1 Objective of the Study

The objectives for this study are:

- Developing high resolution risk information for hydro meteorological hazards (cyclone, fluvial flood, storm surge, urban flood, and tsunami) geophysical hazards (earthquake, landslides) and industrial hazards (industrial fire, toxic release and explosion) for the State.
- Creating a digital ôRisk Information Systemô for the State which comprises data, fineï resolution high fidelity models, and risk information for hydro meteorological hazards (cyclone, flood, storm surge, urban flood, drought and dam breach) geophysical hazards (earthquake, landslides, tsunami) and industrial hazards (industrial fire, toxic release and explosion).
- Development of operational forecasting models and commissioning of integrated operational forecasting system for hydro-meteorological hazards (cyclone, flood, storm surge, and drought) and forecast based real-time inundation models for fluvial flooding, cyclone induced flooding and urban flooding in select cities/towns
- Training of government agencies in the communication, use and application of risk information and improving their understanding of how risk information can be improved through time.

2 Scope of the Study

This Consultancy will support the State Govt through the following components:

1. Development of input datasets for probabilistic and deterministic hazard assessment at State, district, block and village level for hydro meteorological hazards (cyclone, flood, storm surge, urban flood, and tsunami) and block level or finer for geophysical hazards (earthquake and landslides) and industrial hazards (industrial fire, toxic release and explosion).
2. Development of exposure datasets and vulnerability at State, district, block and village level.

3. Development of probabilistic dynamic 1D, 2D and combined models for hydro-meteorological hazard forecasting (Flood, Cyclone, Storm surge) with inputs from automated telemetry sensors installed across the State
4. Development of the hazard layers at State, district, block and village level for hydro meteorological hazards (cyclone, flood, storm surge, urban flood, drought and tsunami), block level or finer for geophysical hazards (earthquake, landslides, tsunami) and industrial hazards (industrial fire, toxic release and explosion)
5. Probabilistic and deterministic risk analysis for hydro meteorological hazards (cyclone, flood, storm surge, urban flood, drought) geophysical hazards (earthquake, landslides, tsunami) and industrial hazards (industrial fire, toxic release and explosion) at the State, district, block and village level.
6. Development of a digital ôRisk Information Systemô for the State which comprises hazard and risk information for the different hazards.
7. Develop catastrophe models to project the financial consequences of potential disasters to quantify the financial impacts
8. Develop forecasting system for hydro-meteorological hazards (cyclone, flood, storm surge, urban flood, drought) to provide real-time warning with longer lead time (72 hours)
9. Integration of probabilistic and deterministic models with Risk information system and weather forecast from national and international agencies to develop integrated operational forecasting system for hydro-meteorological hazards (cyclone, flood, storm surge, urban flood, drought) in the State
10. Engagement with Disaster Management Department on the development of the hazard, impact and risk information, and the communication of the risk results

Component 1: Development of input datasets for probabilistic and deterministic hazard assessment at State, district, block and village level for hydro meteorological hazards (cyclone, flood, storm surge, urban flood, drought and tsunami), block level or finer for geophysical hazards (earthquake, and landslides) and industrial hazards (industrial fire, toxic release and explosion)

Objective

To collect all hazard input datasets, and to update/modify datasets as necessary for use in probabilistic and deterministic hazard assessments.

Activities

1. Compile available historical datasets on the hazard extents and the impacts of major historical natural disaster events in the State, based on the review of scientific and historical studies, and for the purpose of validating risk results.
2. For the seismic hazard assessment:
    a. Collect earthquake input datasets and undertake proper quality assurance and quality checking. This will include, but will be not limited to, a cleaned historical earthquake catalogue, seismic sources (fault lines and area sources) that generated events in historical times with information on activity level, depth and traces, other seismic sources (e.g. identified fault lines), strong ground motion records, micro-zonation studies, shear wave analysis, GPS strain measurements, 3D basin model etc.
    b. Update and modify earthquake input datasets as necessary to ensure the datasets are as complete as possible, including potential addition of global datasets such as GEM Faulted Earth, earthquake catalogues from other geophysical monitoring agencies (e.g., literature survey; AmbraseysEq catalogue, USGS, etc.).
    c. Collect and integrate ancillary hazard GIS data from a range of stakeholders including: surface soil and geology maps, micro-zonation studies, digital elevation data (topographical maps).
3. For the flood hazard assessment:

    The focus of this study will be on fluvial flooding and should use a hydrologic and hydraulic modeling approach and generate1D, 2D and combined flood simulation model and flood risk curves. For the fluvial flood hazard assessment, the following datasets should be collected in GIS format and used:

    a. Hydro-metrological input datasets: rainfall data and associated statistical analysis, hydrographs for relevant rivers, etc.

b. Base datasets: DEM, river bathymetry/cross sections, watersheds etc.
c. Flood management infrastructure: including dams, dikes, levees, pumping stations etc.
d. Urban morphology for urban flood inundation
e. Input data sets to generate site specific dynamic flood forecasting model for major river basins

4. Collect input datasets necessary to generate landslide susceptibility maps for the State, including but not limited to slope, geology and soil characteristics, snow and rainfall intensity, seismicity, historical mass movement etc.

5. Collect input datasets necessary to generate susceptibility maps for industrial hazards, including:
   a. Sources and type of major industrial and environmental hazards.
   b. Details of Hazardous chemicals used, processed, produced and transported by MAH Units in the State
   c. Location of industrial facilities, industrial zones, hazardous and bio-medical waste sites, debris dumping sites, effluent releasing sites etc.
   d. Historical data on extent and impact of major historical industrial hazard events.

6. Collect input datasets necessary to generate hydrodynamic tsunami inundation modelling and storm surge inundation modelling, including but not limited to high resolution coastal topography, coastal morphology, bathymetry and tide gauge data, historical storm surge height data

7. Collect input datasets necessary to generate probabilistic dynamic tropical cyclone model, statistical model and trajectory model. Inputs necessary to generate cascading storm surges from cyclone and cyclone induced inland flooding, including but not limited to historical cyclone track and intensity, topography, bathymetry, surface roughness/land use
   a. Database of cyclone track, frequency, locations of land fall, maximum pressure deficit, surface wind associated with each track etc
   b. Historical data on extent and impact of cyclone and storm surge events.
   c. Input data sets to create dynamic numeric models for cyclone and storm surge forecasting and associated landward inundation in Coast

8. Collect input datasets necessary to generate Drought risk assessment framework using various indices from soil moisture, precipitation, crop, water stress, vegetation etc
9. Develop a short technical report describing the data collected, their limitations and provide recommendations on how these datasets could be progressively improved through time and the resources necessary to do this.

Expected outputs

1. Historical data on disaster footprints and impacts, collected for the purpose of validating risk results.
2. All databases and catalogues that form inputs into the probabilistic seismic hazard assessment, including:
    a. Seismic Source Model:
        i. Geo-referenced fault database with associated attributes based on existing information (including activity level, depth and traces, representative slip behavior, any recurrence information).
        ii. Consistent, statistically complete earthquake catalogue (Mw, earthquake recurrence and maximum magnitude).
        iii. Development of Frequency-Magnitude (G-R) relationships.
    b. Ground Motion Model:
        i. Strong Ground Motion Data and justification of selection of Ground Motion Model based on scientific debate and consensus.
        ii. Crustal velocity structure information.
    c. Site Response Model:
        i. Maps of near surface geology (site classes).
        ii. Shear wave velocity for the top 30 m of geology (Vs30) ï proxies can be used if no shear wave analysis exists.
        iii. Micro-zonation studies.
        iv. Other dynamic soil properties such as shear modulus and damping ratio for possible site amplification analysis when available.

3. All datasets that form inputs into probabilistic flood hazard assessment with, ID, 2D and combined models, including:
    a. Hydro-metrological input datasets: rainfall data and associated statistical analysis, hydrograph datasets for relevant rivers etc.
    b. Base datasets: high resolution DEM, river bathymetry, water sheds etc.
    c. Flood management infrastructure: including dams, dikes, levies, pumping stations etc.
    d. Urban morphology for urban flood inundation modeling
    e. 1D, 2D and combined model to predict flood inundation extent, depth, arrival time and duration in flood plains
4. Input datasets for landslide susceptibility mapping, including but not limited to, slope, geology and soil characteristics, snow and rainfall intensity, seismicity, historical mass movement etc.
5. Input datasets necessary to generate susceptibility maps for industrial hazards, including:
    a. Sources and type of major industrial and environmental hazards.
    b. Details of Hazardous chemicals used, processed, produced and transported by MAH Units in the State
    c. Location of industrial facilities, industrial zones, hazardous and bio-medical waste sites, debris dumping sites, effluent releasing sites etc.
    d. Historical data on extent and impact of major historical industrial hazard events.
6. All data set necessary to generate statistical an
7. statistical and parametric Cyclone Risk Model to simulate the impact over the predicted cyclone track from IMD, ISRO and JTWC; including but not limited to high resolution topography, historical track data and damage data
8. Input datasets necessary to generate hydrodynamic tsunami inundation modelling and storm surge inundation modelling, including but not limited to high resolution coastal topography, coastal morphology, bathymetry and tide gauge data, historical storm surge height data
9. All data sets necessary to generate real-time forecast models for flood, cyclone and storm surge
10. All data sets necessary to generate drought indexes for the past 20 years

11. All datasets developed under this Component are to be transferred onto the Digital Risk Database for the State ï developed under Component 5 ï in an agreed format (and adhering to agreed guidelines).
12. A short technical report describing the collected data, its limitations and recommendations to improve datasets progressively through time.

Component 2: Development of exposure datasets and vulnerability at State, District, Block and Village level

Objectives

- To build a geo-spatial exposure database defined as population, residential buildings, government buildings, transport infrastructure (roads, bridges, airports, etc.) and critical infrastructure / facilities (hospitals, schools, telecommunication facilities, power stations, etc.) in the State.
- To characterize the physical vulnerability of residential, government buildings, exposed population, transport infrastructure and critical infrastructure / facilities to hydro-meteorological hazards, geophysical hazards and industrial hazards.

Activities

1. Population Data: This involves the compilation of a geospatial database of population, including available detail such as gender, age, income level, ethnicity (caste, religion, language, etc.) and other socio-economic indicators.
2. Residential Buildings: This involves the compilation of a geospatial database of residential buildings and structures, including available detail such as number of stories, floor area, inhabitants per building, date and materials of construction, and replacement value. If possible, buildings should be characterized by attributes such as detailed in the GEM Taxonomy, and be mapped to other typologies indicated in NBC. <u>It is not expected that this will be a building by building database but rather a statistical approach to characterizing residential exposure at the block or finer level (depending on data availability).</u>

3. Government Buildings: Consultant shall compile a geospatial database of government (non-military) buildings. Buildings should be characterized by the same attributes as employed for the residential database, supplemented as appropriate for the special characteristics of different government buildings.
4. Infrastructure: A geospatial database should be compiled containing selected transport infrastructure:
    a. Roads and bridges: information on primary (and where data is available secondary) paved and unpaved public roads (classified ï national, state, district, ODR, rural etc.) and bridges (with as much information as possible on the number and size of spans, type of bridge, material, date of construction) shall be compiled.
    b. The location and relevant data on airports should also be included.
5. Critical Infrastructure / Facilities: Compilation of a geospatial database of selected critical facilities:
    a. Critical Buildings such as hospitals, schools, police stations, food warehouses, etc. should be characterized by the same attributes as employed for the residential database, supplemented as appropriate for the special characteristics of different critical buildings.
    b. Critical Infrastructure such as water and electric networks, telecommunication networks, critical roads for evacuation, etc. should be characterized by the same attributes as employed for the infrastructure database including replacement value, supplemented as appropriate for the special characteristics of different critical infrastructure
6. The Consultant should develop vulnerability functions that relate mortality and morbidity for populations, and damage state and loss of monetary value for physical assets, to varying levels of hazard intensity for hydro-meteorological hazards and geophysical hazards. An example vulnerability function would be a curve, tabulated data or equation that quantified cost of repairs to a house as a function of flood water level. Vulnerability functions may be based on engineering analysis, empirical data or expert opinion, but in all cases shall be appropriate to construction and conditions in the State.

The compilation of exposure layers should employ an optimal combination of collation of existing datasets, remote sensing techniques (if appropriate) and statistical approaches which provides a low cost, rapid and accurate method for compiling asset location and attribute information. The Consultant may elect to use crowd sourcing / community mapping to develop building exposure information for exposed buildings as well as secondary roads, particularly in urban environments. This could also be expanded to include the collection of residential buildings. If this approach is to be employed the Consultant should include this approach in their proposal.

Expected outputs

1. A technical report that describes:
    a. The building typologies of government and residential buildings and critical infrastructure / facilities in the exposure database.
    b. The vulnerability curves with detailed mathematical formula (e.g., asset-based vulnerability curves, population based vulnerability curves) for each exposure typology.
    c. Replacement costs and the costs associated with partial/full retrofit and bracing required to improve seismic resilience of residential and government buildings and critical infrastructure / facilities.
2. GIS data layers for each aspect of exposure outlined above ï including appropriate metadata ï to be shared on the Digital Risk Database for the State (developed under Component 5).

Component 3: Development of the hazard layers at State, district, block and village level for hydro-meteorological hazards (cyclone, fluvial flood, storm surge, urban flood, and tsunami), block level or finer for geophysical hazards (earthquake, landslides) and industrial hazards.

Objectives

- To create GIS-compatible probabilistic hazard layers for hydro-meteorological and seismic hazards at the State, district and block or finer level for the State, using state-of-the-art open-source flood, storm surge, cyclone, tsunami, and earthquake modelling methodologies and the datasets compiled in Component 1.
- To create GIS-compatible deterministic layers of landslide, urban flood and industrial hazard susceptibility at the State, district and block level or finer level for the State, using the datasets compiled in Component 1.
- To crate numerical forecasting models for hydro-meteorological hazards (flood, cyclone and storm surge) for real-time modelling using inputs from Component 1, data from telemetric sensors and real time weather information from National and international agencies

Activities

1. Hydro-meteorological and Geophysical hazard analysis, producing probabilistic hazard layers for floods, cyclone, storm surge, tsunami and earthquakes, using state-of-the-art open-source hazard modelling methodologies and the datasets compiled in Component 1.
    a. The hazard layers should define the regions susceptible to events with return periods ranging from 5 to 1,000 years ï including, at the least, the 5, 10, 25, 50 and 100 year return periods.
    b. The probabilistic flood hazard analysis needs to be carried out for current day climate and for climate projections for 2050 using downscaled GCM models.
    c. The hazard layers should include information on the expected intensity for the return period events:
        i. For floods, tsunamis and storm surges: contours for water depth in meters and/or centimeters.
        ii. For earthquakes: contours for PGA and MMI.
    d. Hazard layers should be produced at the State, district, block and village level or finer level with T1, T2, T3é .T5 time scales and inundation speed.
    e. Advanced deterministic 2-D fully-dynamic physically-based hydraulic model for fluvial flood, urban flood, storm surge and tsunami

2. Development of numerical models to predict site specific hydro-meteorological hazards and cascading effect with inputs from Component 1, data from telemetric sensors and situation updates from National and international agencies
3. Development of susceptibility maps of landslides, Urban floods and industrial hazards at the State, district and block level or finer level, using the datasets compiled in Component 1. The hazard layers should include information on the contours for susceptibility levels.

Expected outputs

1. A set of GIS-compatible hazard layers for floods and earthquakes
    a. The hazard layers should define the flood and earthquake prone areas for return periods ranging from 5 to 1,000 years ï including, at the least, the 5, 10, 25, 50 and100 year return periods ï for current day and future climate projections in 2050.
    b. The hazard layers should include information on the expected intensity of the return period event:
        i. For floods: contours for water depth in meters and/or centimeters.
        ii. For earthquakes: contours for PGA and MMI.
    c. Hazard layers should be produced at the State, district and block level or finer with different time scales
2. A set of GIS-compatible hazard layers for landslides, flash floods and industrial hazards
    a. The hazard layers should define the areas susceptible to landslides, flash floods and industrial hazards, and should include information on contours for susceptibility levels.
    b. Hazard layers should be produced at the State, district and block level and village.
3. All hazard layers developed under this component ï including appropriate metadata ï have to be shared on the Digital Risk Database (developed under Component 5).
4. Advanced numerical models to predict site specific hydro-meteorological hazards and cascading effects with real-time input data as explained in activity 2 above
    a. For cyclone
5. A technical report (20 page maximum) describing in an organized and systematic

fashion, the modeling methodology and datasets used to develop the stochastic event catalogs and the hazard layers for all hazards. The Consultant should address limitations in methodologies and identified gaps in the report.

Component 4: Probabilistic and deterministic risk analysis for hydro-meteorological hazards (cyclone, fluvial flood, storm surge, urban flood and tsunami) geophysical hazards (earthquake, landslides) and industrial hazards at the State, district and block level or finer level

Objective

To undertake the impact and risk analysis for cyclones, storm surges, earthquakes, floods, landslides, urban floods, tsunamis, and industrial hazards at the State, district, block and village level, using state-of-the-art open-source hazard specific risk modelling methodologies and data sets compiled in earlier Components.

Activities

1. Assessment of probabilistic losses due to cyclone. The consultancy firm to perform Statistical Analysis and Modeling of Landfall Data and Track to generate swath of destructive winds and to aggregate the probabilistic estimate of severe wind over a defined area. This will provide a portfolio analysis of the potential losses from cyclones to: residential structures disaggregated to appropriate levels for State, district, block and village level assessments (including estimates of mortality and morbidity), government buildings, state-level transport infrastructure and critical infrastructure / facilities. Analysis of direct loss for the different return periods, probable maximum loss and annual average loss should be provided.
2. Assessment of probabilistic losses due to earthquake. This will provide a portfolio analysis of the potential losses from earthquakes to: residential structures disaggregated to appropriate levels for State, district and block level assessments (including estimates of mortality and morbidity), government buildings, state-level transport infrastructure and critical infrastructure / facilities. Analysis of direct loss for the different return periods, probable maximum loss and annual average loss should be provided.
3. Assessment of probabilistic losses due to fluvial flooding. This will provide a portfolio

analysis of the potential losses from fluvial flooding to: residential structures, government buildings, state-level transport infrastructure and critical infrastructure / facilities. Analysis of direct loss for the different return periods, probable maximum loss and annual average loss should be provided.

4. Assessment of probabilistic losses due to tsunamis and storm surges. This will provide a portfolio analysis of the potential losses from tsunamis and storm surges to: residential structures, government buildings, state-level transport infrastructure and critical infrastructure / facilities. Analysis of direct loss for the different return periods, probable maximum loss and annual average loss should be provided.
5. Analysis of residential and government buildings, transport infrastructure and critical infrastructure / facilities in areas with high susceptibility to landslides, urban floods and industrial hazards. This will provide estimates of exposure of population, residential and government buildings, transport networks and critical infrastructure / facilities to landslides, urban floods and industrial hazards.
6. For flood, cyclone, tsunami, storm surge and seismic hazards, critical ñhot-spotò urban areas should be identified with high vulnerability for communities at risk.
    a. For both of the hazards 5 ñhot-spotò urban areas need to be selected for further elaboration of the impacts of events on residential and government buildings, transport infrastructure and/or critical infrastructure / facilities.
    b. Based on the detailed impact assessments, the Consultant should develop risk mitigation, planning and emergency response strategies for the identified ñhot-spotò urban areas (such as land use planning, shelter siting, evacuation routing, seismic retrofitting, flood protection, etc.).
7. Loss estimates developed in Activity 4 above shall be validated by comparison with data from historical events.

Expected outputs

1. A short summary report on the risk profiles for State, district and block level or finer (e.g. hazards, population losses, direct damage losses, annual average loss and probable maximum loss and infrastructure disruption).
2. Results of probabilistic risk analysis for flood, cyclone, tsunami, storm surge and

earthquake.

3. Results of analysis of population and assets exposed to landslides, urban floods and industrial hazards.
4. Cyclone and flood impact analysis for 10 ñhot-spotò urban areas for floods and earthquakes, including risk mitigation, planning and emergency response strategies for the identified hot-spots.
5. All results developed under this component ï including appropriate metadata ï have to be shared on the Digital Risk Information Database for the State.

Component 5: Development of a Digital Risk Information System Data base for the State which comprises hazard and risk information for the different hazards

Objectives

- To develop a Digital Risk Database for the State which comprises data and risk information for Cyclones, fluvial flood, urban flood, tsunamis, storm surges, earthquakes, landslides, and industrial hazard.
- To provide the necessary technical support to the Disaster Management Department to ensure the use of the Digital Risk Database after its initial set-up.

Activities

1. Installation of a GeoNode or equivalent open-source, web and GIS-based platform that will function as the Digital Risk Database for the State.
    a. The Consultant will provide hosting recommendations (remote vs. in-country) and necessary support during the procurement process.
    b. The software will be customized, based on user requirements, to achieve basic branding goals including relevant logos, the name and description of the digital Risk Information System, and a custom theme. The theme should include a categorical entry point to the available tools of the portal, including at least entry points to spatial tools and maps, the spatial data catalogue and a knowledge sharing entry point which provides a user-friendly content management system

to upload experiences, images and videos and navigate this user-generated content on a map interface.

c. The Digital Risk Database will be integrated with Crisis Management Information system for disaster mitigation and management activities and as such it will be used for both static pre-event planning and dynamic response needs. The Consultant will ensure that the design of the digital Risk Information System database allows functionalities for decision support for pre-event planning and in dynamic response needs.

2. Together with Disaster Management Staff the Consultant will populate the digital Risk Information System database with the hazard and risk information developed under the earlier components.
    a. Spatial data layers:
        i. Historical data on disaster footprints and impacts.
        ii. Input datasets for probabilistic fluvial flood, cyclone, tsunami, storm surge and earthquake risk assessments.
        iii. Input datasets for susceptibility mapping for landslides, urban floods and industrial hazards.
        iv. Exposure data layers.
        v. Fluvial flood, cyclone, tsunami, storm surge and earthquake hazard layers.
        vi. Susceptibility maps for landslides, urban floods and industrial hazards.
        vii. Probabilistic flood, cyclone, tsunami, storm surge and earthquake risk maps.
    b. Non-spatial data, such as vulnerability curves.
    c. All uploaded data should include metadata. The metadata should be in compliance with the World Bank GeoSpatial Metadata standards (based on ISO 19115:2003).
    d. Uploaded datasets should be styled using SLD format to allow for basic visualization on the platform.
3. Free and open-source software, such as GeoNode, often have an active developer community, which provides improvements, modifications and bug fixes to the software.

The Consultant will be responsible for performing software upgrades to the latest version of the software as of the end of the project.

4. Additionally, the Consultant will provide 15 hours per month of ad-hoc troubleshooting, bug-fixing and other technical assistance at the request of the software administrators of the State Govt. This support will be provided during the project and will last for a period of 3 months after the completion of the project.

Expected outputs

1. Installed open-source, web and GIS-based platform for the digital Risk Information System database, including customization/branding.
2. All datasets developed under the earlier components have been transferred to the Digital Risk Database platform, and are as such openly available.
3. Platform upgrades and ad-hoc technical support.

Component 6: Development of Integrated Operational forecasting System for hydro-meteorological hazards in State (Heavy rainfall, Flood, cyclone, drought).

Objectives

- To develop appropriate forecasting models for hydro-meteorological hazards in State (Heavy rainfall, Flood, cyclone, drought)
- Integration of forecasting models with digital risk information system to generate forecast based scenario modelling
- Testing, Calibration and commissioning of integrated hydro-meteorological forecasting system for State

Activities

1. Evaluate real-time weather information/forecasts from national and global sources pertaining to State and identify requirements to develop best fit forecasting models for Heavy rainfall, Flood, cyclone and drought

2. Develop the most appropriate calibrated and validated model/package for Heavy rainfall, Flood, cyclone and drought based on observed and forecasted short and long-term meteorological and hydrologic variables.
3. Incorporate outputs from other weather forecasting models into the short term, medium range and extended range weather forecasting model being developed by the consultant for State
4. Integrate forecasting model with flood models (1D and 2D models), tsunami inundation model, cyclone models and drought models generate in Task Two and develop the integrated system as an operational forecasting system for real-time scenario generation.
5. Development of real-time simulations of storm surges on various combinations of input parameters with respect to the forecasted track and intensity of the live event.
6. Develop an easy to use graphical user interface for the hydro-meteorological forecasting system. Users should be able to interact with the models and generate the out puts based on user-selectable model parameters such as rainfall measurements, estimates and forecasts from global and national sources, and thematic data from the digital risk information system.

7. Dynamic linking of forecasting model with the real-time/near real-time data from field stations to generate time based multiple scenarios of the extreme events. The data inputs to integrate include sensors deployed in the State by various agencies and data from other national or international agencies
    a. State level data (sensors for air temperature, humidity, wind speed, pressure sensors, soil moisture sensors, river gauges, reservoir level sensors, tde gauge sensors)
    b. Data on Dams and storage capacity available from India-WRIS Portal
    c. Ground Water level sensor data
    d. Weather information, forecasts and hazard updates from IMD, INCOIS, NASA, ISRO, JTWC, CWC, NOAA National Weather Service, NOAA Hurricane Centre etc.
8. Integration of forecasting system with the scenario generation models and the total digital risk information system to develop an integrated forecasting system for heavy rainfall, flood, drought and cyclone

9. Calibrate and validate forecast model and scenario generation model using historic data, and possibly during a flood and cyclone seasons prior to project closure.
10. Commissioning of the Automated operational Cyclone forecasting facility at Disaster Management Authority/Department using WRF model

Expected Output

1. Operational Forecasting models for heavy rainfall, flood, cyclone and drought
2. Validated models integrated with risk information system capable of dynamic data exchange for real-time scenario generation
3. Integrated forecasting system capable of generating real-time scenarios of heavy rain fall, flood, cyclone and cyclone induced flooding
4. Customised application with easy to use Graphical User Interface for real-time forecasting and scenario generation for heavy rainfall, flood, cyclone, cyclone induced flooding and drought.
5. Calibrated and validated forecast model and scenario generation model using historic data, and possibly during a flood and cyclone seasons prior to project closure.
6. Operational Forecasting System for Hydro-meteorological hazards Commissioned for State

Component 7: Engagement with Disaster Management Department on the development of the users guide and trainers guide, risk information products, and the communication of the risk results; sustainability of the inititaive

Objectives

- To ensure that all analysis and results of the hazard, impact and risk assessments can be updated, interactively communicated and understood by Govt staff and other relevant stakeholders.
- To ensure the use of the Digital Risk Information System after its initial set-up by Disaster Management Department and relevant stakeholders.
- To propose a strategy or the ongoing maintenance of DRIS
- To deliver a detailed road map and embedment plan for the maintenance of the data and the ongoing approaches and tools delivered under this contract

Activities

1. A userôs guide/manual and trainersô s guide/manual shall be developed on how to use the database, update the data and management of the website
2. Develop a final report that articulates the following:
    a. Description of input datasets and models used in this study, their limitations and recommendations for how these datasets can be improved with time and resources. This includes the vulnerability models, replacement costs, loss data, etc.
    b. The development of the probabilistic flood and seismic hazard and risk assessments and impact assessments for landslides, flash floods and industrial hazards, including assumptions made, justification of modelling choices, and description of uncertainty.
    c. Results of all the analysis.
3. The Consultant will provide training to ensure that hazard, impact and risk assessments can be understood and updated by Disaster Management Department staff and other relevant stakeholders. This will include at least
    a. A 3-5 day workshop on probabilistic cyclone and storm surge hazard and risk assessment, addressing all aspects of probabilistic risk assessment, including the datasets required to undertake this style of analysis.
    b. A 3-5 day workshop on probabilistic flood hazard and risk assessment, addressing all aspects of probabilistic risk assessment, including the datasets required to undertake this style of analysis.
4. The Consultant will provide a 3-day workshop on understanding, communicating and using results of the risk assessment for decision making (once the analysis is complete).
5. The Consultant will provide training to ensure the use of the digital Risk Information System database after the initial set-up. These trainings should at least include
    a. Basic use of the software used for the Digital Risk Database, including at least uploading and managing data, creating metadata, and making maps.
    b. Basic GIS training.

6. The Consultant will provide a separate technical training to relevant staff on topics related to maintenance, administration and troubleshooting using the software for the Digital Risk Database.
7. The Consultant will provide a training package including sample data, necessary hand-outs, PowerPoint presentations, and a trainerôs guide that will facilitate the conduct of trainings provided in the future, for all the trainings under this Component.

Expected outputs

1. Userôs Guide
2. Trainerôs Gudie
3. A range of trainings, including
    a. 3-5 day workshops on probabilistic cyclone and flood hazard and risk assessment.
    b. 3-day workshop on understanding, communicating and using results of risk assessments for decision making.
    c. Courses on the use and maintenance of the digital Risk Information System .
4. Training packages for all the trainings, including sample data, necessary hand-outs, PowerPoint presentations, and a trainerôs guide.
5. A final report.