Development of Centralized Spatial Database Server for Indian Tsunami Early Warning System

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Abstact: _India is one of the most vulnerable developing countries to suffer very often from various natural disasters, namely drought, flood, cyclone, earthquake, landslide, forest fire etc. Which strike causing a devastating impact on human life, economy and environment, Though it is almost impossible to fully recoup the damage caused by the disasters, it is possible to minimize the potential risks by developing early warning strategies. The recent advancements in space technology and satellite remote sensing playing a crucial role in efficient mitigation of disasters. There is a desperate need of establishing early warning systems in order to raise alerts for taking preventive measures before a natural hazard occurs. One of the dangerous natural hazards for a country like India having a long coastal line is tsunami. On 26th December 2004, the Indian coastline experienced the most devastating tsunami in recorded history and Tsunami inundation in coastal zones caused damage to buildings, infrastructures, as well as properties and poses the threat to lives._

The ITEWS comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR), tide gauges and 24 X 7 operational tsunami warning centre to detect tsunamigenic earthquakes, to monitor tsunamis and to provide timely advisories to vulnerable community by means of latest communication methods with back-end support of a pre-run scenario database and Decision Support System (DSS).The National Tsunami Early Warning Centre at INCOIS is operational since October 2007. The Indian National Tsunami Early Warning Centre started exchanging service level-I earthquake information basically qualitative tsunami advisory about tsunamigenic potential. India is now geared up to provide service level-II bulletins for the Indian Ocean region (based as tsunami numerical modeling and with use of open ocean propagation tsunami scenario data base.) service level-III in this level inundation vulnerability mapping for identified vulnerable regions.

Service level-I was operated in 2007.Service level-II was operated in 2011.Service level-III is initiating now. Here we are using sources for this one is spatial data sets of open ocean propagation tsunami scenario data base. Spatial data sets of coastal inundation modeling inputs: i) identification of high vulnerable coastal regions from MHVM (Multi-Hazard Vulnerability Map), ii) high resolution coastal topography, iii) bathymetry data, iv) observation networks.) Spatial layers of inundation model and respective grids. Centralized spatial data base server. Data reception, data processing, tsunami vulnerability mapping, inundation decision making and tsunami advisory generation .

**Key words: Tsunami, Early warning systems, Decision support systems, Arcsde**

1.INTRODUCTION

Natural disasters are inevitable and it is almost impossible to fully recoup the damage caused by disasters. But it is possible to minimize the potential risk by developing disaster early warning strategies, prepare and implement developmental plans to provide resilience to such disasters and to help in rehabilitation and post disaster reduction. The use of GIS and integration with the modeling results can be served as a successful tool in disaster management as it allows the combination of the different kinds of spatial data, with non- spatial data, attribute data and use them as important information in the various stages of disaster management. Spatial analyses in a geo information system are a widely used approach in emergency planning by providing features to centralize and visually displaying spatial information.

2.OBJECTIVES

- ➢ Optimization of spatial data sets.

- ➢ Development of centralized spatial data base server.

- ➢ Centralized spatial data repository in standard GIS format.

- ➢ Application server with front end GIS application.

- ➢ Outputs from the server giving to DSS system.

- ➢ The following flowchart depicts the procedure followed for the implementation of project

3. METHODOLOGY

- Spatial datasets utilizing in ITEWC have been extracted from different data sources.

- Standardization of all these spatial datasets under one centralized system to maintain persistent storage and appropriate hierarchical data structure with proper version control and meta data information.

- For concurrent editing of these spatial datasets the data has been structured into

Oracle database using ArcSDE and connection has been established between application interface and spatial data.

- To access, update and versioning of all these datasets from multiple clients an interface is developed using Arc engine (Arc objects with java)

- Through DSS digital spatial data dissemination in the form of maps and reports.

The following flowchart depicts the procedure followed for the implementation of project
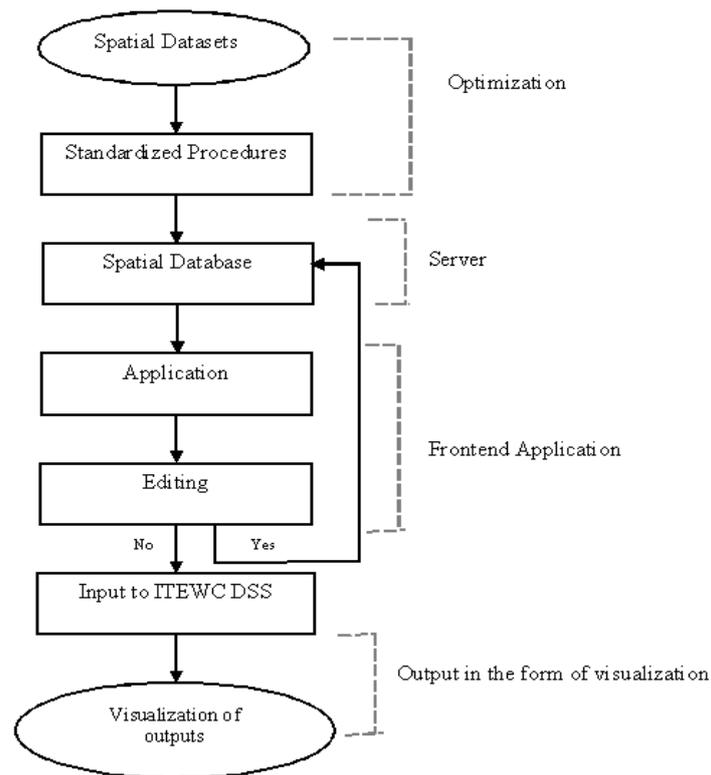
Figure 1: Methodology Flow Chart

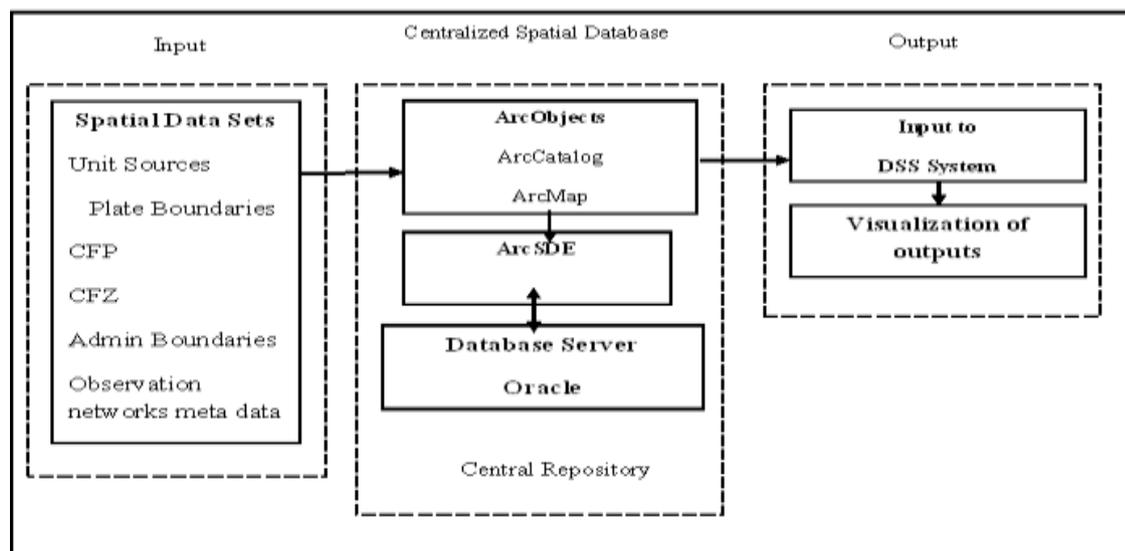## 4. Centralized spatial Database Server

Figure 2: Block Diagram of Components of Centralized Spatial Database Server

Above block diagram depicts the components of the centralized spatial database server .In this project spatial datasets pushed through ArcSDE in to oracle database server. Using ArcObjects we can edit the versions using versioning tool in ArcMap frontend desktop application. This spatial data can be served in to ITEWC DSS System .This spatial datasets will be stored in central repository versioning, editing, etc. All those required operation according to tsunami warning system done through ArcObjects.

In this central repository, the interlinking between the spatial database are maintained in such a way that any changes in any one of the spatial meta data layer reflectes in other inter related spatial layers. For instance if the plate boundaries got updated versioning will be added existing spatial layers intern creates new version of unit sources. In similar way the inter linkage between other layers such as CFP's,CFZ's,…etc can be constantly maintained through the centralized database, essentially meets the main objective of this project.

4.1 Procedure for inserting data into ArcSDE

- **Connecting to a spatial database with an ArcSDE service**

These instructions allow you to connect to an ArcSDE enterprise geodatabase using an ArcSDE service. Instructions for connecting directly to an ArcSDE geodatabase are covered in the "Adding a direct connection to..." sections.

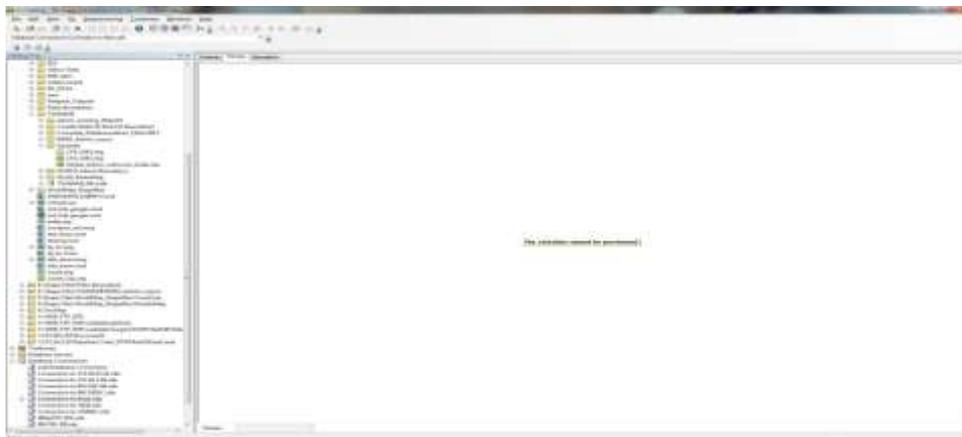1. Click the Database Connections folder in the Catalog tree.

Figure 3: Showing the Database Connections folder in the Catalog tree

2. Double-click Add Spatial Database Connection to open the Spatial Database Connection Properties dialog box.
3. Type the name or Internet Protocol (IP) address of the server to which you want to connect in the Server text box.
4. Type the name or port number of the service to which you want to connect in the Service text box.
If you want to connect to a geodatabase in a user's schema in an Oracle database, type the port number and schema in the Service text box separated by a:; for example, 5153:daisy.
5. If the data is stored in a SQL Server, IBM DB2, Informix, or PostgreSQL RDBMS, type the name of the database to which you want to connect in the Database text box. If the data is stored in Oracle, skip this step.
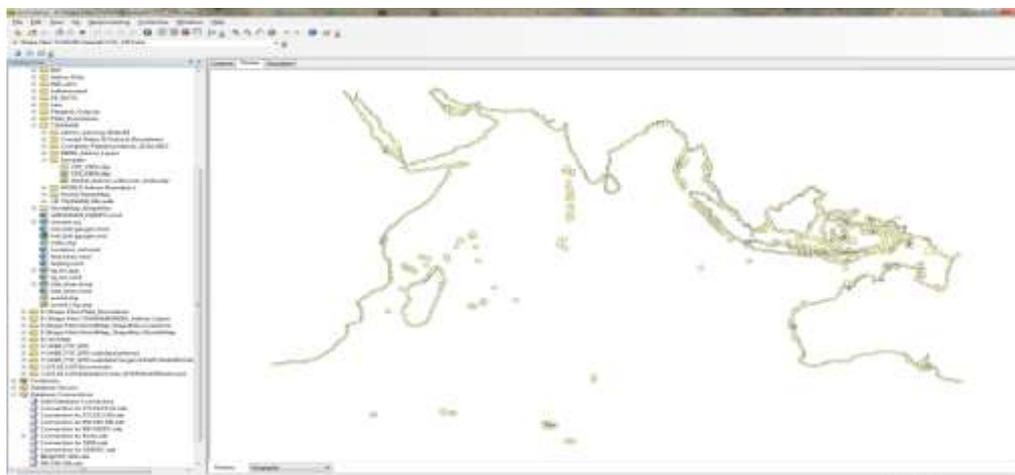

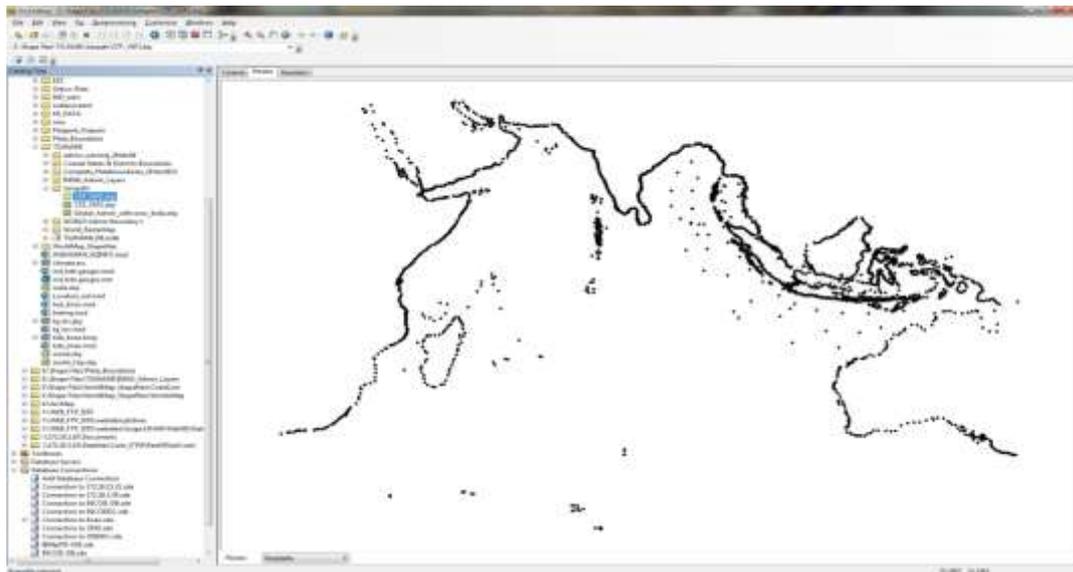**Figure 4: Adding CFZ to open the Spatial Database Connection in ArcCatalog**

Figure 5: Adding CFP to open the Spatial Database Connection in ArcCatalog

6. If using database authentication, type your user name and password for the database. If you don't want to save the user name and password with this connection file, uncheck Save username and password.

Figure 6: Connecting to a spatial database with an ArcSDE service in ArcCatalog

7. If using operating system authentication, click the Operating system authentication button. The database authentication information becomes unavailable.

8.If you are connecting to a geodatabase in a user's schema in an Oracle database or to a dbo-schema geodatabase in SQL Server, you must change the version to which you are connecting by clicking Change in the Connection details section and choosing the geodatabase from the list of transactional versions. For details on connecting to a specific version of a database, see Connecting to a specific version of the database.
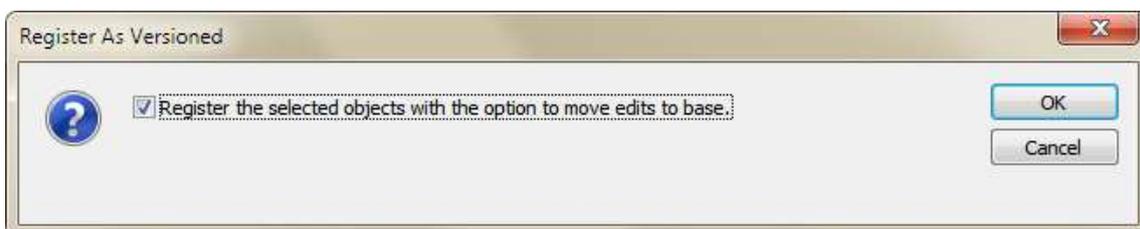

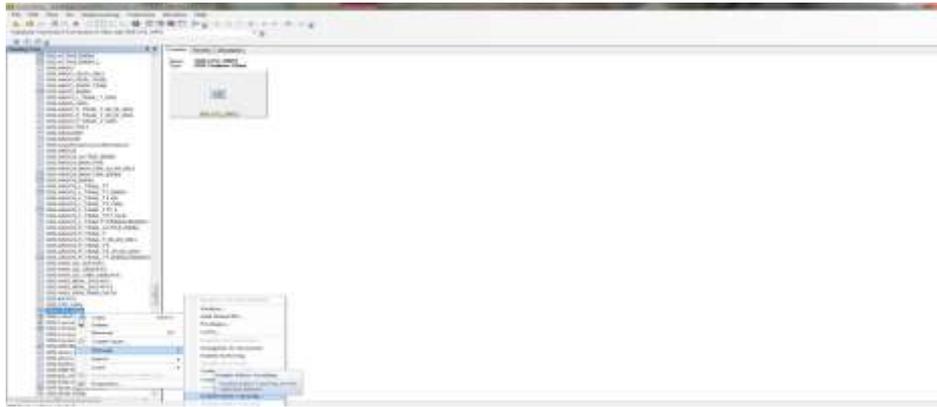**Figure 7: Versioning option enabled in ArcCatalog**

Figure 8: Editor tracking Option Enabled in ArcCatalog

9. If you do not want to save the version connection information you provided in the last step, uncheck Save the version with the connection file.

10. Click Test Connection.

If the test is successful, the button becomes unavailable. If the test fails, you are unable to retrieve data until you've provided the correct information or the database problem has been resolved.

11. Click OK.

12. Type a new name for the database connection.

13. Press Ok.

3.2.2 User Interface for accessing and editing of spatial datasets

3.2.2(a) Open a SDE connection with the server API

The following code example uses ArcObjects to connect directly to ArcSDE and get datasets rather than using the MapServer object to get the ArcSDE layers in a map.

- Create a WorkspaceFactory object in the server's context. See the following code example:

[Java]

```
IWorkspaceFactory pWorkspaceFactory = new IWorkspaceFactoryProxy

(context.createObject("esriDataSourcesGDB.SdeWorkspaceFactory"));
```

- Create an instance of a PropertySet for an Oracle ArcSDE connection. The PropertySet acts as an array of keyed values that ArcSDE uses from which to collect the connection values. See the following code example:

[Java]

```
PropertySet propSet = new PropertySet(context.createObject("esrisystem.PropertySet"));

propSet.setProperty("SERVER", "Kiran");

propSet.setProperty("INSTANCE", "INCOISDC");

propSet.setProperty("DATABASE", "");

propSet.setProperty("USER", "sde");

propSet.setProperty("PASSWORD", "sde");

propSet.setProperty("VERSION", "SDE.DEFAULT");
```

4.2 Generation of standardized spatial database for ITEWC

4.2.1Versioning and organization of spatial datasets with SDE

4.2.1(a) What Is Versioning

Versioning is the mechanism that enables concurrent multiuser geodatabase editing in ArcSDE geodatabases. It uses an optimistic concurrency data-locking model, which means no locks are applied to affected features and rows during long transactions. It is the default editing environment in enterprise ArcSDE geodatabases and supports complex editing workflows that are required by enterprise GIS systems.

Versioning records and manages states of individual features and rows as they are edited while preserving integrity in the database. It is the basis for multiple users accessing and editing data simultaneously in enterprise ArcSDE geodatabases. Conceptually, a version of the geodatabase represents an alternative, independent, persistent view of the geodatabase. It supports multiple concurrent editors and does not involve creating a copy of the data. A version references a specific state of the geodatabase. It contains all the datasets in the geodatabase and evolves over time. Users access data in an enterprise ArcSDE geodatabase through a version. Behind the scenes, simple queries in the underlying DBMS are used to view and work with the referenced state for a particular point in time or to see an individual user's current edits.

4.2.1(b) Creating versions

The following figures show the version manager tool to create versioning. In this figure we can observe the Sealevel meta data
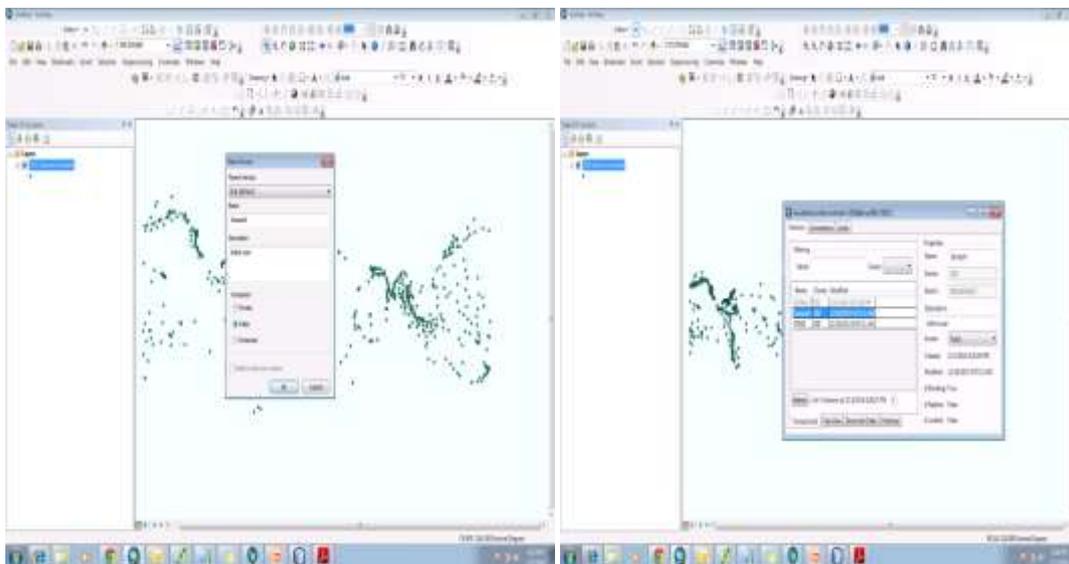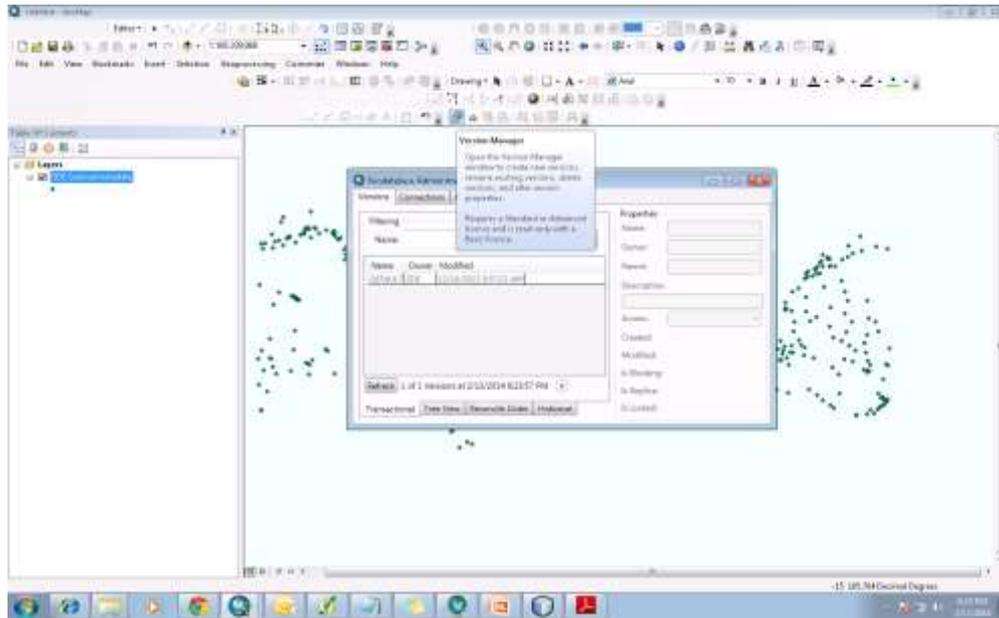

Figure 9: Creating new version in ArcMap

4.2.2 The version editing process

The following figure shows the version editing tool to edit the versions
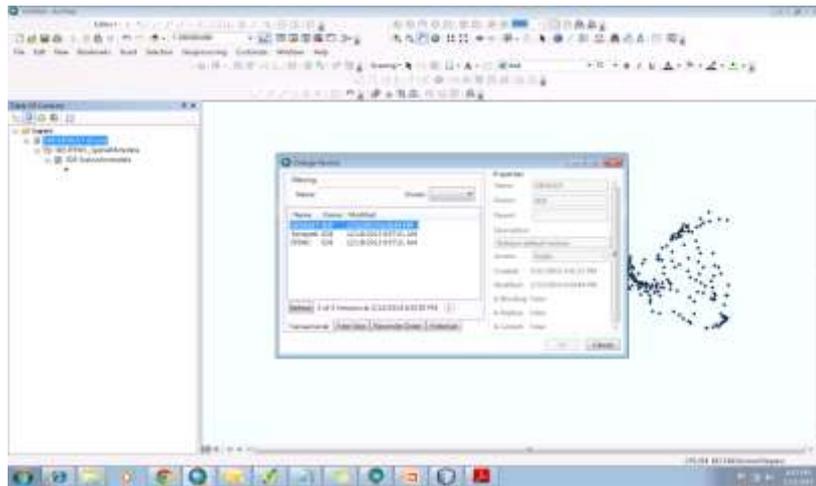
Figure 10: Figure depicts the version editing in ArcMap

The following figure shows comparing edited version and non edited version .In this project comparing sea level metadata of ITEWC (non edited) version with version 2 (edited)
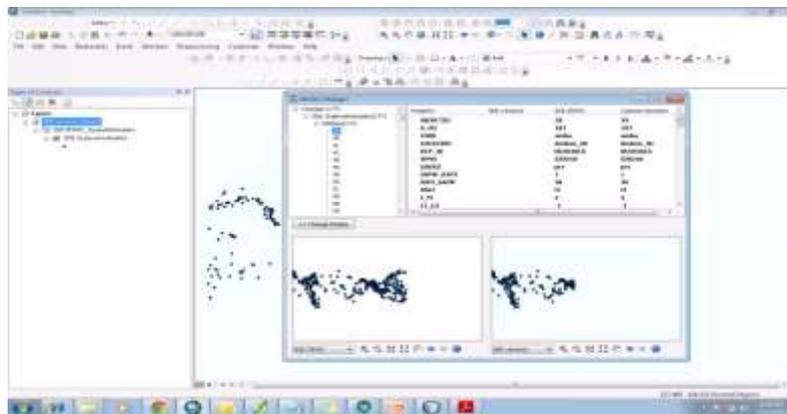

Figure 11: Comparing parent version (ITEWC) with child version (Version 2) in ArcMap

5. RESULTS:

The concept of Tsunami early warning system and visualization of model outputs was discussed in methodology chapter and further, results obtained from model execution, spatial analysis of outputs, concept preparation of base data for global unit sources, CFZ, and CFP's are discussed in this chapter

Following figures 12, 13 shows the Global Unit sources constructed for entire Global ocean region and Indian Ocean region.
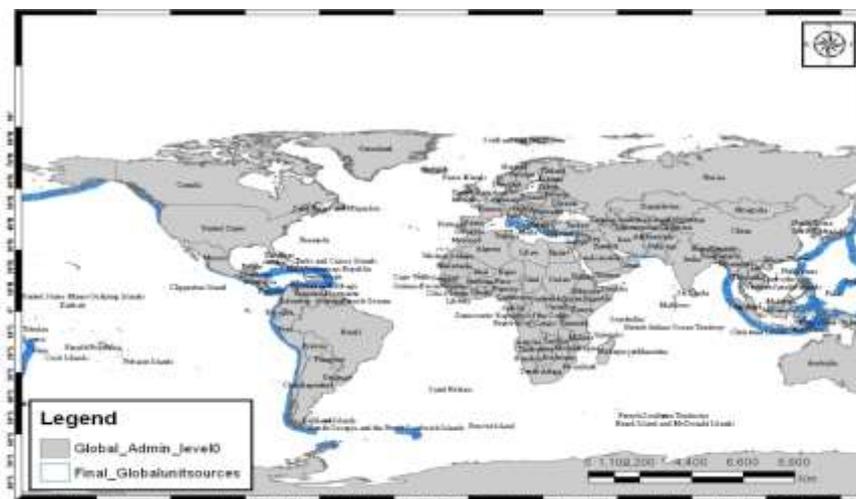

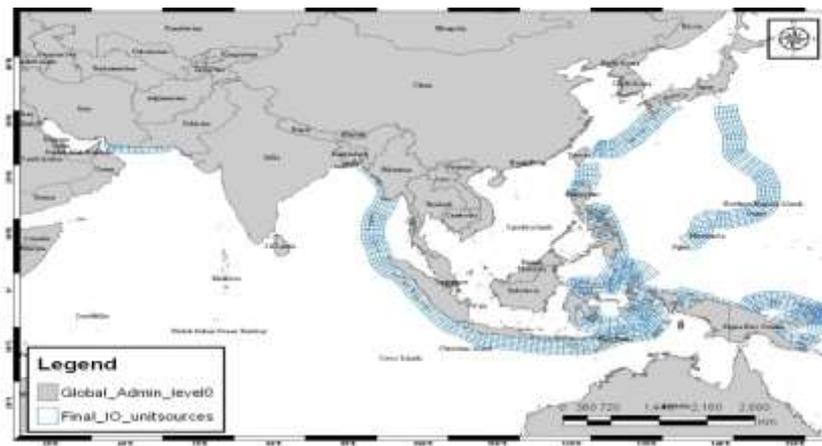
Figure 12: Unit Sources for Global Ocean

Figure 13: Unit Sources for Indian Ocean

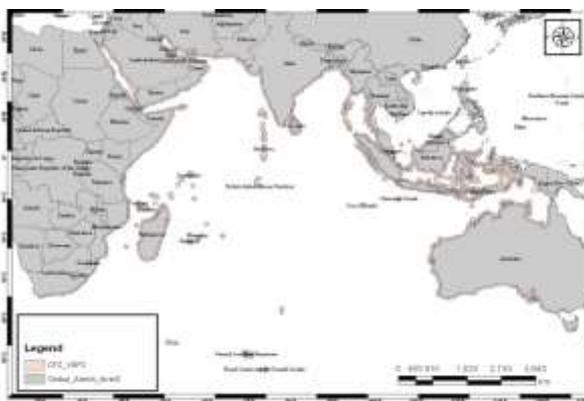The following figure 14 shows the Coastal forecast zone (CFZ version 5.2)

Figure 14: Coastal Forecast Zone

The following figure 15 shows the Coastal forecast points (CFP version 5.2)
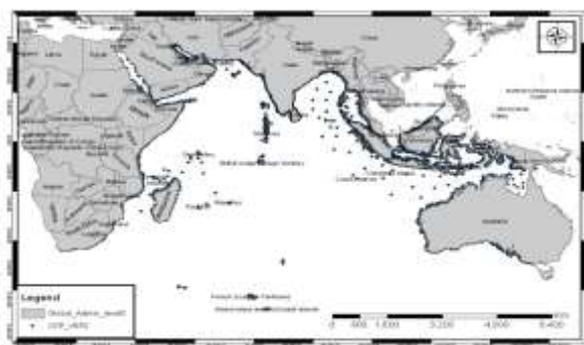

Figure 15: Coastal Forecast Points

5.1 DSS Outputs for Simulated Event in Indian Ocean

The following figure 16 shows the Tsunami travel time contours with 30 min interval.
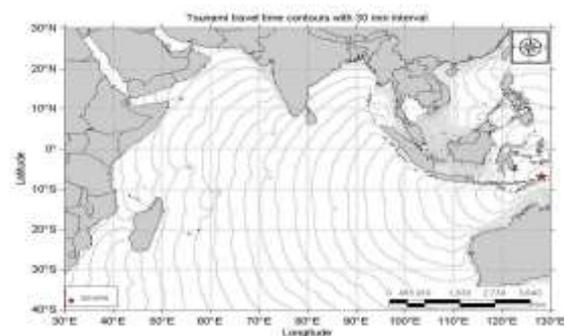

Figure 16: Tsunami travel time contours with 30 min interval for hypothetical event

The following figure 17 shows the earthquake location magnitude with different magnitudes.
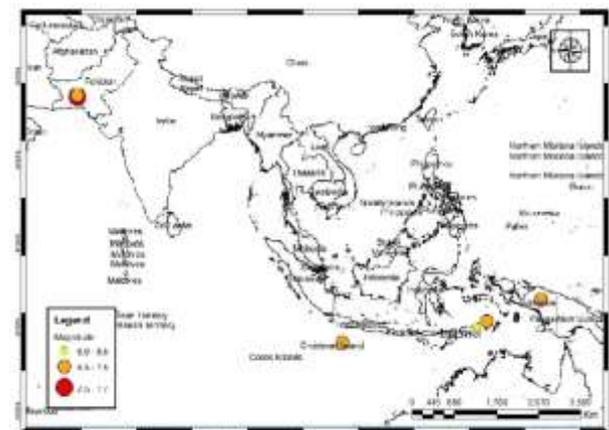

Figure 17: Location of earthquake of magnitude7.5 and other magnitudes

The following figure 18 shows the Directivity grid obtained by taking the maximum cell values from all the inundation model output grids. From the figure we can see that the Directivity map for Makran magnitude of 9.0. In this image Red colour represent that he region under WARNING and THREAT, Vessels should move into deep Ocean.. Orange colour represent that the regions under ALERT.Green colour represent that the region under WATCH and NO THREAT
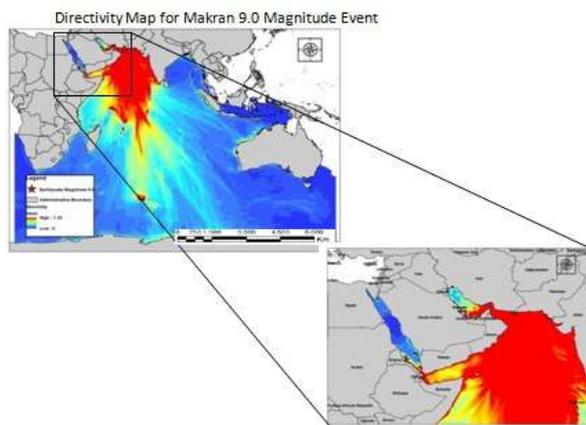
Figure 18: Directivity Map for Makran 9.0 Magnitude for hypothetical event

The following figure 19 shows the threat map for Makran magnitude of 9.0. In this image for regions under THREAT (RED), public should be advised to move in-land towards higher grounds. Vessels should move into Deep Ocean. For regions under NO THREAT (Green), no immediate action is required
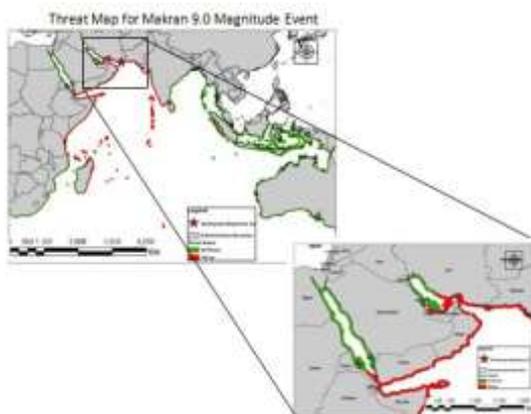

Figure 19: Threat Map for Makran 9.0 Magnitude for hypothetical event

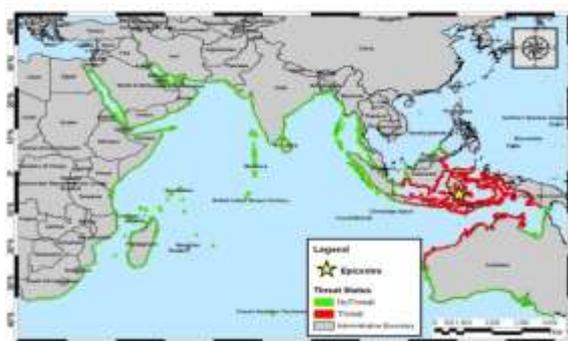The following figure 20 shows the Threat Status Map for a simulated event

Figure 20: Threat Status Map for a simulated event

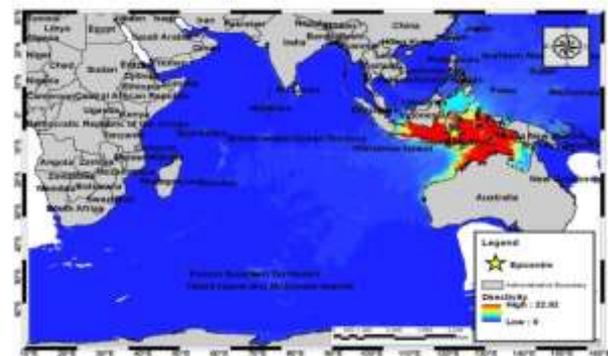The following figure 21 shows the Directivity Map for a simulated event

Figure 21: Directivity Map for a simulated event

Figure 22: Map depicting threat levels for RTSP estimated according the standard operating procedure

6. CONCLUSION:

The methodology implemented in the present study serves as a base foundation for centralized spatial meta database in order to extent the current operational services of ITEWC services from regional to global level.

The customized GIS interface developed in the present study is of open source and serves as a quick viewer to spatially visualize the model outputs without opting for proprietary GIS software. It can perform all basic vector querying and Raster analysis.

The inter linkage between spatial layers in central repository is essential and critical to upgrade existing service to global level. The same functionality plays major role to meet the constant improvements and up gradation in DSS requirements. With this project above discussed requirements are well addressed by the implementation of centralized spatial database server.

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http://tsunami.incois.gov.in/ITEWS/seismic.jsp
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www.idsemergencymanagement.com