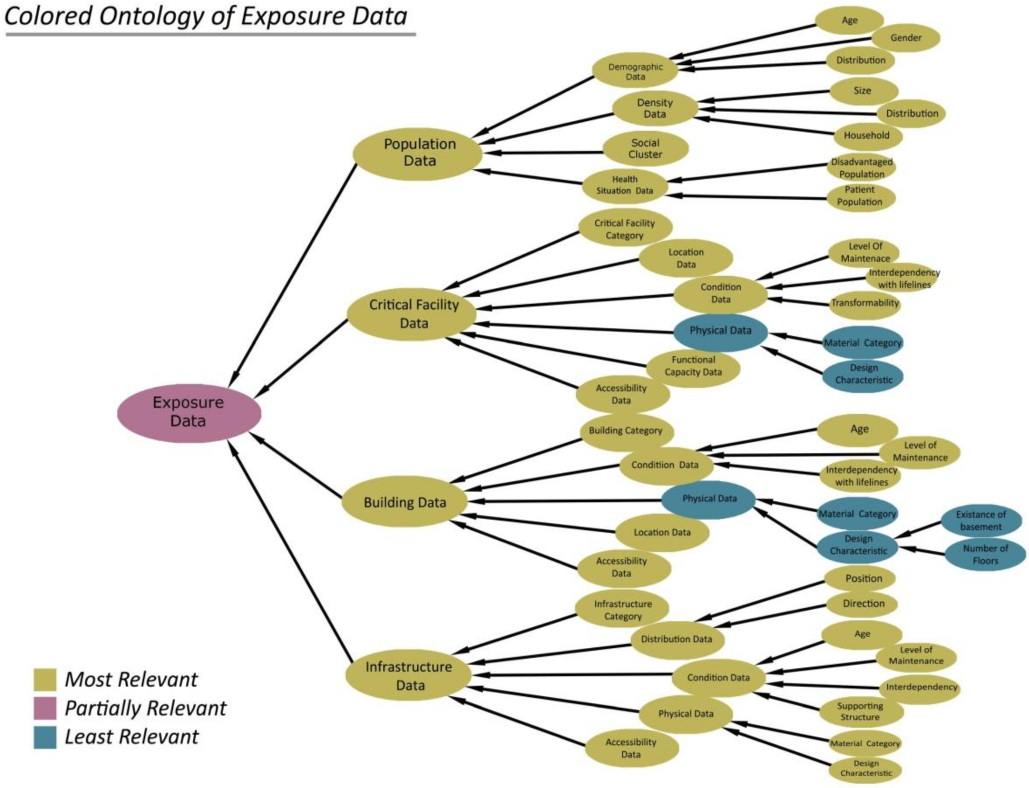


Appendix 9 Ontology of Direct Consequence Data

Ontology of Indirect Consequence Data

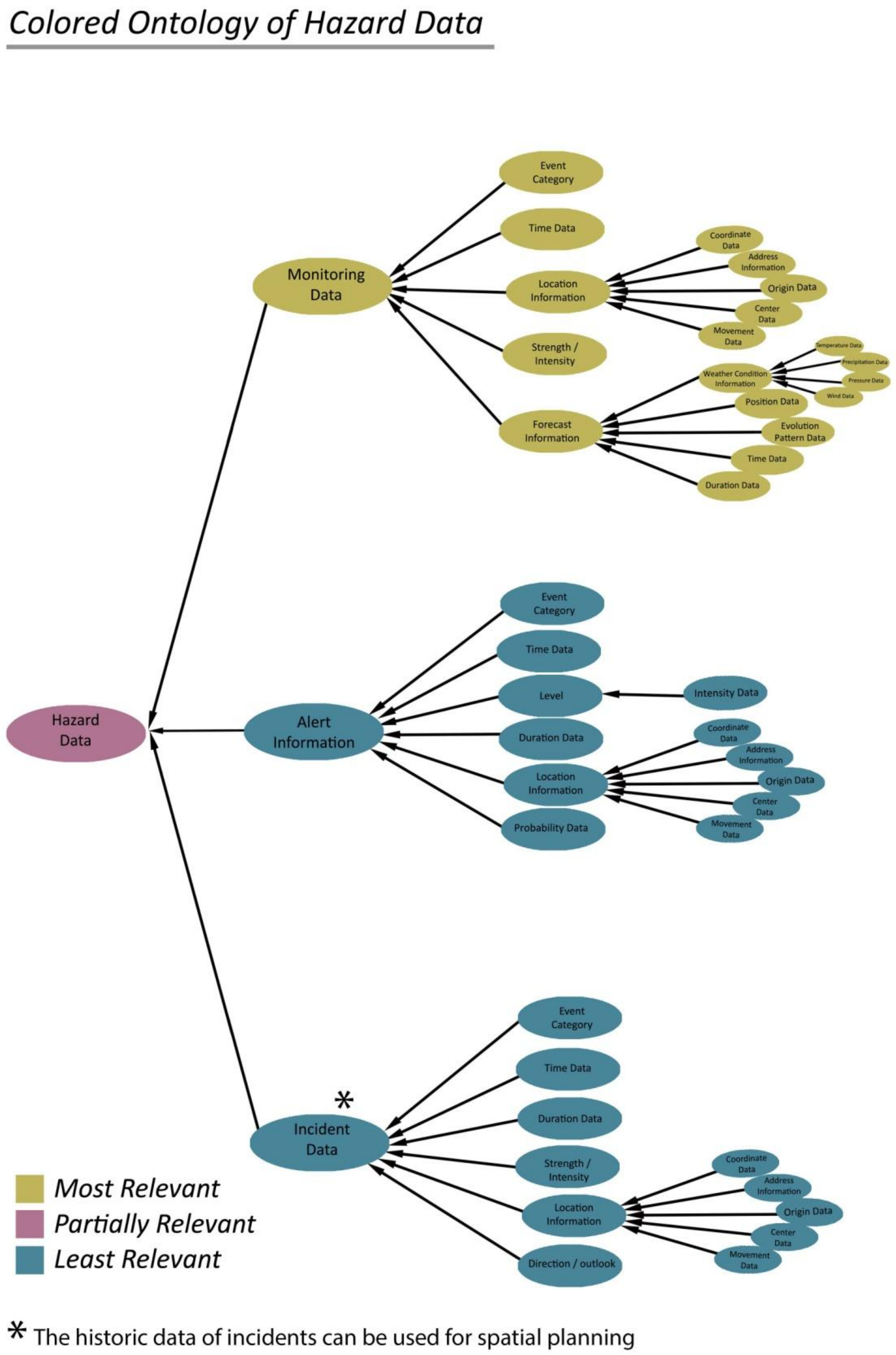


Appendix 10 Ontology of Indirect Consequence Data



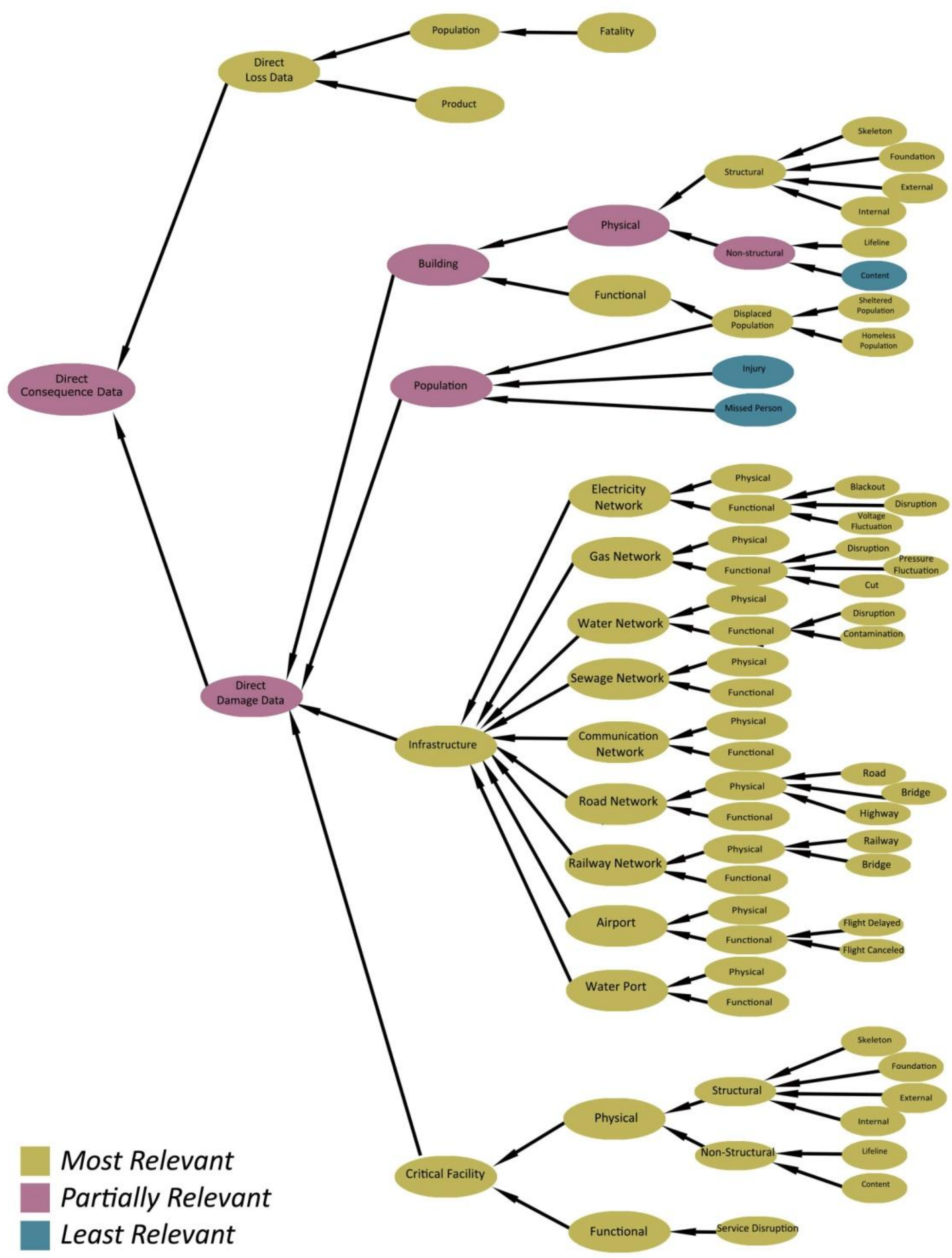
Appendix 11Coloured Ontology of Exposure Data Depicting Relevance to Spatial Planning

Appendix 12 Coloured Ontology of Resource Data Depicting Relevance to Spatial Planning

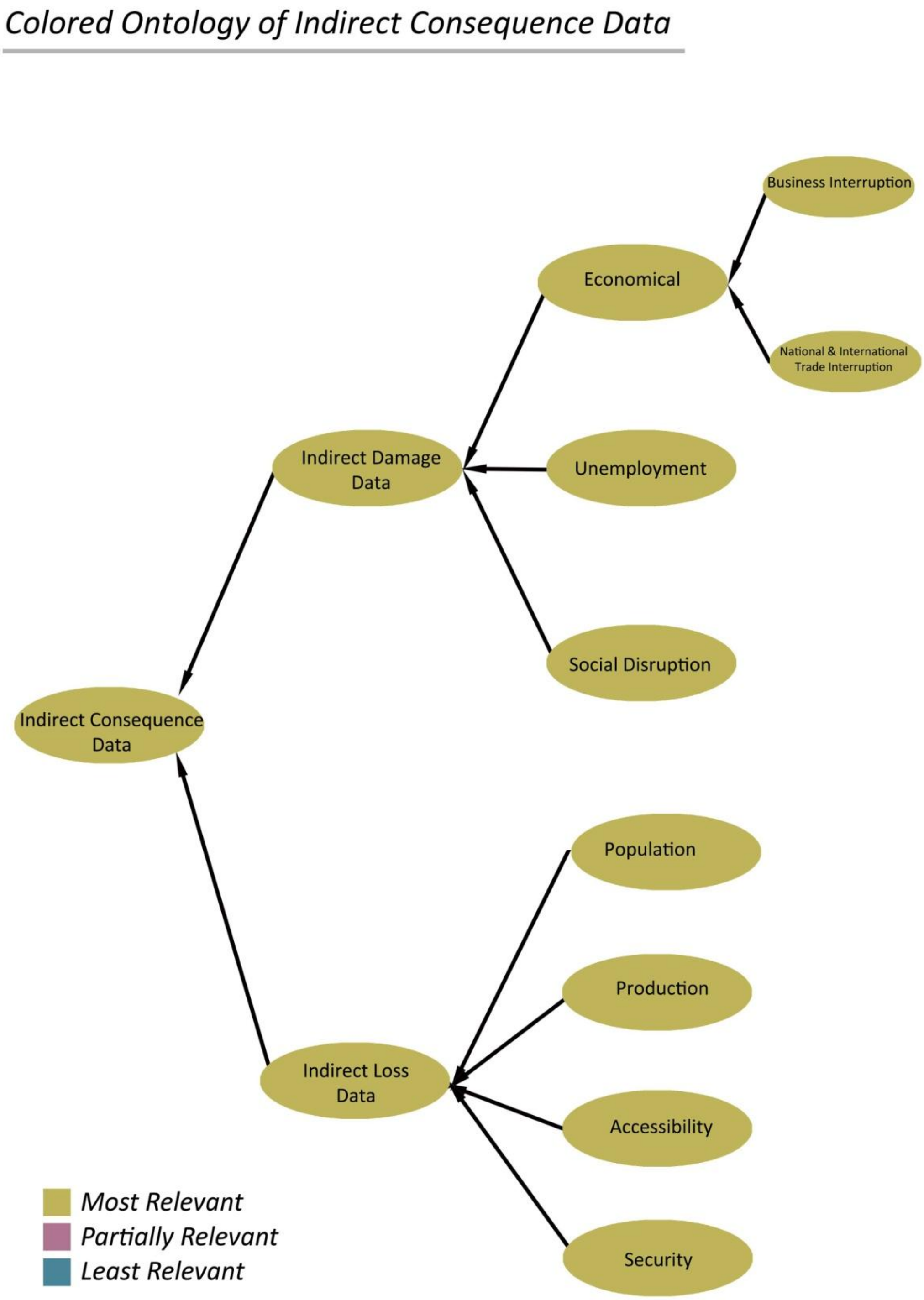


Appendix 13 Coloured Ontology of Hazard Data Depicting Relevance to Spatial Planning

Colored Ontology of Direct Consequence Data



Appendix 14 Coloured Ontology of Direct Consequence Data Depicting Relevance to Spatial Planning



Appendix 15 Coloured Ontology of Indirect Consequence Data Depicting Relevance to Spatial Planning

Appendix 16 VDD Sorting Table

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
									Context		Crisis		
				Volunteered Data	Traditional	Hazard	Exposure	Resource	Resource	Exposure	Hazard	Disaster Consequence	
Population distribution	Geographic Reference Map	Cebu North / Daanbantayan and Medellin Municipalities	Population Data (2010) AsiaPop		x		Population			Density Distribution			
			Vector Data (2013) GADM, OpenStreetMap				Infrastructure - Road Network			Primary Road Network			
			Center for Satellite Based Crisis Information (ZKI)				Infrastructure - Road Network			Secondary Road Network			
Damage Assessment Map	Geographic Reference Map	Cebu North / Medelline Municipality- Bogo City - San Remigio	Center for Satellite Based Crisis Information (ZKI)	This map is a result of shared mapping between SERTIT and DLR/ZKI emergency response teams	x		Building					Direct Damage-Physical	Detailed damage assessment has been conducted by visual interpretation of post-event Pleiades satellite data acquired on 14th Nov. 2013. Counts of damaged buildings are aggregated on a 500m grid. In areas with cloud coverage damage values are likely
			Pleiades satellite image (2013) CNES/SPOT				Infrastructure - Road Network			Primary Road Network			
			Vector Data (2013) DLR/ZKI, SERTIT, OpenStreetMap, USGS2000				Infrastructure - Road Network			Secondary Road Network			
							Critical Facility - Hospital			Location			
							Critical Facility - School			Location			
							Critical Facility - Gas station			Location			

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
				Volunteered Data	Traditional	Hazard	Exposure	Resource	Context		Crisis		
									Resource	Exposure	Hazard	Disaster Consequence	
							Infrastructure - Seaport			Location			underestimated.
Damage Assessment Map	Geographic Reference Map	Cebu North / Daanbantayan Municipality	Center for Satellite Based Crisis Information (ZKI)	This map is a result of shared mapping between SERTIT and DLR/ZKI emergency response teams	x		Building					Direct Damage-Physical	Detailed damage assessment has been conducted by visual interpretation of post-event Pleiades satellite data acquired on 14th Nov. 2013. Counts of damaged buildings are aggregated on a 250m grid. In areas with cloud coverage damage values are likely underestimated.
			Pleiades satellite image (2013) CNES/SPOT				Infrastructure - Road Network			Primary Road Network		Direct Damage-Functional (Road Possibly Blocked)	
			Vector Data (2013) DLR/ZKI, SERTIT, OpenStreetMap, USGS2000				Infrastructure - Road Network			Secondary Road Network		Direct Damage-Functional	
							Critical Facility - Industrial plant			Location			
							Infrastructure - Seaport			Location			
Pre-event Situation	Geographic Reference Map	Cebu North, Bogo-San Remigio	RapidEye Imagery (2013) BlackBridge		x		Infrastructure - Road Network			Primary Road Network			The map shows the pre-event situation in the north of Cebu island.
			Vector Data (2013) OpenStreetMap				Infrastructure - Road Network			Secondary Road Network			
			Center for Satellite Based Crisis Information (ZKI)				Infrastructure - Seaport			Location			

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
									Context		Crisis		
				Volunteered Data	Traditional	Hazard	Exposure	Resource	Resource	Exposure	Hazard	Disaster Consequence	
							Critical Facility - Hospital	Medical Center		Location			
							Critical Facility - School			Location			
							Critical Facility - Police Station	Police Station	Location	Location			
							Critical Facility - Fire Station	Fire Station	Location	Location			
Situation Map	Static Map	Philippines-Vietnam	European Union (2013)		x	Natural-Rainfall	Population				Monitoring-Intensity-Location-Time	Direct Loss- Fatality	
						Natural-Other Geologic/Hydrologic-Landfall		Evacuation Center	Location-Quantity per Province		Incident-Location-Time	Direct Damage-Injured-Displaced	
						Natural-Hydrologic-Storm surge/Flash Flood					Alert-Location-Level		
							Infrastructure - Airport				Incident-Location-Intensity	Direct Damage-Functional	Flight Cancelled
						Natural-Atmospheric-Typhoon	Infrastructure-Electricity Network				Monitoring-Strength-Forecast	Direct Damage-Functional	power outage
							Infrastructure-Communication Network				Alert-Location-Level-Time	Direct Damage-Functional	Disruption Communication
											Incident-Location-Strength-Time-Direction		
Municipality Boundaries Map	Static Map	Iloilo	International Federation Of Red Cross		x		Municipality			Location			Only fore Internal use of IFRC- Base Map

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
									Context		Crisis		
				Volunteered Data	Traditional	Hazard	Exposure	Resource	Resource	Exposure	Hazard	Disaster Consequence	
Terrain Map	Static Map	Cebu North	(IFRC)		x		Municipality			Location			from Openstreetmap
Terrain Map	Static Map	Leyte			x		Municipality			Location			
Landslide Susceptibility	Static Map	Artuz Quadrangle/ Barotac Viejo / Gigantes Islands / Iloilo Quadrangle / Tigbauan	Mines and Geosciences Bureau		x	Natural-Other Geologic/Hydrologic-Landslide	Infrastructure - Road Network			Location	Monitoring-Susceptibility-Location		This map Doesn't include in crisis information but it can considered in long term monitoring
Landslide & Flood Susceptibility	Static Map	Philippines			x	Natural-Other Geologic/Hydrologic-Landslide/Flood	Infrastructure - Road Network			Location	Monitoring-Susceptibility-Location		
Flood Susceptibility	Static Map	Tacloban			x	Natural-Hydrologic-Flood	Infrastructure - Road Network			Location	Monitoring-Susceptibility-Location		
Estimated Economic Impact	Static Map	Philippines	Pacific Disaster Center		x		Infrastructure					Direct Damage	Total cost of Damaged Infrastructure and Agriculture by Typhoon based on report NDRRMC
							Agriculture					Direct Damage	
Number Of Damaged Houses	Static Map				x		Population			Density Distribution			This map depicts the number of houses destroyed or partially damaged by
							Building					Direct Damage	

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
				Volunteered Data	Traditional	Hazard	Exposure	Resource	Context		Crisis		
									Resource	Exposure	Hazard	Disaster Consequence	
													Typhoon based on Report NDRRMC
REACH Rapid Assessment	Static Map	Philippine	REACH		x	Natural-Atmospheric-Typhoon	Municipality			Distance from Hazard	Incident-Location/Path		
Emergency Shelter Distribution	Static Map	Philippine					Population	Shelter	Capacity per municipality			Direct Damage-Displaced-Sheltered/Homeless	
							Building					Direct Damage-Functional	
Distance from Typhoon Path and Population	Static Map	Philippine				Natural-Atmospheric-Typhoon	Population			Density Distribution/Distance from Hazard	Incident-Location/Path		
Distance from Typhoon Path and Poverty Rate	Static Map	Philippine				Natural-Atmospheric-Typhoon	Population			Poverty distribution/Distance From Hazard	Incident-Location/Path		
Infrastructure	Static Map	North Iloilo and Capiz	MapAction& OCHA		x		Infrastructure - Airport			Location			
							Infrastructure - Seaport			Location			
							Infrastructure - Road Network			Primary Road Network			
							Infrastructure - Road Network			Secondary Road Network			
Storm Surge & Medical	Static Map	Philippine			x	Natural-Atmospheric-Typhoon	Critical Facility - Hospital			Location	Incident-Location/Path		

File name	File type	Location	Source	Open data production categories		Taxonomy			Emergency Management Data Ontology				Remarks
				Volunteered Data	Traditional	Hazard	Exposure	Resource	Context		Crisis		
									Resource	Exposure	Hazard	Disaster Consequence	
Facilities						Natural-Hydrologic-Storm surge					Alert-Forecast-Level		
Population Density & Medical Facilities	Static Map	Philippine			x	Natural-Atmospheric-Typhoon	Critical Facility - Hospital Population			Location Density Distribution	Incident-Location/Path		
Infrastructure	Static Map	Guiuan			x		Infrastructure - Road Network Infrastructure - Airport Infrastructure - Seaport Infrastructure-Bridge			Road Networks Location Location Location		Direct Damage-Physical/Functional (Impassable roads)	
Evacuation Center	Static Map	Leyte			x	Natural-Atmospheric-Typhoon	Population	Evacuation Center	Location-Capacity		Incident-Location/Path	Affected population Distribution	

Appendix 17 Refined VDD Sorting Table

Document Name	Document Type					Area of Interest (Location of Incident or Event)	Source / Origin (Name of generator, producer, owner)	OD Prod.		EM Data Ontology																		Remarks / Other Details	Link to Document Location (if any)
										Context										Crisis									
										Exposure				Resource						Hazard			Disaster Consequence						
	Text	Image	Static Map	Georeferenced Map	Others (State file type)			Volunteered Data	Traditional	Population	Building	Critical Facility	Infrastructure	Human	Monetary	Vehicle	Vital Line	Shelter	Equipment	Monitoring	Alerts	Incidents	Direct Loss	Direct Damage	Indirect Loss	Indirect Damage		
Post disaster Rapid Needs Assessment	x					Iloilo	ADRA		x	x							x	x					x	x		x	Shelter, Water, Livelihood, Food	
HEARS PLUS Report	x		x			PH	DOH		x	x				x	x				x				x	x		x	Health	
Updated DOH Report on Typhoon Yolanda	x					PH	DOH		x																	x	Health	
Ground-truthing OSM Damage Assessment Review	x		x			PH	ACTED/ REACH/ American Red Cross		x															x			Accuracy check: Not reliable enough to utilize for damage analysis and recovery planning	http://americanredcross.github.io/OSM-Assessment/
Landslide & Flood Suscepti-bility			x			PH	MGB		x				x							x							Official map for validation use / Scale 1:50,000	
Storm Surge & Medical Facilities			x			PH	MapAction /OCHA		x			x									x	x					Scale 1: 50,000 (at A3)	http://www.mapaction.org/map-catalogue/maps.html?deployment_filter=224

Document Name	Document Type					Area of Interest (Location of Incident or Event)	Source / Origin (Name of generator, producer, owner)	OD Prod.		EM Data Ontology																	Remarks / Other Details	Link to Document Location (if any)
										Context										Crisis								
										Exposure				Resource						Hazard			Disaster Consequence					
	Text	Image	Static Map	Georeferenced Map	Others (State file type)			Volunteered Data	Traditional	Population	Building	Critical Facility	Infrastructure	Human	Monetary	Vehicle	Vital Line	Shelter	Equipment	Monitoring	Alerts	Incidents	Direct Loss	Direct Damage	Indirect Loss	Indirect Damage		
Population Density & Medical Facilities			x			PH	MapAction /OCHA		x	x		x										x					Scale 1: 50,000 (at A3)	http://www.mapaction.org/map-catalogue/maps.html?deployment_filter=224
Crisis Map				x		PH	GISCorps	x														x	x	x			Urgent need Tweets/ Info about needed resources not available resources.	http://giscorps.maps.arcgis.com
Google Crisis and Relief Map				x		PH	GISCorps	x				x	x		x		x	x		x		x						
Disaster Info Map				x		PH	Rappler	x														x	x	x	x	x	Reports on Flood, Damage or Rescue call out by public	http://www.rappler.com/
Tacloban Damage Assess-ment Report			x		Vector Files	PH	Copernicus		x															x			Scale 1:12,500	http://emergency.copernicus.eu/mapping/list-of-components/EMSR058
Various Land Use Maps			x			Tacloban	Tacloban City Government		x		x		x														Scale 1:25,000	
Flood Suscepti-bility Map			x			Tacloban	MGB		x				x							x							Official map for validation use / Scale 1:50,000	

Document Name	Document Type					Area of Interest (Location of Incident or Event)	Source / Origin (Name of generator, producer, owner)	OD Prod.		EM Data Ontology																	Remarks / Other Details	Link to Document Location (if any)
										Context										Crisis								
										Exposure				Resource						Hazard			Disaster Consequence					
	Text	Image	Static Map	Georeferenced Map	Others (State file type)			Volunteered Data	Traditional	Population	Building	Critical Facility	Infrastructure	Human	Monetary	Vehicle	Vital Line	Shelter	Equipment	Monitoring	Alerts	Incidents	Direct Loss	Direct Damage	Indirect Loss	Indirect Damage		
Tacloban Storm Surge Hazard Map			x			Tacloban	Tacloban LGU		x											x							Official map for validation use / Scale 1:17,000	
Landslide Hazard Map			x			Tacloban	Tacloban LGU		x											x							Official map for validation use / Scale 1:17,000	
Compre-hensiveLand Use Plan	x	x	x	x	Table/ Graph	Tacloban	Tacloban LGU		x	x	x	x	x							x								
Tacloban Infra-structure			x			Tacloban/ PH	Tacloban LGU		x				x															
Phils. Typhoon Haiyan/ Yolanda Map (Aggregated)				x			Harvard / World Map	x	x													x		x				http://worldmap.harvard.edu/maps/typhoon_haiyan

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