National Cyclone Risk Mitigation Project (NCRMP)

National Disaster Management Authority (NDMA)

Consulting Services for Hazard, Risk and Vulnerability Assessment for 13 states and UT's in India

Data Inventory and Data Review Report

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Submitted by

RMSI
A-8, Sector 16
Noida 201301, INDIA
Tel: +91-120-251-1102, 2101
Fax: +91-120-251-1109, 0963
www.rmsi.com

Contact: Pushpendra Johari
Team Lead
Email: pushpendra.johari@rmsi.com




For the attention of:

The Project Director
National Cyclone Risk Mitigation Project (NCRMP)
National Disaster Management Authority (NDMA)
A-Wing , 2nd Floor, Lok Nayak Bhawan,
Khan Market, New Delhi - 110 003

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2.0	23 Jan 2014	Sushil Gupta, Kishore Dhore, Ujjwal Sur, Indu Jain, Muralikrishna, Niva Srivastava, Dr. Murthy, U Mahadevan	Revised version with editorial changes
3.0	08 March 2014	Sushil Gupta, Kishore Dhore, Ujjwal Sur, Indu Jain, Muralikrishna, Niva Srivastava, Dr. Murthy, U Mahadevan	Revised version with update on data status as on today

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Abbreviations Used

Abbreviation	Expanded Form
CAPRA	Central American Probabilistic Risk Assessment
CGDI	Canadian Geospatial Data Infrastructure
CGWB	Central Ground Water Board
COI	Census of India
CPCB	Central Pollution Control Board
CWC	Central Water Commission
DEM	Digital Elevation Model
DRR	Disaster Risk Reduction
DSS	Decision Support System
ER	Entity Relationship
FEMA	Federal Emergency Management Agency
FGDC	Federal Geographic Data Committee
FSI	Forest Survey of India
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information System
GOI	Government of India
GSI	Geological Survey of India
HAZUS-MH	Hazards United States Multi-Hazards
IMD	India Metrological Department
INCOIS	Indian National Center for Ocean Information Services
INSPIRE	Infrastructure for Spatial Information in the European Community
ISO	International Standards Organization
ISRO	Indian Space Research Organization
JTWC	Joint Typhoon Warning Center
MHA	Ministry of Home Affairs
MnhPRA	Morocco Natural Hazard Probabilistic Risk Assessment
NATMO	National Atlas and Thematic Mapping Organization
NBSSLUP	National Bureau of soil survey and land use Planning
NCAER	National Council of Applied Economic Research
NCC	National Climate Centre
NCRMP	National Cyclone Risk Mitigation Project
NDMA	National Disaster Management Authority
NHO	National Hydrographic Office
NIRD	National Institution of Rural Development
NRSC	National Remote Sensing Center
NSDI	National Spatial Data Infrastructure
OGC	Open Geospatial Consortium
OGC	Open GIS Consortium
OSDMA	Odisha State Disaster Management Authority
OPTCL	Odisha Power Transmission Cooperation Limited

Abbreviation	Expanded Form
PacRIS	Pacific Risk Information Systems
PMU	Project Management Unit
RDBMS	Relational Database Management System
SMRC	SAARC Metrological Research Center
SRTM	Shuttle Radar Topography Mission
WGS	World Geodetic System
WRIS	Water Resources Information System

1 Introduction

1.1 Background

The Indian coast is highly vulnerable to natural hazards, particularly to severe cyclone and cyclone induced heavy rain and flooding. An estimated 40% of the total population lives within 100 km of the coast. India is taking initiatives to develop a proactive approach in integrating disaster mitigation in development planning.

The National Cyclone Risk Mitigation Project (NCRMP) is a pioneer project of the Ministry of Home Affairs (MHA), Government of India (GOI) and is being implemented through NDMA with the financial support of the World Bank. The aim of NCRMP is to create suitable physical infrastructure to mitigate/reduce the adverse effects of cyclones. Part of this involves the setting up of a web-based risk assessment system that will inform a risk management framework for decision makers in the States/UTs and the Central Government to take mitigation steps to protect the people and assets of the country.

This report, 'Data Inventory and Data Review Report' is the second deliverable of this project and provide the data availability/gap and state the proxy data propose to use for further analysis. Any limitation of using the proxy data is also mentioned.

1.2 Purpose of the Report

The objective of this report is to provide clarity on the data standards and explain the data collected that is available with various departments of the two pilot states and with key national organizations. The data inventory and gap analysis will help in providing the status on data availability, data gaps, and RMSI's proposition of using proxy data.

The main objectives of the report are to provide the following:

1. Details of the data collected for the two pilot States and their review
2. Data standards
3. Description of database structure and its update mechanism

1.3 Organization of this Report

The present report is organized into four sections. Each section further drills down to the details specifically required under this section.

1. Introduction (the present section): provides a brief background of the project and this report.
2. Status of data collected: presents the status of data that has been collected till date from various national and state organizations. RMSI has only considered data related to the two pilot states though data that is available at a national level for some variables, has also been mentioned. This section also provides what proxy data RMSI is proposing to use in the absence of specified data.
3. Data standards: This section provides data standard practices across the world and particularly in India. The section, along with the best practice review of geodatabase in risk assessment software, also details the National Spatial Data Infrastructure (NSDI) standards on metadata and the key mapping standards RMSI will be following as part of the project.
4. Database structure and updating mechanism: This section explains in detail the database structure, building relationship between different entities and how they are defined in the database. This section also provides details of data updating and maintenance mechanism both in terms of technical aspects as well as institutional aspects.

2 Status of Data Collected

The project team, with the help of Project Management Unit (PMU), NDMA initiated data collection from the national organizations and State departments of the two pilot States – Andhra Pradesh and Odisha. As the project needs data for 13 coastal States and UTs, it is appropriate to start the data collection from national organizations so that authentic data can be acquired for the entire study area.

The input data for hazard analysis includes historical data related to storm surge and flood due to cyclone rainfall hazards and climatic and physiographic data for the study area. Since both these datasets are available from single sources, the project team has collected the datasets for all the 13 States and UTs. However, since exposure data has to be collected from various concerned State departments, the project team has collected data only for the two pilot States as required by the ToR. Therefore, for exposure data, this report provides the status on the two pilot States only.

As the first step of the data inventory and collection exercise, the project team prepared a comprehensive list of data required (presented in the inception report) along with the possible sources. The output quality of the cyclone model and the Web GIS Atlas would solely depend on the quality of the input data provided in the data list. Hence, the team's first preference is to get high-resolution and latest vintage data (preferred data mentioned in the data list). However, in absence of high resolution data of recent vintage, alternate data sources have been also mentioned as a fall back mechanism. The present section explains the data availability, gaps in detail and the proxy data we will be using for the further analysis. Through this report, we take concurrence of client in using the proxy data in the absence of the preferred data.

It is worth mentioning here that there have been certain delays and difficulties in procuring specific data, which will serve as critical inputs for model development. The delays and difficulties are attributable to the classified nature of data and/or the lack of precedence in involving private consulting firms in these kinds of projects.

The data collected till date is presented under two categories – input data related to hazard analysis and input data related to exposure development. These are the two key input data required for vulnerability and risk assessment.

2.1 Input Data for Hazard Analysis

The input data for hazard analysis presented below under two categories - input data for storm surge modeling and input data for flood modeling. The following sections (Section 2.1.1 and Section 2.1.2) detail the hazard data collected, their sources, description and data gaps associated with them.

2.1.1 Data Input For Storm Surge Modeling

In order to achieve greater confidence in numerical surge prediction along the Indian coasts, one requires good quality data inputs on a number of parameters for the model. These parameters include oceanographic, hydrographic, and meteorological parameters, along with basin characteristics, coastal geometry, wind stress, and information on astronomical tides. Meteorological inputs are mainly concerned with the characteristics of tropical storm. The main characteristics are pressure drop, maximum sustained winds, the radius of maximum winds, vector motion of the storm, point of landfall, and duration of the storm. In addition, the accuracy of surge heights along the coast depends heavily on the quality of the bathymetry data and the coastal DEM data.

Deterministic scenario generations require a cyclone track and intensity database that spans a long time-period of more than 100 years. The status of data availability related to surge modeling is given in the table below.

Table 2-1: Data availability for storm surge modeling

S. No.	Thematic data	Data Source	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
1	Historical cyclone track data	IMD	There are 3 sources of cyclone track data available with IMD. 1) Cyclone track and intensity data for (1877-2012) (Partially available in Public Domain) 2) CD version (2008 ed.) of cyclone track data is available only for 1891-2007. (Not in Public Domain but is available with RMSI) 3) IMD website has cyclone track data for (1990- 2012) at six hourly intervals. (In Public Domain)	The Cyclone tracks data for (1877-1890) are not available either on IMD website or on CD.	Cyclone track data for 1891-2007 (provided by IMD in CD 2008 ed.), will be used. The three reports provided by IMD do not have adequate intensity information to incorporate in the cyclone model to be developed. RMSI will use the data of International Best Track Archive for Climate Stewardship (IBTrACS) at six hourly intervals for missing parameters.
2	Historical cyclone intensity data (Pressure drops and Maximum sustained winds)	IMD	1) IMD website has cyclone intensity data for (1990-2012) at six hourly intervals.	Cyclone intensity data (pressure drop and maximum sustained winds) for the period 1877-1989 is missing.	RMSI will use maximum sustained wind data of IBTrACS. To derive pressure drop, wind-pressure relationship will be used
3	Surge height, extent of inundation and water levels	IMD, SMRC report (1998), published reports and research publications available in public domain	Several reports on cyclonic disturbances over North Indian Ocean are available on IMD	No data gaps	Reports of IMD, SMRC report (1998), published literature and research publications available in public domain will be

S. No.	Thematic data	Data Source	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
			website since 2007. Besides this, many research publications are also available in public domain		used.
4	Bathymetry	NHO, NRSC, and INCOIS	So far, we have received data from INCOIS, which is GEBCO_08 grid data of 1km x 1km resolution in ASCII and NetCDF format. This data set is also available in public domain	High-resolution coastal bathymetry is very crucial for surge development. Gebco-08 can be used and has no data gaps.	NDMA has to procure these paper maps and provide to RMSI. RMSI will refine the GEBCO data for the shelf region using NHO bathymetric charts.
5	Land Topography (DEM)	NRSC		Not available so far	NRSC has agreed with NDMA to provide 10m DEM on chargeable basis.
6	Coastal-Geometry	SOI	For the entire country of 2011 vintage	No data gaps	RMSI will be using this data for storm surge modeling
7	Tidal data	SOI and Le Provost's tidal database	Tidal data for ports are available in Indian tidal table published by SOI. Global Le Provost's tidal data is available for open ocean at 50 km x 50 km resolution (in public domain)	No data gaps	The tidal data from Indian tidal table will be used for validation of tidal heights at coast generated by the model. Global Le Provost's tidal data will be used in the open ocean for storm surge modeling.

2.1.1.1 Elevation data comparison from various sources

National Remote Sensing Centre (NRSC) has developed DEM for the entire country from Cartosat satellite data, which is available in the public domain through the Bhuvan web site. The team has downloaded this data and carried out quality checks. Figure 2:1 to Figure 2:3 show the analyses results of the data available on Bhuvan.

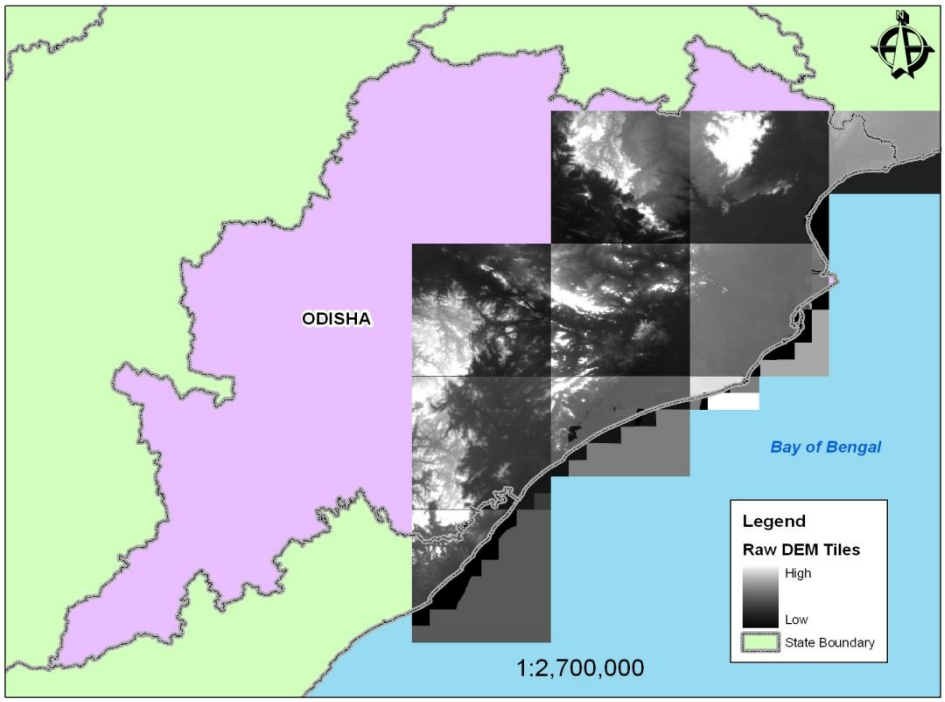

Figure 2:1: Downloaded Cartosat DEM Data from Bhuvan Site

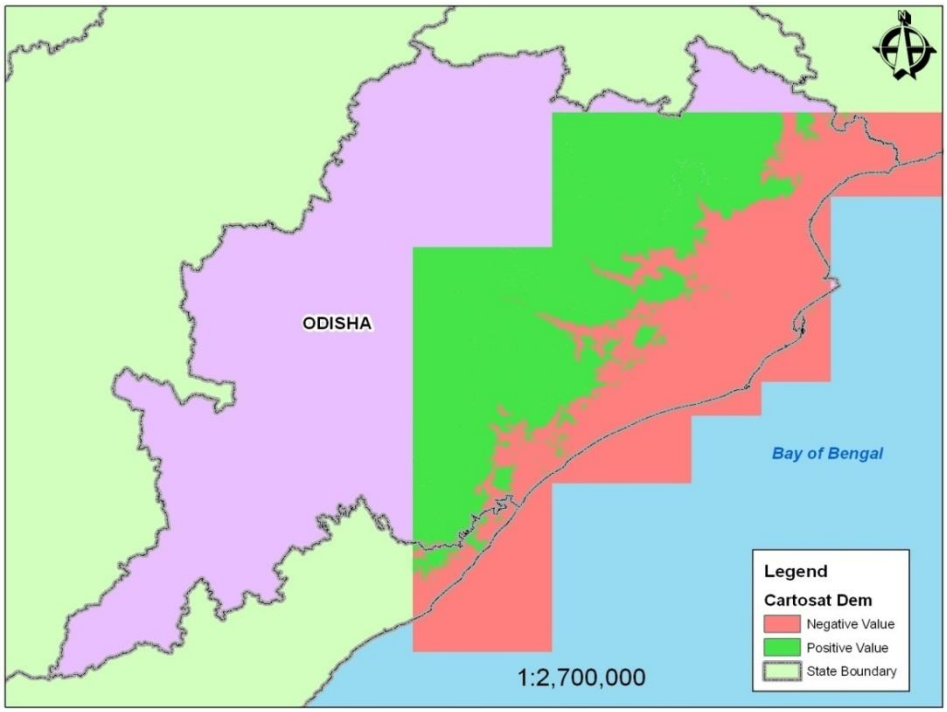

Figure 2:2: Classified Mosaic Cartosat DEM showing areas that come under Negative and Positive elevation values

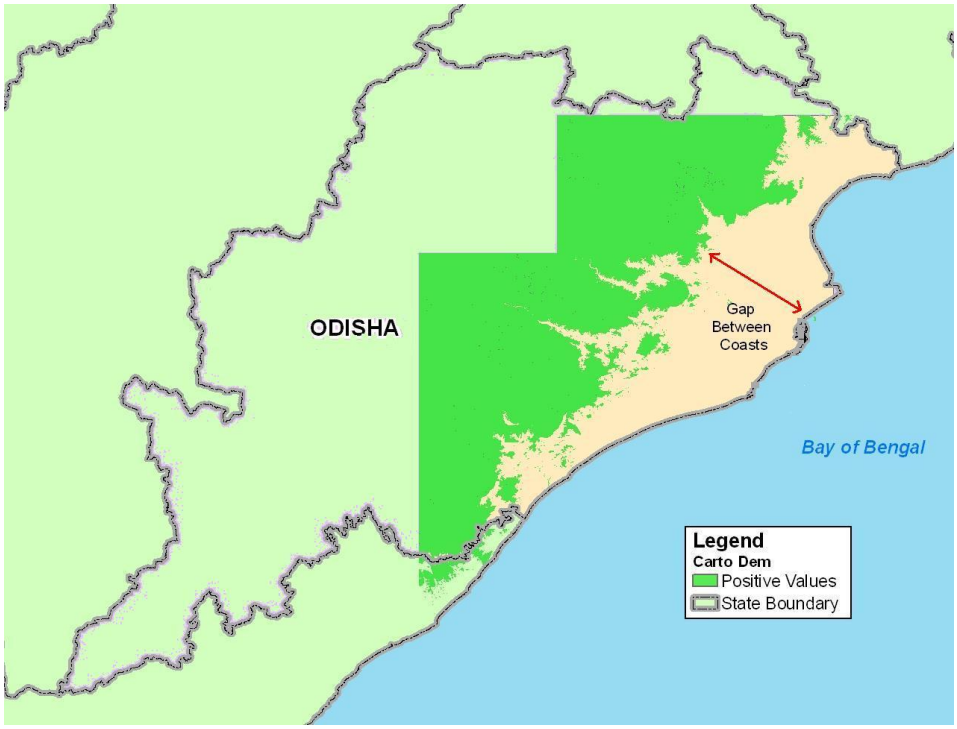

Figure 2:3: Data Gap in Cartosat based DEM and Actual Coast

The team also carried out an accuracy comparison of various DEM/Contour elevation data sources such as toposheet, SRTM, Google Earth, and cartosat images on Bhuvan. The summary of the analysis is provided in the Table 2-2. This data constraints has been presented to the NDMA and the WB team. Accordingly, NDMA and RMSI team had discussions with NRSC, which finally agreed to provide 10 m DEM on chargeable basis to NDMA.

Table 2-2: Elevation data comparison of various data sources

City	State	Geographic location		Elevation in meters						
		Longitude	Latitude	Toposheet Elevation (Spot/ triangulated height)	Google Elevation	SRTM Height	Cartosat Elevation	Difference between Toposheet & Google Earth	Difference between Toposheet & SRTM	Difference between Toposheet & Cartosat
Hyderabad	Andhra Pradesh	78°25'12.945"E	17°20'47.706"N	579	558	557	470	21	22	109
		78°28'2.644"E	17°19'53.824"N	574	582	586	486	-8	-12	88
		78°30'25.415"E	17°19'10.424"N	541	541	538	502	0	3	39
		78°34'16.231"E	17°16'7.678"N	548	548	541	477	0	7	71
		78°40'48.939"E	17°29'39.27"N	614	604	607	432	10	7	182
Nashik	Maharashtra	73°47'2.708"E	20°14'38.569"N	715	672	683	608	43	32	107
		73°49'57.489"E	20°14'28.275"N	652	634	640	573	18	12	79
		73°59'41.825"E	20°14'23.368"N	698	643	635	577	55	63	121
		73°59'31.664"E	20°6'45.368"N	582	581	580	518	1	2	64
		73°46'40.964"E	20°0'20.3"N	583	581	584	520	2	-1	63
		73°47'9.866"E	19°53'48.298"N	775	717	682	625	58	93	150

City	State	Geographic location		Elevation in meters						
		Longitude	Latitude	Toposheet Elevation (Spot/ triangulated height)	Google Elevation	SRTM Height	Cartosat Elevation	Difference between Toposheet & Google Earth	Difference between Toposheet & SRTM	Difference between Toposheet & Cartosat
		73°57'59.39"E	19°53'58.828"N	696	669	668	606	27	28	90
		73°59'32.695"E	19°45'41.381"N	970	958	938	870	12	32	100
		73°45'48.462"E	19°46'53.49"N	662	640	636	571	22	26	91
Madurai	Tamilnadu	78°2'3.932"E	9°56'39.617"N	343	324	318	159	19	25	184
		78°12'32.746"E	9°58'52.675"N	250	194	181	94	56	69	156
		78°7'33.108"E	9°54'28.115"N	135	133	135	49	2	0	86
		78°14'37.995"E	9°46'38.705"N	104	102	104	11	2	0	93
Tiruchirapalli	Tamilnadu	78°31'5.905"E	10°57'49.338"N	96	93	90	2	3	6	94
		78°44'10.694"E	10°56'49.312"N	102	92	93	4	10	9	98
		78°42'54.093"E	10°45'57.454"N	85	87	87	-5	-2	-2	90
		78°39'12.163"E	10°45'16.527"N	82	81	81	-11	1	1	93
Vellore	Tamilnadu	79°0'43.917"E	12°58'35.868"N	398	367	345	297	31	53	101
		79°12'16.957"E	12°59'47.053"N	331	310	291	173	21	40	158
		79°12'26.869"E	12°45'44.566"N	475	436	411	187	39	64	288
		79°0'27.744"E	12°45'42.538"N	781	753	703	689	28	78	92
		79°8'47.836"E	12°54'58.398"N	467	442	417	238	25	50	229
Mean elevation difference from toposheet								18.4	26.2	115.4

2.1.2 INPUT DATA FOR FLOOD MODELING

High-resolution daily gridded rainfall data sets for the Indian region have been procured from the National Climate Centre (NCC), India Meteorological Department, Pune. These datasets are available for the period of 1901-2007 on a daily basis at one-degree grid resolution. The data are interpolated using quality controlled station rainfall data. The data is consistent and is of high quality with no gaps found.

Table 2-3: Rainfall and river flow data for flood modeling

S. No.	Thematic data	Data Source	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
1	Rainfall data	NCD, IMD Pune	Data available in binary and ascii format from 1901-2007	No data gap	Use this data for hydrological modeling
2	River flow/discharge data	India Water Resources Information System (WRIS) website (CWC)	Mean Gauge m), Discharge (cumec) - observed/computed Period 1965-2012	Kasai, Hoogly, Damodar (of Ganga) and Ganga (above Kolkata)not available as this is classified data	NDMA request is under consideration and CWC may release this data in a month's time

Table 2-4: List of flow gauge stations and flow data availability period

Sr. No	Station	Start Year	End Year
1	Addoor	1998	2012
2	Adityapur	1971	2013
3	Ananadpur	1972	2012
4	Arangaly	1978	2012
5	Arcot	1979	2011
6	Ashramam	1996	2012
7	Avarankuppam	1978	2012
8	Avershe	1998	2012
9	Ayilam	1978	2012
10	Badlapur	1981	2012
11	Bantwal	1970	2012
12	Bhadrachalam	2007	2012
13	Chengalpet	1977	2012
14	Chennur	1989	2012
15	Derol Bridge	1980	2012
16	Durvesh	1971	2012
17	Erinjipuzha	1984	2012
18	Gadat	1979	2012
19	Ganod	1970	2011
20	Garudeshwar	1972	2012
21	Ghala	1977	2012
22	Ghatsila	1971	2013
23	Govindpur (NH5 Road Bridge)	1978	2013
24	Haladi	1984	2012
25	Hathmati Weir	2003	2009
26	Hoshangabad	1972	2012
27	Irrukkankudi	1989	2012
28	Jamshedpur	1972	2013
29	Jenapur	1979	2012
30	Kallooppara	1985	2012
31	Karathodu	1985	2012
32	Kashinagar	1971	2013
33	Keesara	1965	2012
34	Khanpur	1978	2012
35	Kidangoor	1985	2012
36	Kolad	1996	2006

Sr. No	Station	Start Year	End Year
37	Konta	1964	2012
38	Kudalaiyathur	1991	2011
39	Kumarapalayam	1999	2011
40	Kumbidi	1978	2011
41	Kuniyil	1978	2011
42	Kuttyadi	1996	2011
43	Kuzhithurai	1998	2011
44	Lowara	1970	2012
45	Mahuwa	1970	2012
46	Malakkara	1984	2012
47	Mangaon	1980	2011
48	Motinaroli	1990	2012
49	Murappanadu	1977	2012
50	Muri	1988	2013
51	Musiri	1971	2012
52	Naidupet	1977	2011
53	Neeleswaram	1971	2011
54	Nellore	1987	2012
55	Padmavati	1979	2012
56	Panposh	1972	2012
57	Paramakudi	1971	2011
58	Pattazhy	1978	2012
59	Pen	1996	2012
60	Perumannu	1984	2012
61	Perur	1965	2012
62	Pingalwada	1989	2012
63	Polavaram	1965	2012
64	Pulamanthole	1985	2012
65	Purushottampur	1978	2013
66	Ramamangalam	1978	2012
67	Santeguli	1988	2012
68	Srikakulam	1988	2013
69	Sulurpet	1988	2012
70	Thammavaram	1977	2012
71	Thumpamon	1977	2012
72	Tikarapara	1971	2012
73	Tilga	1978	2012

Sr. No	Station	Start Year	End Year
74	Vautha	1999	2012
75	Vijayawada	1965	2012
76	Villupuram	1971	2012
77	Wadenapalli	1965	2012
78	Yennehole	1989	2012

2.2 Exposure Data

Exposure is a critical component of any risk model. Exposure data constitutes data related to demography, the built environment, systems that support infrastructure and livelihood functions, or other elements present in the study area that can thereby be subjected to potential losses.

The development of the exposure database includes the organization and categorization of the different elements at risk. For example, the population in the hazard zone can be categorized by age, gender, education, and occupation; and buildings in which they live and the infrastructural facilities can be categorized by their line of business (occupancy), construction material, structural type, age, and height.

The subsections below provide the status on collection of exposure data for the two pilot States under consideration – Andhra Pradesh and Odisha.

2.2.1 ANDHRA PRADESH

Table 2-5: Exposure data status for Andhra Pradesh

S. No.	Data Category	Data Sources	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
Administration and demographic data					
1	Administrative boundaries	Survey of India (SOI)	Contains boundary information for 2008 received as GIS shape file. The attributes include State, district, taluka/Mandal and village boundaries and names	Boundary bifurcation of villages after 2008 is not available. For Urban areas, Ward level boundaries are not available	SOI agreed to provide this data, except Ward boundary data. Ward boundary data will be collected from respective municipalities for hot-spot locations.
2	Demographic data	Census of India	Village/Ward level demographic details like gender, caste, age and occupation are available (Census, 2011)	No gap in data	RMSI will use this data
3	Housing data	Census of India	Details include structure type, amenities at district level (Census, 2011)		NDMA is procuring Ward and Village level household data from Census of India.
Essential facilities					

S. No.	Data Category	Data Sources	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
4	Schools	Andhra Pradesh Education Department	Data not received	Not Available (NA)	SOI agreed to provide spatial data Received school information in tabular form at district level. RMSI will combine these two data.
5	Health facilities	Andhra Pradesh Health Department	Data not received	NA	Andhra Pradesh Health Department agreed to provide tabular data in health institutions. SOI has agreed to provide location information
6	Safe shelters	Andhra Pradesh Revenue and Disaster Management Department	Data not received	NA	Andhra Pradesh Revenue and Disaster Management Department agreed to provide this data.
7	Police stations	Andhra Pradesh Police Department	Data not received	NA	SOI has agreed to provide spatial data Andhra Pradesh Police Department agreed to provide this data
8	Fire stations	Andhra Pradesh State Fire Department	Fire station locations and asset information is available for 2011	No gaps in the data	RMSI will use this data
9	Post offices	Postal Department	Data not received	NA	SOI has agreed to provide spatial data
Public buildings					
10	Government offices	Various Government Departments	Data not received	NA	SOI has agreed to provide location information but the building specific information not available
11	Cultural heritage	Department of Tourism of Andhra Pradesh	Data not received	NA	SOI has agreed to provide spatial data. Attribute information will be gathered from Archeological and tourism web sites
Religious buildings					

S. No.	Data Category	Data Sources	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
12	Places of Worship	Department of Tourism	Number of units at district level available for 2011	Attribute information including geographic coordinates, construction material, size, etc. are not available	SOI has agreed to provide location information
Utilities					
13	Electric Power	Electricity Department	Data not received	NA	Approached AP TRANSCO several times but data not received
14	Potable Water	Public Works Department	Data not received	NA	Approached AP PWD, data not received
15	Waste Water	Public Works Department	Data not received	NA	Approached AP PWD, data not received
16	Communication Systems	Telecom Regulatory Authority	Data not received	NA	AP Telecom Regulatory Authority agreed to provide details of MTNL network. Other network not available
17	Oil and Gas Infrastructure	Andhra Pradesh Gas Infrastructure Corporation	Data not received	NA	RMSI is trying to get the data for Oil and Gas from Andhra Pradesh Gas Infrastructure Corporation
18	Power plants and sensitive installations	Andhra Pradesh Power Generation Corporation	Data not received	NA	Approached AP CPDCL (Central Power Distribution Company of AP Ltd.) several time. Data not received
Transportation					
19	Roads	SOI and Andhra Pradesh Transport Department	Data developed by SOI received for year 2010. Road type information available for about 78% data	Attributes information like names of roads, surface type of roads, width of roads, number of lanes, etc., are missing. Geometry and location of roads does not match the high resolution images	SOI agreed to provide spatial data. Attribute data may be limited and RMSI will depend on public domain maps and satellite data for updating
20	Railways	Andhra Pradesh Transport Department	Spatial data available for year 2008	Projection information of shape file is not present	SOI agreed to provide spatial data.
21	Airports	Airports Authority of	Data not received	NA	SOI agreed to provide spatial data. Attribute

S. No.	Data Category	Data Sources	Observations on Data	Data Gaps and Constraints	RMSI Plan of Action
		India			information will be captured from various airport website
22	Seaports	Port Authority of India	Data not received	NA	SOI agreed to provide spatial data.
Agriculture					
23	Crop data	Andhra Pradesh Agriculture Department	Available in GIS format with area and production of four key crops at district level for 2011	This data is not available at sub district and village level	This data will be used
Land use and soil data					
24	Coastal plantations	Forest Survey of India, Dehradun	Data not received	NA	FSI agreed to provide spatial data of coastal plantation and mangroves
25	Land use land cover	SOI	Data not received	NA	SOI agreed to provide this
26	Soil data	Andhra Pradesh Agriculture Department	This data contains attribute information like soil depth, soil type, soil texture, physiographic division (Year 2010)	No gaps	RMSI will use this data
Industrial establishment					
27	Major and hazardous industries	Andhra Pradesh Revenue and Disaster Management Department	Data not received	NA	SOI agreed to provide spatial data. But attribute information which is important is not available

2.2.2 ODISHA

Table 2-6: Exposure data status for Odisha

S. No.	Data Category	Data Source	Observations on Data	Data gaps and Constraints	RMSI Plan of Action
Administration and demographic data					
1	Administrative boundaries	SOI	Data not received	NA	SOI agreed to provide this data, except Ward boundary data. Ward boundary data will be collected from respective municipalities for hot-spot locations

S. No.	Data Category	Data Source	Observations on Data	Data gaps and Constraints	RMSI Plan of Action
2	Demographic data	Census of India	Village/Ward level demographic details like gender, caste, age and occupation are available (Census, 2011)	No gap in data	RMSI will use this data
3	Housing data	Census of India	Details include structure type, amenities at district level (Census, 2011)		NDMA is procuring Ward and Village level household data from Census of India
Essential facilities					
4	Schools	Odisha Education Department	Data not received	NA	SOI agreed to provide spatial data. Attribute data not available
5	Health facilities	Department of Health and family welfare, Odisha	GIS data as point features with type information is available for entire state	Attribute information including building types, size, facility associated with hospitals are not present	Received spatial and some attribute data from Department of Health and family welfare
6	Safe shelters	OSDMA	Data received	NA	OSDMA has provided the spatial data for shelter locations
7	Police stations	Police Department	Data not received	NA	SOI agree to provide spatial data. However, no attribute data available
8	Fire stations	State Fire Department	Fire station locations and asset information available for 2011	No gap in data	RMSI will use this data
9	Post offices	Postal Department	Data not received	NA	SOI has agreed to provide spatial data
Public buildings					
10	Government offices	Government departments	Data not received	NA	SOI has agreed to provide location information but the building specific information not available. Rural department has provided building and road data at district level in xls.
11	Cultural heritage sites	Department of Tourism	Data not received	NA	SOI has agreed to provide spatial data.
Religious buildings					

S. No.	Data Category	Data Source	Observations on Data	Data gaps and Constraints	RMSI Plan of Action
12	Places of Worship	Department of Tourism	Number of units at district level available for 2011		SOI has agreed to provide location information
Utilities					
13	Electric Power	Electricity Department	Data not received	NA	Received power lines and power stations information in Excel format at district level. Received drawing file of network data from Department of OPTCL. SOI agreed to provide this. Only district level aggregate analysis can be carried out
14	Potable Water	Public Works Department	Data not received	NA	No data received. Approach Odisha PWD
15	Waste Water	Public Works Department	Data not received	NA	No data received. RMSI will use census data (number of houses with sewerage facility) available at district level.
16	Communication Systems	Telecom Regulatory Authority	Data not received	NA	Received landline network data in xls which can only be used for district aggregate level analysis RMSI will supplement this data census data (number of houses with landline, internet and mobile facilities) available at district level.
17	Oil and Gas Infrastructure	Odisha Industrial Infrastructure Development Corporation (IDCO) and relevant department	Data not received	NA	No data received
18	Power plants and sensitive installations	Odisha Power Generation Corporation	Data not received	NA	No data received

S. No.	Data Category	Data Source	Observations on Data	Data gaps and Constraints	RMSI Plan of Action
Transportation					
19	Roads	Odisha Transport Department	Data not received	NA	SOI agreed to provide spatial data. Attribute data may be limited and RMSI will depend on public domain maps and satellite data for updating
20	Railways	Odisha Transport Department	Data not received	NA	SOI agreed to provide spatial data.
21	Airports	Airports Authority of India	Data not received	NA	SOI agreed to provide spatial data. Attribute information will be captured from various airport website
22	Seaports	Port Authority	Data not received	NA	SOI agreed to provide spatial data.
Agriculture					
23	Crop data	Agriculture Department	Available in GIS format with area and production of four key crops at district level for 2011	This data is not available at sub district and village level	This data will be used
Land use and soil data					
24	Coastal plantation	FSI	Data not received	NA	FSI agreed to provide spatial data of coastal plantation and mangroves
25	Land use land cover	SOI	Data not received	NA	SOI agreed to provide this
26	Soil data	Agriculture Department	This data contains attribute information like soil depth, soil type, soil texture, physiographic division, etc. for the Year 2010	No gaps	RMSI will use this data
Industrial establishments					
27	Major and hazardous industries	Odisha Revenue and Disaster Management Department	Data not received	NA	SOI to provide spatial data. Received tabular data for the industries of Odisha

3 Data Standards

3.1 Data Standards followed by NSDI, India

Standards facilitate data sharing and increase interoperability among geographic information systems (GIS). For the present project, the team intends to follow data standards laid down and followed by NSDI, India since most of the data providing agencies are using these standards. In addition, the team also studied some important international organizations whose data standards are followed globally in the field of risk management initiatives using GIS data. These have been summarized in Annexes 1 and 2.

The purposes of the Data Content Standards are:

1. To provide common definitions for geo-spatial information found in public records, which will facilitate the effective use, understanding, and automation of business processes
2. To standardize attributes that will enhance data sharing
3. To resolve discrepancies related to the use of homonyms and synonyms in the datasets of various organizations/agencies, which will minimize duplication within and among them
4. To provide guidance and direction for geo-spatial professionals on standardized attributes and definitions, which will improve data creation and their management
5. To use participatory involvement in the Standard development to reach out to various organizations, which will encourage application of the Standard

NSDI was established in 2000 by the Government of India with the objective of developing a common format and platform for easy data sharing between various organizations in the country. The key focus and consideration was given to the geospatial data and its varied applications in the present day environment. NSDI envisioned a common data platform, which will help consistency of data use and avoid recreation of data by different organizations. NSDI envisages to acquire, process, store, distribute, and improve utilization of spatial data, which would be a gateway of spatial data being generated by various agencies of the Government of India, and where the data producing agencies of the Government of India shall be initially the contributing agencies.

NSDI provides a base or structure of practices and relationships among data producers and users that facilitates data sharing and use. It is a set of actions and new ways of accessing, sharing and using geographic data that enables far more comprehensive analysis of data that is required to help decision makers choose the best course of action.

The guiding principles of NSDI are that the infrastructure for spatial information in the country should be designed to ensure that spatial data are stored, made available and maintained at the most appropriate level. Further, it should be possible to combine spatial data and services from different sources across the Community in a consistent way and share them between several users and applications. It should be possible for spatial data collected at one level of government / public authority to be shared between all the different levels of government / public authorities; and spatial data and services should be made available under conditions that do not restrict their extensive use. It is easy to discover available spatial data, to evaluate their fitness for purpose and to know the conditions applicable to their use. To ensure that the spatial data infrastructures are compatible and usable in a community and in a trans-boundary context, common Standards need to be adopted in a number of specific areas at the National level, and should be binding in their entirety.

3.2 List of Data and Nodal Agencies as defined by NSDI India

As far as will be practically possible, the project team will try to source data from the Nodal agencies prescribed by NSDI. However, it should be noted that this may not always be possible due to matters pertaining to national and/or data security, organizational restraints, and the fact that these agencies do not have a mandate to share such data with private consultants.

Coordinate Reference System	Survey of India (SOI)
Transportation	Survey of India (SOI)
Orthoimagery	Indian Space Research Organization (ISRO)
Addresses	National Atlas and Thematic Mapping (NATMO)
Soil	National Bureau of Soil Survey and Land Use Planning (NBSSLUP)
Forest	Forest Survey of India (FSI)
Population	Census of India (COI)
Hydrography	National Hydrographic Office (NHO)
Land Use	National Remote Sensing Centre (NRSC)
Meteorological Surface data	India Meteorological Department (IMD)
Physical water bodies	Central Water Commission (CWC), National Hydrographic Office (NHO)
Ground Water Profile	Central Ground Water Board (CGWB)
Mineral and Energy Resources	Geological Survey of India (GSI)
Water quality data	Central Pollution Control Board (CPCB), Central Ground Water Board (CGWB)
Economic Data	National Council of Applied Economic Research (NCAER)
Natural Disaster data	National Disaster Management Authority (NDMA)

3.3 Metadata Standards defined by NSDI

This section presents the metadata standards defined by NSDI India (NSDI Metadata Standards Version 2.0). A wide variety of Spatial Data Infrastructures especially with respect to metadata standards and strategies adopted by USA, Australia, Europe, the ISO documents, the Global Spatial Data Infrastructure Cookbook were consulted while formulating these standards. It also takes into account articles by renowned National and International experts in finalizing NSDI Metadata Standards Version 2.0 at National Level.

The proposed standard contains 28 elements and 102+ Schema, which may be sufficient for the data generating agencies. Efforts were taken to find out the necessary elements for the Indian scenario/ organizations. The standard defines the information required by a prospective user are:

1. to determine the availability of a set of spatial data,
2. to determine the compliance of a set of spatial data for an intended use,
3. to determine the means to access the set of geospatial data, and
4. to access the set of spatial data successfully (http://nsdiindia.gov.in/nsdi).

The present project envisages to use these metadata standards while creating the spatial database. The essential elements of these standards are highlighted in the table below.

Table 3-1: Metadata Standards for NSDI with the essential elements and their schema

S. No.	Elements	Scheme
1	Data Identification Information	Name of the Dataset Name of the Data Theme Keywords Access Constraints Use Constraints Purpose of Creating Data Data Type
2	Contact Information	Contact Person Organization Mailing Address City/Locality Country Contact Telephone Contact Fax Contact Email
3	Coverage	coverage.x.min coverage.x.ma coverage.y.min WGS84LL coverage.t.late CE date coverage.t.early coverage.PlaceName coverage.PeriodName coverage.spatial.resolution coverage.spatial.georeference coverage.spatial.aggregation coverage.temporal.precision coverage.temporal.interval coverage.temporal.aggregation coverage.note coverage.AlternativeMetadata
4	Citation	Data Prepared by Original Source Source Scale and Date Mapping year digitizing year survey year Lineage Associated Project preparing the data Associated Publications person.Email person.Affiliation CorporateName CorporateName.Address
5	Metadata date stamp	MD_Metadata.dateStamp ISO08601
6	Dataset topic category	MD_Metadata.identificationInfo MD_DataIdentification.topicCategory
7	Language	language ISO0639-2Bsh
8	Abstract describing the data	MD_Metadata.identificationInfo MD_DataIdentification.abstract
9	For Image	Name of the Satellite Sensor

	Data	Path Row Image Acquired From Date and Time of Image File Format Bits per Pixel Spatial Resolution Spatial Resolution Unit Number of Bands Number of Rows Number of Cols Purchased or Obtained on Exchange Basic

4 Database Structure and Update Mechanism

This section presents the database structure of the web based GIS atlas by providing a high-level view of the application. It provides insight into the database and the relationships between the various tables with the help of Entity Relationship (E-R) diagrams.

4.1 Database Structure

The database will be built using PostgreSQL, which is an open source, object relational database system. The adopted database framework will ensure scalability, normalization and other important advantages. The database will comprise of tables containing exposure, hazard and vulnerability details. It will contain details about states, districts, villages, aggregated and site specific exposure etc.

Based on the understanding of requirements, RMSI proposes the following database structure. The E-R diagram shown in Figure 4-1 provides an overview of how data will be stored in the application.

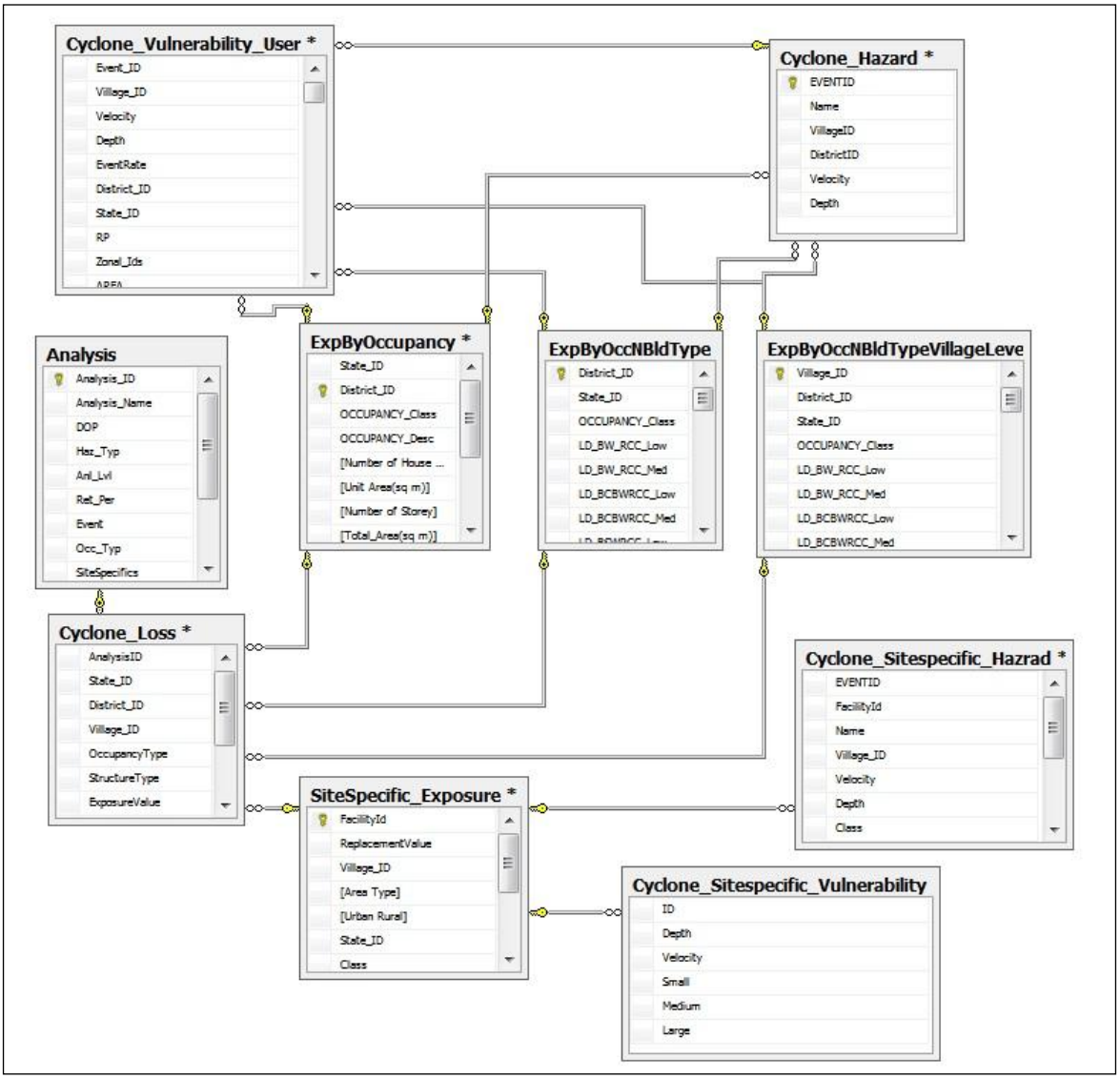

Figure 4-1: E-R-diagram for composite risk atlas – Cyclone loss calculations

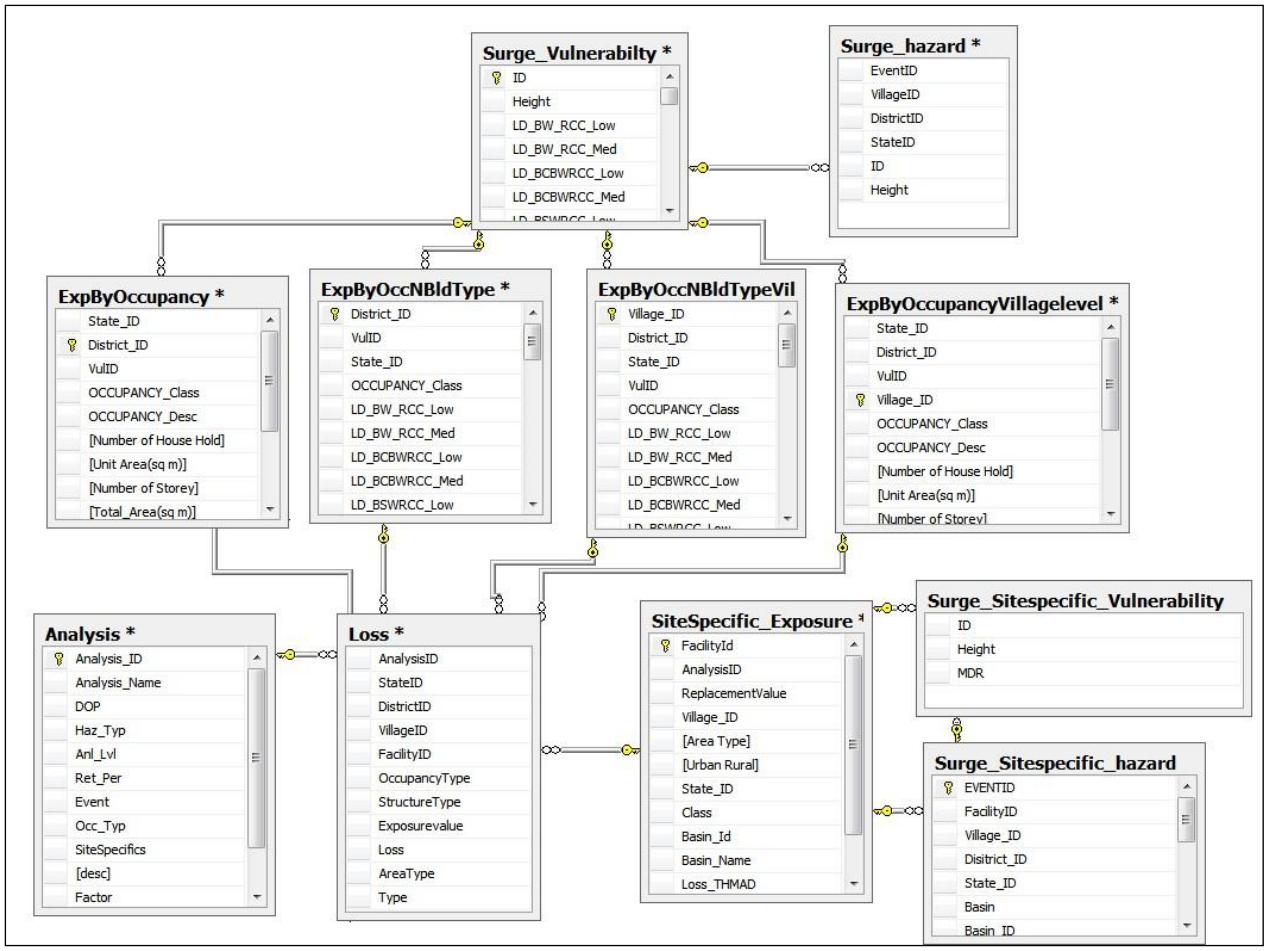

Figure 4-2: E-R-diagram for composite risk atlas – Storm surge loss calculations

The subsections below give the structure of some of the important tables that will be used in risk analysis in the proposed risk atlas software.

[dbo].[Analysis]

This table will contain analysis details like Analysis name, Hazard type, return period, event Occupancy Type etc.

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
PK C	Analysis_ID	int	4	False	
	Anal_Name	varchar(100)	100	True	
	DOP	date	3	True	
	Haz_Typ	varchar(20)	20	True	
	Anl_Lvl	varchar(20)	20	True	
	Ret_Per	varchar(20)	20	True	
	Event	varchar(50)	50	True	
	Occ_Typ	text	max	True	
	SiteSpecifics	text	max	True	
	desc	varchar(20)	20	True	
	Factor	int	4	False	((1000))
	ID	int	4	True	

Indexes

Key	Name	Columns	Unique
PK C	PK_Analysis	Analysis_ID	True

Used By

[dbo].[Cyclone_Loss]

[dbo].[Cyclone_Loss]

This table will contain the loss details at occupancy, state, district and village levels.

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
FK	AnalysisID	int	4	True
	State_ID	int	4	True
	District_ID	int	4	True
	Village_ID	int	4	True
	OccupancyType	varchar(4)	4	True
	StructureType	varchar(50)	50	True
	ExposureValue	float	8	True
	Loss	float	8	True
	AreaType	text	max	True
	Type	text	max	True

Foreign Keys

Name	Columns
FK_Cyclone_Loss_Analysis	AnalysisID->[dbo].[Analysis].[Analysis_ID]

Uses

[dbo].[Analysis]

[dbo].[Cyclone_Sitespecific_Hazrad]

This table will contain cyclone site-specific hazard data at state, district and village levels.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
EVENTID	varchar(50)	50	True
FacilityId	int	4	True
Name	varchar(254)	254	True
Village_ID	int	4	True
Velocity	numeric(6,2)	5	True
Depth	numeric(6,2)	5	True
Class	varchar(50)	50	True
RATE	float	8	True
the_geom	geometry	max	True
State_ID	int	4	True
Distrct_ID	int	4	True
Urban Rural	text	max	True
MDR	numeric(6,4)	5	True

[dbo].[Cyclone_Sitespecific_Vulnerability]

This table will contain the cyclone site-specific damage functions at class level as small, medium and high.

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
PK C	ID	int	4	False
	Depth	numeric(3,1)	5	True
	Velocity	numeric(3,1)	5	True
	Small	numeric(6,4)	5	True
	Medium	numeric(6,4)	5	True
	Large	numeric(6,4)	5	True

[dbo].[Cyclone_Vulnerability]

This table will contain the aggregate cyclone damage functions at building level. Users cannot change these damage functions.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
Event_ID	varchar(30)	30	True
Village_ID	int	4	True
Velocity	numeric(6,2)	5	True
Depth	numeric(6,2)	5	True
EventRate	float	8	True
District_ID	int	4	True
State_ID	int	4	True
RP	numeric(6,2)	5	True
Zonal_Ids	varchar(255)	255	True
AREA	float	8	True
Affected_Area_Percentage	float	8	True
LD_BW_RCC_Low	numeric(6,4)	5	True
LD_BW_RCC_Med	numeric(6,4)	5	True
LD_BCBWRCC_Low	numeric(6,4)	5	True
LD_BCBWRCC_Med	numeric(6,4)	5	True
LD_BSWRCC_Low	numeric(6,4)	5	True
LD_BSWRCC_Med	numeric(6,4)	5	True
LD_BBWMM_Low	numeric(6,4)	5	True
LD_BBWMM_Med	numeric(6,4)	5	True
LD_BSBWMM_Low	numeric(6,4)	5	True
AMW_MM_Low	numeric(6,4)	5	True
SSW_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Med	numeric(6,4)	5	True
SqSMM_Low	numeric(6,4)	5	True
FrS_BW_RCC_Low	numeric(6,4)	5	True
FrS_BW_RCC_Med	numeric(6,4)	5	True
FrS_BW_RCC_High	numeric(6,4)	5	True
FrS_CBW_RCC_Low	numeric(6,4)	5	True
FrS_CBW_RCC_Med	numeric(6,4)	5	True
FrS_CBW_RCC_High	numeric(6,4)	5	True
FrS_CW_RCC_Low	numeric(6,4)	5	True

Name	Data Type	Max Length (Bytes)	Allow Nulls
FrS_CW_RCC_Med	numeric(6,4)	5	True
FrS_CW_RCC_High	numeric(6,4)	5	True
FrS_SCW_RCC_Low	numeric(6,4)	5	True
FrS_SCW_RCC_Med	numeric(6,4)	5	True
FrS_SCW_RCC_High	numeric(6,4)	5	True
SS_CBW_Low	numeric(6,4)	5	True
SS_CBW_Med	numeric(6,4)	5	True
SS_CBW_High	numeric(6,4)	5	True
Casualty	numeric(6,4)	5	True
TGridId	int	4	True
AreaType	varchar(50)	50	True

[dbo].[Cyclone_Vulnerability_User]
This table will contain the user specific aggregate cyclone damage functions at building level. Users can change these damage functions

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
Event_ID	varchar(30)	30	True
Village_ID	int	4	True
Velocity	numeric(6,2)	5	True
Depth	numeric(6,2)	5	True
EventRate	float	8	True
District_ID	int	4	True
State_ID	int	4	True
RP	numeric(6,2)	5	True
Zonal_Ids	varchar(255)	255	True
AREA	float	8	True
Affected_Area_Percentage	float	8	True
LD_BW_RCC_Low	numeric(6,4)	5	True
LD_BW_RCC_Med	numeric(6,4)	5	True
LD_BCBWRCC_Low	numeric(6,4)	5	True
LD_BCBWRCC_Med	numeric(6,4)	5	True
LD_BSWRCC_Low	numeric(6,4)	5	True
LD_BSWRCC_Med	numeric(6,4)	5	True
LD_BBWMM_Low	numeric(6,4)	5	True
LD_BBWMM_Med	numeric(6,4)	5	True
LD_BSBWMM_Low	numeric(6,4)	5	True
AMW_MM_Low	numeric(6,4)	5	True
SSW_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Med	numeric(6,4)	5	True
SqSMM_Low	numeric(6,4)	5	True
FrS_BW_RCC_Low	numeric(6,4)	5	True
FrS_BW_RCC_Med	numeric(6,4)	5	True
FrS_BW_RCC_High	numeric(6,4)	5	True
FrS_CBW_RCC_Low	numeric(6,4)	5	True
FrS_CBW_RCC_Med	numeric(6,4)	5	True
FrS_CBW_RCC_High	numeric(6,4)	5	True
FrS_CW_RCC_Low	numeric(6,4)	5	True
FrS_CW_RCC_Med	numeric(6,4)	5	True
FrS_CW_RCC_High	numeric(6,4)	5	True
FrS_SCW_RCC_Low	numeric(6,4)	5	True
FrS_SCW_RCC_Med	numeric(6,4)	5	True
FrS_SCW_RCC_High	numeric(6,4)	5	True

Name	Data Type	Max Length (Bytes)	Allow Nulls
SS_CBW_Low	numeric(6,4)	5	True
SS_CBW_Med	numeric(6,4)	5	True
SS_CBW_High	numeric(6,4)	5	True
Casualty	numeric(6,4)	5	True
Prev_Contents	numeric(6,4)	5	True
Prev_LD_BW_RCC_Low	numeric(6,4)	5	True
Prev_LD_BW_RCC_Med	numeric(6,4)	5	True
Prev_LD_BCBWRCC_Low	numeric(6,4)	5	True
Prev_LD_BCBWRCC_Med	numeric(6,4)	5	True
Prev_LD_BSWRCC_Low	numeric(6,4)	5	True
Prev_LD_BSWRCC_Med	numeric(6,4)	5	True
Prev_LD_BBWMM_Low	numeric(6,4)	5	True
Prev_LD_BBWMM_Med	numeric(6,4)	5	True
Prev_LD_BSBWMM_Low	numeric(6,4)	5	True
Prev_AMW_MM_Low	numeric(6,4)	5	True
Prev_SSW_MM_Low	numeric(6,4)	5	True
Prev_LD_BCB_MM_Low	numeric(6,4)	5	True
Prev_LD_BCB_MM_Med	numeric(6,4)	5	True
Prev_SqSMM_Low	numeric(6,4)	5	True
Prev_FrS_BW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_BW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_BW_RCC_High	numeric(6,4)	5	True
Prev_FrS_CBW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_CBW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_CBW_RCC_High	numeric(6,4)	5	True
Prev_FrS_CW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_CW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_CW_RCC_High	numeric(6,4)	5	True
Prev_FrS_SCW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_SCW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_SCW_RCC_High	numeric(6,4)	5	True
Prev_SS_CBW_Low	numeric(6,4)	5	True
Prev_SS_CBW_Med	numeric(6,4)	5	True
Prev_SS_CBW_High	numeric(6,4)	5	True
Prev_Casualty	numeric(6,4)	5	True
TGridId	int	4	True
AreaType	varchar(50)	50	True

[dbo].[ExpByOccNBldType]

This table will contain the aggregate building wise exposure details at occupancy, state and district levels

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
District_ID	int	4	True	
State_ID	int	4	True	
OCCUPANCY_Class	varchar(10)	10	True	
LD_BW_RCC_Low	float	8	True	((0))
LD_BW_RCC_Med	float	8	True	((0))
LD_BCBWRCC_Low	float	8	True	((0))
LD_BCBWRCC_Med	float	8	True	((0))
LD_BSWRCC_Low	float	8	True	((0))
LD_BSWRCC_Med	float	8	True	((0))

Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
LD_BBWMM_Low	float	8	True	((0))
LD_BBWMM_Med	float	8	True	((0))
LD_BSBWMM_Low	float	8	True	((0))
AMW_MM_Low	float	8	True	((0))
SSW_MM_Low	float	8	True	((0))
LD_BCB_MM_Low	float	8	True	((0))
LD_BCB_MM_Med	float	8	True	((0))
SqSMM_Low	float	8	True	((0))
FrS_BW_RCC_Low	float	8	True	((0))
FrS_BW_RCC_Med	float	8	True	((0))
FrS_BW_RCC_High	float	8	True	((0))
FrS_CBW_RCC_Low	float	8	True	((0))
FrS_CBW_RCC_Med	float	8	True	((0))
FrS_CBW_RCC_High	float	8	True	((0))
FrS_CW_RCC_Low	float	8	True	((0))
FrS_CW_RCC_Med	float	8	True	((0))
FrS_CW_RCC_High	float	8	True	((0))
FrS_SCW_RCC_Low	float	8	True	((0))
FrS_SCW_RCC_Med	float	8	True	((0))
FrS_SCW_RCC_High	float	8	True	((0))
SS_CBW_Low	float	8	True	((0))
SS_CBW_Med	float	8	True	((0))
SS_CBW_High	float	8	True	((0))
AreaType	varchar(10)	10	True	
Casualty	int	4	True	((0))

[dbo].[ExpByOccNBldTypeVillageLevel]

This table will contain the aggregate building-wise exposure details at occupancy, state,district and Village levels

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
Village_ID	int	4	True
District_ID	int	4	True
State_ID	int	4	True
OCCUPANCY_Class	varchar(10)	10	True
LD_BW_RCC_Low	float	8	True
LD_BW_RCC_Med	float	8	True
LD_BCBWRCC_Low	float	8	True
LD_BCBWRCC_Med	float	8	True
LD_BSWRCC_Low	float	8	True
LD_BSWRCC_Med	float	8	True
LD_BBWMM_Low	float	8	True
LD_BBWMM_Med	float	8	True
LD_BSBWMM_Low	float	8	True
AMW_MM_Low	float	8	True
SSW_MM_Low	float	8	True
LD_BCB_MM_Low	float	8	True
LD_BCB_MM_Med	float	8	True
SqSMM_Low	float	8	True
FrS_BW_RCC_Low	float	8	True
FrS_BW_RCC_Med	float	8	True
FrS_BW_RCC_High	float	8	True

Name	Data Type	Max Length (Bytes)	Allow Nulls
FrS_CBW_RCC_Low	float	8	True
FrS_CBW_RCC_Med	float	8	True
FrS_CBW_RCC_High	float	8	True
FrS_CW_RCC_Low	float	8	True
FrS_CW_RCC_Med	float	8	True
FrS_CW_RCC_High	float	8	True
FrS_SCW_RCC_Low	float	8	True
FrS_SCW_RCC_Med	float	8	True
FrS_SCW_RCC_High	float	8	True
SS_CBW_Low	float	8	True
SS_CBW_Med	float	8	True
SS_CBW_High	float	8	True
AreaType	varchar(10)	10	True
Casualty	int	4	True

[dbo].[ExpByOccupancy]

This table will contain aggregate exposure details like number of houses, number of storeys, unit area / sq m at occupancy level, state and district levels etc.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls	Default
State_ID	int	4	True	
District_ID	int	4	True	
OCCUPANCY_Class	varchar(10)	10	True	
OCCUPANCY_Desc	varchar(255)	255	True	
Number of House Hold	int	4	True	((0))
Unit Area(sq m)	numeric(30,2)	17	True	((0))
Number of Storey	int	4	True	((1))
Total_Area(sq m)	numeric(30,2)	17	True	
Cost(per sq m in INR)	numeric(30,2)	17	True	
Total Cost(in INR)	numeric(30,2)	17	True	((0))
AreaType	varchar(10)	10	True	
ExpType	varchar(20)	20	True	

[dbo].[ExpByOccupancyVillagelevel]

This table will contain aggregate exposure details like number of houses, number of storeys, unit area / sq m at occupancy level, state, district and village levels etc.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
State_ID	int	4	True
District_ID	int	4	True
Village_ID	float	8	True
OCCUPANCY_Class	varchar(10)	10	True
OCCUPANCY_Desc	varchar(255)	255	True
Number of House Hold	int	4	True
Unit Area(sq m)	numeric(30,2)	17	True
Number of Storey	int	4	True
Total_Area(sq m)	numeric(30,2)	17	True
Cost(per sq m in INR)	numeric(30,2)	17	True

Total Cost(in INR)	numeric(30,2)	17	True
AreaType	varchar(10)	10	True
ExpType	varchar(20)	20	True

[dbo].[OccWiseSurgeLoss]

This table will contain surge loss details at occupancy, state, district and village levels.

Columns

Key	Name	Data Type	Max Length (Bytes)	Allow Nulls
FK	AnalysisID	int	4	True
	State_ID	int	4	True
	District_ID	int	4	True
	Village_ID	int	4	True
	OccupancyType	varchar(4)	4	True
	StructureType	varchar(50)	50	True
	ExposureValue	float	8	True
	Loss	float	8	True
	AreaType	text	max	True
	Type	text	max	True

Foreign Keys

Name	Columns
FK_OccWiseSurgeLoss_Analysis	AnalysisID->[dbo].[Analysis].[Analysis_ID]

Uses

[dbo].[Analysis]

[dbo].[SiteSpecific_Exposure]

This table will contain site-specific exposure at state, district and village levels. Replacement value is the exposure value.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
FacilityId	int	4	True
ReplacementValue	numeric(15,1)	9	True
Village_ID	int	4	True
Area Type	varchar(254)	254	True
Urban Rural	varchar(254)	254	True
State_ID	int	4	True
Class	varchar(1)	1	True
Basin_Id	int	4	True
Basin_Name	varchar(1)	1	True
Loss_THMAD	float	8	True
District_ID	int	4	True

[dbo].[Surge_Sitespecific_hazard]

This table will contain the site-specific surge hazard at state, district, basin and village levels

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
EVENTID	int	4	True
Village_ID	int	4	True
Disitrict_ID	int	4	True
State_ID	int	4	True
Basin	varchar(255)	255	True
Basin_ID	int	4	True
Height	numeric(6,2)	5	True
Affected_Area_Percentage	float	8	True
Return_Period	float	8	True
ReplacementValue	numeric(20,2)	13	True
Area Type	varchar(50)	50	True
MDR	numeric(6,4)	5	True
ActualEventID	int	4	True
RATE	float	8	True

[dbo].[Surge_Sitespecific_Vulnerability]

This table will contain the site-specific surge damage.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
ID	int	4	True
Height	numeric(6,2)	5	True
MDR	numeric(6,4)	5	True

[dbo].[Surge_Vulnerabilty]

This table will contain the building-wise damage functions. Users cannot change these damage functions

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
ID	int	4	True
Height	numeric(6,2)	5	True
LD_BW_RCC_Low	numeric(6,4)	5	True
LD_BW_RCC_Med	numeric(6,4)	5	True
LD_BCBWRCC_Low	numeric(6,4)	5	True
LD_BCBWRCC_Med	numeric(6,4)	5	True
LD_BSWRCC_Low	numeric(6,4)	5	True
LD_BSWRCC_Med	numeric(6,4)	5	True
LD_BBWMM_Low	numeric(6,4)	5	True
LD_BBWMM_Med	numeric(6,4)	5	True
LD_BSBWMM_Low	numeric(6,4)	5	True
AMW_MM_Low	numeric(6,4)	5	True
SSW_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Med	numeric(6,4)	5	True
SqSMM_Low	numeric(6,4)	5	True
FrS_BW_RCC_Low	numeric(6,4)	5	True
FrS_BW_RCC_Med	numeric(6,4)	5	True

Name	Data Type	Max Length (Bytes)	Allow Nulls
FrS_BW_RCC_High	numeric(6,4)	5	True
FrS_CBW_RCC_Low	numeric(6,4)	5	True
FrS_CBW_RCC_Med	numeric(6,4)	5	True
FrS_CBW_RCC_High	numeric(6,4)	5	True
FrS_CW_RCC_Low	numeric(6,4)	5	True
FrS_CW_RCC_Med	numeric(6,4)	5	True
FrS_CW_RCC_High	numeric(6,4)	5	True
FrS_SCW_RCC_Low	numeric(6,4)	5	True
FrS_SCW_RCC_Med	numeric(6,4)	5	True
FrS_SCW_RCC_High	numeric(6,4)	5	True
SS_CBW_Low	numeric(6,4)	5	True
SS_CBW_Med	numeric(6,4)	5	True
SS_CBW_High	numeric(6,4)	5	True
Casualty	numeric(6,4)	5	True
Contents	numeric(6,4)	5	True

[dbo].[Surge_Vulnerabilty_user]

This table will contain the building-wise user damage functions. Users can updated these damage functions.

Columns

Name	Data Type	Max Length (Bytes)	Allow Nulls
ID	int	4	True
Height	numeric(6,2)	5	True
Contents	numeric(6,4)	5	True
LD_BW_RCC_Low	numeric(6,4)	5	True
LD_BW_RCC_Med	numeric(6,4)	5	True
LD_BCBWRCC_Low	numeric(6,4)	5	True
LD_BCBWRCC_Med	numeric(6,4)	5	True
LD_BSWRCC_Low	numeric(6,4)	5	True
LD_BSWRCC_Med	numeric(6,4)	5	True
LD_BBWMM_Low	numeric(6,4)	5	True
LD_BBWMM_Med	numeric(6,4)	5	True
LD_BSBWMM_Low	numeric(6,4)	5	True
AMW_MM_Low	numeric(6,4)	5	True
SSW_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Low	numeric(6,4)	5	True
LD_BCB_MM_Med	numeric(6,4)	5	True
SqSMM_Low	numeric(6,4)	5	True
FrS_BW_RCC_Low	numeric(6,4)	5	True
FrS_BW_RCC_Med	numeric(6,4)	5	True
FrS_BW_RCC_High	numeric(6,4)	5	True
FrS_CBW_RCC_Low	numeric(6,4)	5	True
FrS_CBW_RCC_Med	numeric(6,4)	5	True
FrS_CBW_RCC_High	numeric(6,4)	5	True
FrS_CW_RCC_Low	numeric(6,4)	5	True
FrS_CW_RCC_Med	numeric(6,4)	5	True
FrS_CW_RCC_High	numeric(6,4)	5	True
FrS_SCW_RCC_Low	numeric(6,4)	5	True
FrS_SCW_RCC_Med	numeric(6,4)	5	True
FrS_SCW_RCC_High	numeric(6,4)	5	True
SS_CBW_Low	numeric(6,4)	5	True
SS_CBW_Med	numeric(6,4)	5	True

Name	Data Type	Max Length (Bytes)	Allow Nulls
SS_CBW_High	numeric(6,4)	5	True
Prev_Contents	numeric(6,4)	5	True
Prev_LD_BW_RCC_Low	numeric(6,4)	5	True
Prev_LD_BW_RCC_Med	numeric(6,4)	5	True
Prev_LD_BCBWRCC_Low	numeric(6,4)	5	True
Prev_LD_BCBWRCC_Med	numeric(6,4)	5	True
Prev_LD_BSWRCC_Low	numeric(6,4)	5	True
Prev_LD_BSWRCC_Med	numeric(6,4)	5	True
Prev_LD_BBWMM_Low	numeric(6,4)	5	True
Prev_LD_BBWMM_Med	numeric(6,4)	5	True
Prev_LD_BSBWMM_Low	numeric(6,4)	5	True
Prev_AMW_MM_Low	numeric(6,4)	5	True
Prev_SSW_MM_Low	numeric(6,4)	5	True
Prev_LD_BCB_MM_Low	numeric(6,4)	5	True
Prev_LD_BCB_MM_Med	numeric(6,4)	5	True
Prev_SqSMM_Low	numeric(6,4)	5	True
Prev_FrS_BW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_BW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_BW_RCC_High	numeric(6,4)	5	True
Prev_FrS_CBW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_CBW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_CBW_RCC_High	numeric(6,4)	5	True
Prev_FrS_CW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_CW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_CW_RCC_High	numeric(6,4)	5	True
Prev_FrS_SCW_RCC_Low	numeric(6,4)	5	True
Prev_FrS_SCW_RCC_Med	numeric(6,4)	5	True
Prev_FrS_SCW_RCC_High	numeric(6,4)	5	True
Prev_SS_CBW_Low	numeric(6,4)	5	True
Prev_SS_CBW_Med	numeric(6,4)	5	True
Prev_SS_CBW_High	numeric(6,4)	5	True
Casualty	int	4	True

4.2 Convenience of Updating and Maintaining Data in PostgreSQL

This section explains various tools and mechanisms available in PostgreSQL to keep the database updated and running. Since the Web risk atlas database will use this technology, which will have dynamic entities, it is essential to keep the data in a standard and well-organized manner. To ensure smooth running of the database, maintenance activities are required that focus on updating data when required, finding out signs of corruption in data, and by performing re-indexing and compression activities. Sections 4.2.1 to 4.2.5 provide explains how the PostgreSQL database can be updated and maintained using simple operations. Detailed user instructions will be provided in user manual which is a deliverable at a later stage of the project.

4.2.1 Querying and Updating Database

PostgreSQL is a Relational Database Management System (RDBMS) that stores data in the form of a relation. Each relation is a collection of rows that has same set of named columns. There are a number of queries that can be performed on the tables to retrieve, store, update, and delete data to or from the table. To perform queries, users need to open the SQL editor pane.

The SQL editor pane allows users to perform several functions on the tables of the selected database. These are further explained in the subsections below.

4.2.1.1 Performing Select Operation

The Select operation allows users to query data from table in the database. It retrieves information from specified columns or from all the columns in a table. The basic syntax of the Select statement is as follows:

```
SELECT column_name1, column_name2
FROM  table_name;
WHERE column_name operator value
```

4.2.1.2 Performing Update Operation

The Update operation allows users to update a single or multiple records in a table. The basic syntax of the Update statement is:

```
UPDATE table_name
SET cloumn1=value1, column2=value2,…..,columnN= valueN
WHERE [condition]
```
[1]

4.2.1.3 Performing Delete Operation

The Delete operation allows users to delete rows from a table. This operation can be used whenever rows, which are no longer required, exist in a table. The basic syntax to perform delete operation is as follows:

```
DELETE FROM table_name WHERE [condition];
```
[2]

4.2.1.4 Create Table Operation

This operation is used to create a new empty table in the existing database. The basic syntax to create a table is as follows:

```
CREATE TABLE table_name
(column1 datatype, column2 datatype, column3 datatype,column
datatype
```

Example: Suppose the user needs to create a new table called 'CriticalFasc_cycclone2_Cyclone_Village. The user needs to execute the following query, in the SQL editor pane.

```
REATE TABLE "CriticalFasc_cycclone2_Cyclone_Village"
(
  gid serial NOT NULL,
  "Village_Id" text,
  "Village" text,
  "Commune" text,
  "District" text,
  windspead numeric,
  "MDR_hospital" numeric,
  "No_of_Hospital" integer,
  "No_of_Hospital_damage" integer,
  "MDR_FStation" numeric,
  "No_of_FStation" integer,
  "No_of_FStation_damage" integer,
  "MDR_PStation" numeric,
```

1 In update statement, the where clause identifies the rows that get affected. If the user does not include the 'where' clause all the rows in the column get affected. So, it should be used with extra care.

2 In delete statement where clause is optional. It identifies the rows in the column that gets deleted. If user do not include the where clause, all the rows in the table gets deleted. So, this statement should be used with extra care.

```
    "No_of_PStation" integer,
    "No_of_PStation_damage" integer,
    "MDR_EInstitute" numeric,
    "No_of_EInstitute" integer,
    "No_of_EInstitute_damage" integer,
    "MDR_RgPlaces" numeric,
    "No_of_RgPlaces" integer,
    "No_of_RgPlaces_damage" integer,
    "Hospitals_Reconstructed" integer DEFAULT (-9999),
    "Fire_Reconstructed" integer DEFAULT (-9999),
    "Power_Reconstructed" integer DEFAULT (-9999),
    "EInst_Reconstructed" integer DEFAULT (-9999),
    "Rlgp_Reconstructed" integer DEFAULT (-9999),
    the_geom geometry,
    "Status_date" date NOT NULL DEFAULT ('now'::text)::date
)
```

This creates a table " CriticalFasc_cycclone2_Cyclone_Village " in the database.

4.2.1.5 Insert Into Operation

After creating a table, the next task is to insert data into the table. The Insert into operation is used to insert new records in a table. The basic syntax for inserting data into a table is:

```
INSERT INTO TABLE_NAME (column1, column2, column3,...columnN)]
VALUES (value1, value2, value3,...valueN);
```

4.2.2 RESTORING DATABASE

PostgreSQL provides a simplified restore interface. With the help of this, users can restore a single table or a whole database, depending on the user's needs, with the help of this interface.

4.2.3 DATABASE BACKUP

One of the major aspects of database maintenance is taking the backup of the database so that in case of disk failure or data loss there will be another copy available. It is usual to take a backup of the database at least once in a month. However, depending on the changes, this period can be reduced so that the changes made in the database are not lost.

To take a backup of the database, the following steps have to be followed:

1. Right click the database, which has to be backed up. A context menu as shown in Figure 4-3 will be displayed.

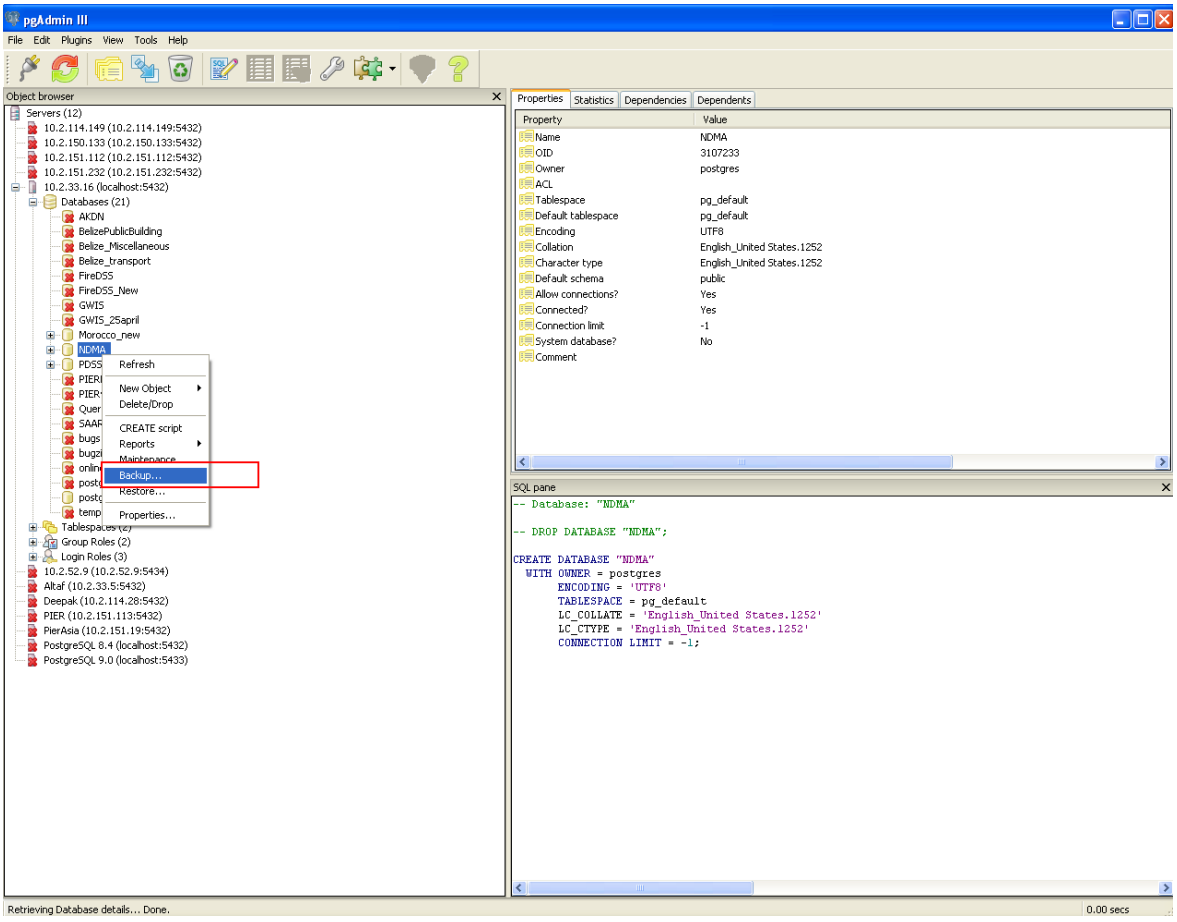

Figure 4-3: Window showing context menu for database backup

2. Click the Backup context menu item. A dialog box as shown in Figure 4-4 will be displayed.

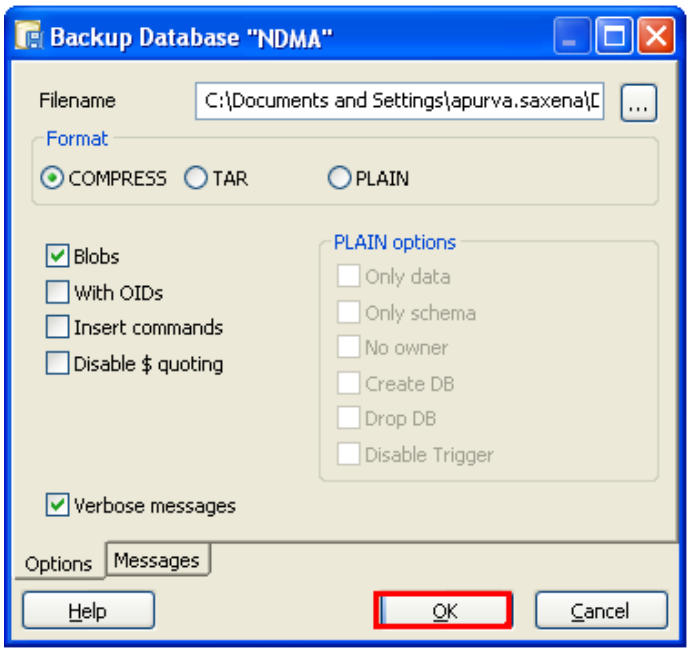

Figure 4-4: Backup database dialog box

3. Click the ... button to specify the location where backup file will be stored.

4. Click the OK button to start the backup process. Once the backup is completed, a dialog box as shown in Figure 4-5 will be displayed.

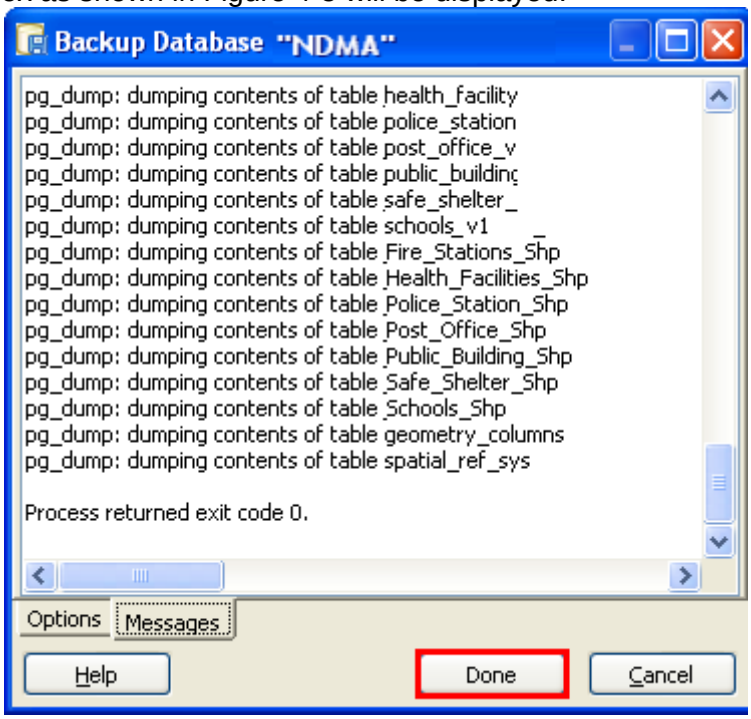

Figure 4-5: completion of database backup

5. Click the Done button. This completes the database backup process.

4.2.4 DATABASE INDEXING

Indexing is done to quickly and efficiently locate the data without having to search every row in a table every time a table is accessed. Indexes are used to increase the performance of the database. The basic syntax of creating index is as follows:

```
CREATE INDEX index_name
ON table_name (column_name)
```

The syntax to create a unique index on a table is:

```
CREATE UNIQUE INDEX index_name
ON table_name (column_name)
```

PostgreSQL also allows the user to do re-indexing, which rebuilds an index using the data stored in the index's table, replacing the old copy of the index. Re-indexing is preferred in the following cases:

1. An index has become corrupt and no longer contains valid data

2. An index contains several empty or nearly empty pages

To perform re–indexing, follow the steps mentioned below:

1. Select the table or database on which indexing is to be done.
2. Click the REINDEX radio button as highlighted by the red rectangle in Figure 4-6.

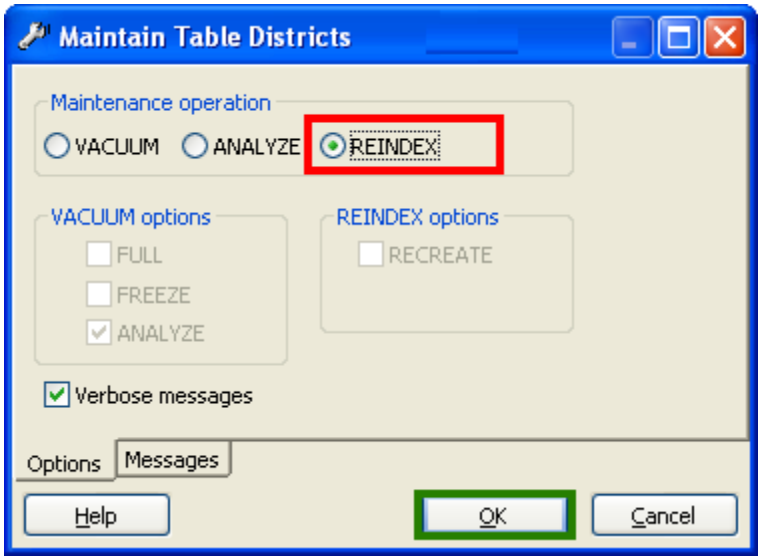

Figure 4-6: Re-indexing of a table

3. Click the OK button as highlighted by the green rectangle in Figure 4-7.

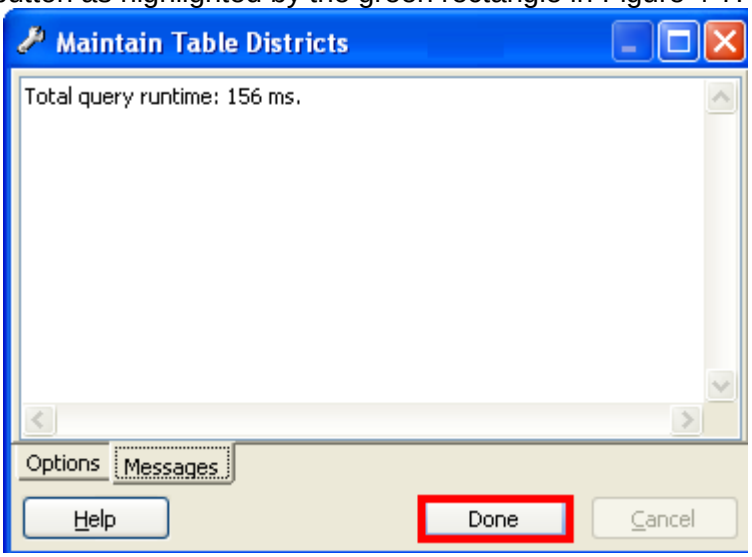

Figure 4-7: Message displayed after execution of re-index process

4. Click the Done button as highlighted by red rectangle in Figure 4-7. This completes the re-indexing process.

4.2.5 DATABASE COMPRESSION

In order to reduce resource usage such as data storage space, PostgreSQL provides a maintenance tool named Vacuum that scans the database for tables that are not in use any more. Depending on the usage of the database, this activity should be performed on a regular basis to ensure that the database does not contain any redundant/unused data that may degrade performance.

To perform database compression, follow the steps mentioned below:

1. Select the database, which has to be compressed.
2. Right click on the database. A window as shown in Figure 4-8 is displayed.

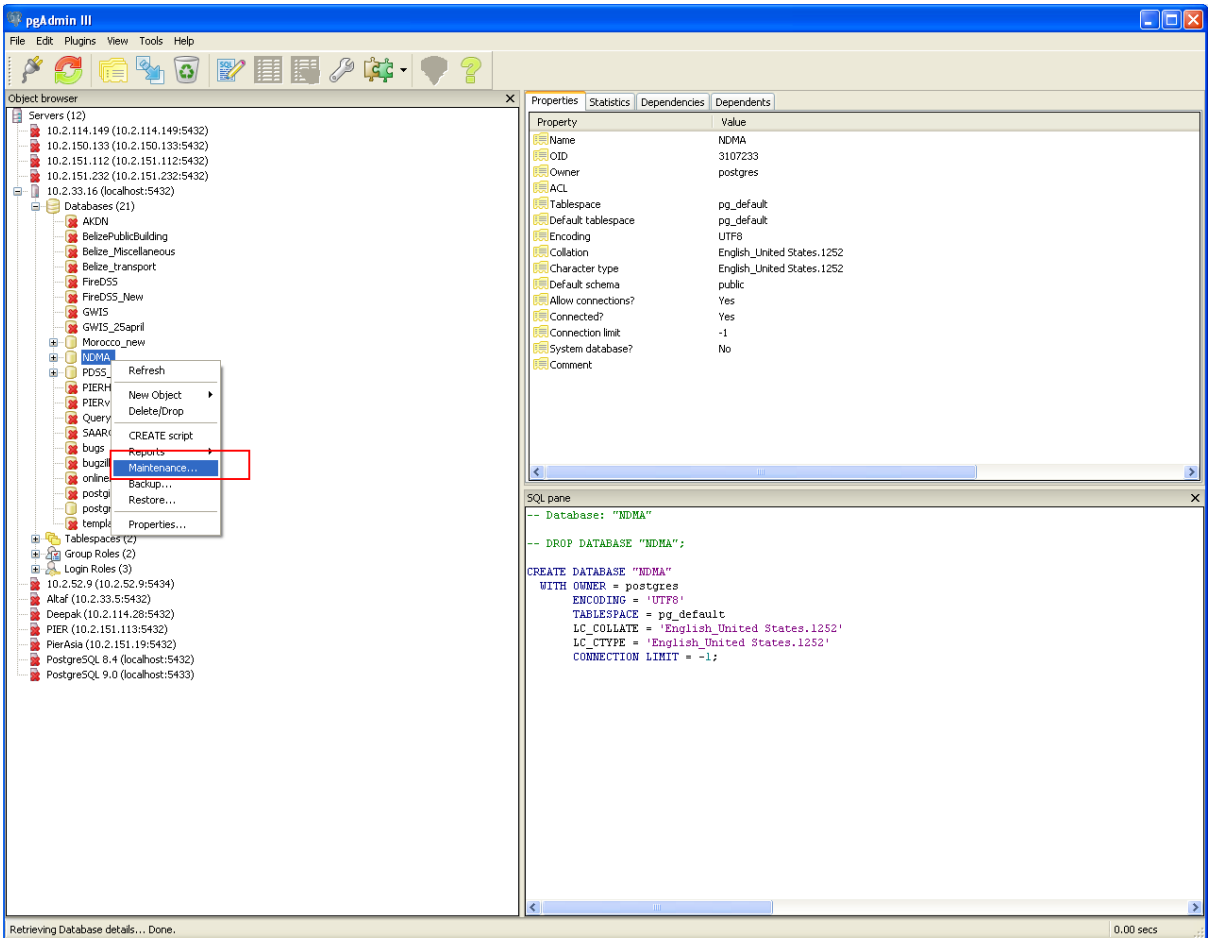

Figure 4-8: Window showing context menu for NDMA database

3. Click the Maintenance context menu item. A dialog box as shown in Figure 4-9 will be displayed.

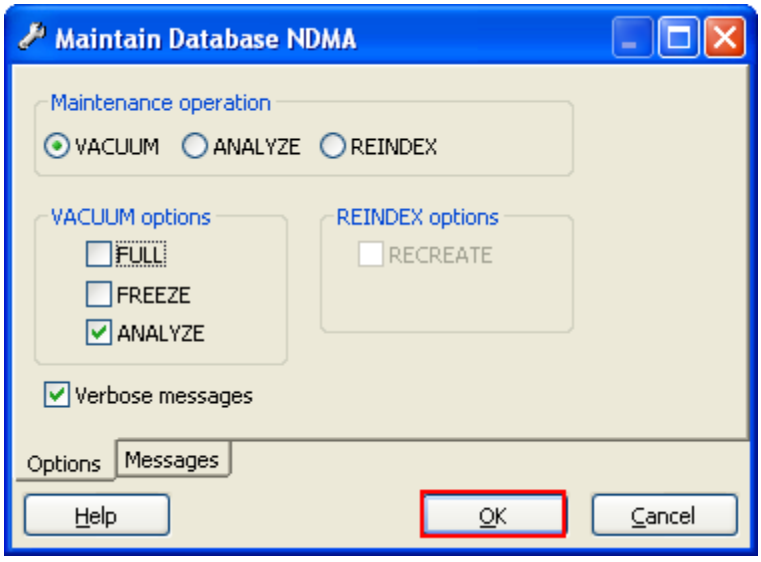

Figure 4-9: Maintenance database NDMA dialog box

4. Click the VACUUM radio button. It provides the user with three Vacuum options, namely:
    1. **FULL**: Selecting this option carries out an extensive processing by compacting the database files to a minimum number of disk blocks. The Full

Vacuum option is generally needed when a huge amount of data in a table has been deleted. It should not be ideally used on a regular basis.

2. **FREEZE**: Selecting this option allows aggressive "freezing" of tuples (rows). Specifying FREEZE is equivalent to performing VACUUM with the parameter set to Zero. This is generally not preferred.
3. **ANALYZE:** Selecting this option performs a VACUUM and then an analysis for each selected table. It collects statistics about the database. This operation can be performed in isolation by selecting the ANALYZE radio button from the Maintenance operation frame.

5. After selecting the required option, click the OK button as shown by the red rectangle in Figure 4-9 to start the vacuum process.
6. Click the Done button to close the window.

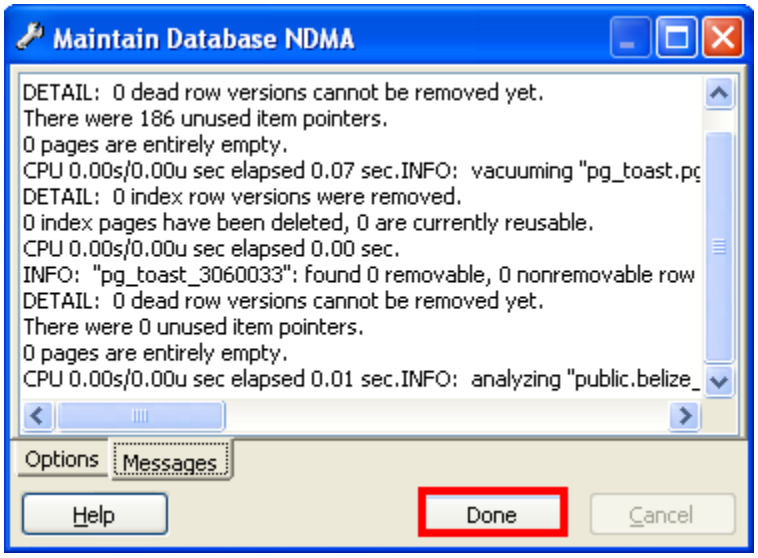

Figure 4-10: Message displayed after completion of vacuum process

4.3 Institutional Mechanism for Data Updating

It is equally important to have defined guidelines and institutional mechanisms to streamline such issues as: who will own the data system and who will update and maintain the database system while being accessed by all users across 13 States and UTs and other national organizations. Since the data in the web atlas is mainly related to hazard and exposure, where the latter is dynamic in nature, it would be ideal to update the data at least on an annual basis. Once the Web risk atlas is in place with defined data standards and structure, it will be easy to perform data updates. Any of the three below mentioned modes of operation can be chosen as an institutional mechanism for data updating.

4.3.1 Decentralized Data Updating

As the system is web enabled, data updating can take place at State/UT levels. Designated State/UT organizations can take charge of data updating and will need to coordinate with other departments/organizations for collecting data in the required format and standards as per the pre-defined timeline to facilitate the nodal organization to perform data updating. The nodal organization will also be responsible for checking the data quality and completeness. However, enhancing the data quality and completing the data will be the responsibility of the respective departments. State/UT nodal agencies will also have to coordinate with other State/UT agencies to synchronize data across the study area. Access for data updating will be given to administrators and these rights will be given only to authorized officials.

4.3.2 CENTRALIZED DATA UPDATING

The data updating can also take place at a centralized location. This can be taken up by NDMA or NDMA can identify a national organization to carry out this task. The States/UTs will have to provide the required data in the format and quality required as per the pre-defined timeline. Updating data at a centralized location will help in synchronizing the data across the States/UTs as well as help in ensuring proper data backups for easy roll back to previous versions, if required.

4.3.3 DATA UPDATING ENGAGING A PROFESSIONAL ORGANIZATION

The third option is to outsource the data updating task to a professional organization in the private sector. The States/UTs should provide the data required in the format and quality to the identified professional organization. Being a professional organization, it will take care of all the required technicalities of updating, maintenance and backup as they do this kind of work on a routine basis. Outsourcing would be beneficial for NDMA and States/UTs as professional organizations will take the responsibility of maintaining the database to the required quality and standards.

4.3.4 SUMMARY

The three options for updating data of the risk atlas are mentioned along with their advantages and disadvantages. The first or third option is preferred to the second one for several reasons. However, the primary reason against selecting the second option is that it would shift the key focus of NDMA to putting efforts in developing the input data for the Web risk atlas rather than its key mandate of using the system for disaster reduction activities.

Table 4-1: Comparison of different data update mechanisms

Update mechanism	Method	Advantage	Disadvantage
Decentralized data updating	Identify a nodal agency in each State and concerned departments in each state will provide data to this nodal organization for data updating	States and UTs will develop ownership of web risk atlas and this will lead to better utilization of the system for DRR activities	Duplicate data in the database as many datasets cut across States/UTs Mismatch of data resolution across States/UTs as data resolution may vary across State/UT levels
Centralized data updating	Single identified national agency responsible for data updating while the States/UTs will provide the required data in format and quality	Single window for data update mechanism will have a control on data uniformity Safe data backup in case required to roll back to older version of data	Dependency on States/UTs to provide the data on time Support of all States/UTs to have completeness and high quality of data
Data update engaging an external organization	Outsource the data update mechanism to a professional organization to which the States/UTs will provide the required data in format and quality	Single window for data update mechanism will have a control on data uniformity The updating process will be handled in a highly skilled manner Safe data backup in case required to roll back to older version of data	The States/UTs may lose interest and ownership of the web risk atlas as they are not involved directly in the data updating activities

References

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Thematic & Cartographic Maps, GIS Databases and Spatial Outputs

Town and Country Planning Organization, Government of India, Ministry of Urban Development, July 2006-National Urban Information System, Design and Standards

National Spatial Data Infrastructure, June 2010- "Data Specifications" – Definition of Annex Themes and Scope

National Spatial Data Infrastructure, June 2009- Metadata Standards for Digital Geospatial data

An ESRI® White Paper, January 2003, Spatial Data Standards and GIS Interoperability

Annexure 1: Global Perspective on Data Standards

GIS standards are publicly available due to the involvement of many organizations in creating, reviewing and publishing these standards. There are a number of organizations working on developing standards to make GIS more accessible and easier to use. The major such organizations are described below:

The Federal Geographic Data Committee (FGDC)

The Federal Geographic Data Committee (FGDC) is an interagency committee that promotes the coordinated development, use, sharing, and dissemination of geospatial data on a national basis. This nationwide data publishing effort is known as the National Spatial Data Infrastructure (NSDI). The NSDI is a physical, organizational, and virtual network designed to enable the development and sharing of nation's digital geographic information resources. FGDC activities are administered through the FGDC Secretariat, hosted by the U.S. Geological Survey.

International Standards Organization (ISO)

The ISO is one of the major standard organizations – which addresses Standards in various topics. The ISO Technical Committee 211 is the specific group that focuses on Geographic Information and Geomatics (www.isotc211.org). This group has membership of 23 member countries and 13 countries as observer status. The ISO TC-211 addresses standardization in the field of digital geographic information and aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. The ISO standards specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations.

Infrastructure for Spatial Information in the European Community (INSPIRE)

INSPIRE is based on the infrastructure for spatial information established and operated by the 27 Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative "regional" approach.

Open Geospatial Consortium (OGC)

OGC is an international industry consortium of 472 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC Standards support interoperable solutions that "geo-enable" the Web, wireless, and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.

Annexure 2: Best Practices of Data Standards in International Risk Initiatives

The team has reviewed the best practice standards followed globally by different organizations in risk management initiatives, such as Hazards United States Multi-Hazards (HAZUS-MH), Central American Probabilistic Risk Assessment (CAPRA), Pacific Risk Information Systems (PacRIS), and the Morocco Natural Hazard Probabilistic Risk Assessment (MnhPRA). The key findings of this review is given below:

Hazus-MH: developed by FEMA is a powerful risk assessment software program for analyzing potential losses from floods, hurricane winds, and earthquakes. In Hazus-MH, current scientific and engineering knowledge is coupled with the latest geographic information systems (GIS) technology to produce estimates of hazard-related damage before, or after, a disaster occurs. The software has served as a benchmark for other similar software development programs outside the United States, which have adopted this framework for specific countries.

The Hazus-MH Geodatabase, reviewed by the project team, gives details of all the data and their attributes related to risk assessment that need to be captured. The database design reflects the multi-hazard nature of the software. Some of the salient features of the database include:

- Data for every type of exposure element is split into four parts. One part has all the common attributes associated to the exposure element and the remaining three parts have hazard specific attributes – one each for earthquake, flood, and cyclone. All the four tables are related by a common key
- Roads have been split into multiple sections, where each section represents the part of the road that is within a Census Tract
- The data captures general information of the roads like name, type, location, length, width, ownership, traffic, and replacement cost
- Structural information of the road/other infrastructure is not captured separately, it is judged based on the type of road
- General information about bridges and tunnels is captured. For bridges, in addition to general information like name, ownership, length, location, etc., there is detailed structural information on bridge structure type, number of spans, skew angle, width, etc.
- The roads, bridges and other infrastructure tables have clustered indexes on the Unique IDs
- Default replacement costs of all types of roads and bridges are present.

CAPRA: CAPRA has consolidated hazard and exposure data organized in Postgres and is widely recommend format for risk assessment applications by UN organizations.

The publicly searchable aspects of the CAPRA database indicate that it contains data related mainly to buildings footprints. Data on other exposure elements are also systematically organized in the database system

- Linear infrastructure features are created in segments and attribute specific to that segments are linked to this.
- All exposure elements that have separate location associated to them should be captured as separate entities

- Taking into consideration of better performance, the features has given Unique ID that represents every element in each entity uniquely and there is a clustered index on this Unique ID

PacRIS: is one of the largest collections of geospatial information for the Pacific island region (15 Pacific island countries) that provides detailed probabilistic risk information for a range of decision makers including disaster risk management agencies. PacRIS contains information and data layers on administrative details, geological maps, hazard maps, building infrastructure details, details about population, buildings, etc. The PacRIS geodatabase follow OGC compliant format with standard metadata, with all defined geodatabase information like ownership, vintage, and project details.

The infrastructure data layers of PacRIS primarily has spatial locations and attributes to assess the size and structural aspects of the infrastructure.

MnhPRA: is an integrated system for identifying and quantifying natural hazard risks based on advanced science and engineering technology. The goal of MnhPRA is to help national and local governments, and communities to estimate the impacts of disasters and further assist the insurance industry in developing catastrophic insurance products. The database of MnhPRA is in Postgres and follow OGC norms. Some of the salient features of the MnhPRA database are:

- All basic layers required for risk assessment – hazard and exposure data are available in each theme as separate layers
- Infrastructure database mainly includes various attributes such as categories type, name, location, dimension (if available), and replacement costs per km
- Linear infrastructure features like roads, rails are stored as multiple segments, and attribute information is linked to each segments

END OF INCEPTION REPORT