Annex 4.2: Report on the first regional workshop on tsunami inundation mapping

CONCEPT NOTE

FIRST REGIONAL WORKSHOP ON TSUNAMI INUNDATION MAPPING

UNESCAP TTF-31 Project: "Strengthening Tsunami Early Warning in the North-West Indian Ocean through Regional Cooperation"

7 September 2022

BACKGROUND

Tsunami inundation mapping has been identified as one of the priority topics to be addressed in the five partner countries in the North-West Indian Ocean (NWIO) region in order to improve inundation mapping and evacuation planning in support of tsunami preparedness.

The TTF-31 Project will support finalisation of a Probabilistic Tsunami Hazard Assessment (PTHA model (V1.0)), including an exchange of experts to be trained in its architecture and use. There will also be a Scientific Exchange Meeting to share the PTHA results with the region for adoption, as well as report on the latest regional/international studies on the tsunami hazard in the Makran subduction zone. The project will also support the establishment of a NWIO Regional Working Group on Tsunami Inundation Modelling and Mapping (RWG-TIMM), with input from international experts, to foster ongoing regional cooperation and exchange of knowledge on inundation modelling and mapping. A gap analysis of tsunami inundation modelling and mapping capabilities in the region will be undertaken. The regional working group will aim to develop a unified methodology for tsunami inundation modeling in order to assure inter-comparable results throughout the region.

The project will provide information on existing approaches, methodologies and input data for tsunami inundation modelling and mapping. To facilitate joint learning and national implementation, the project suggests the establishment of national working groups on tsunami inundation modelling and mapping to facilitate and inform a gap analysis by the project in each of the five countries participating in the project (India, Iran and Pakistan with funding from the project; Oman and United Arab Emirates (UAE) through self-funding). The project will later use this information to provide recommendations to the NWIO countries about what fits best and how to proceed regarding the development of necessary and feasible approaches for tsunami inundation mapping.

By this the participating countries can develop a solid foundation that will help achieving the goals of the UN Ocean Decade Tsunami Programme to make all communities highly at risk prepared for and resilient to tsunamis by 2030.

OBJECTIVES

Through this regional workshop it is intended to kick-off a joint working process among the five partner countries and the project team to identify the requirements for tsunami inundation modelling and mapping in the region. During the workshop the following shall be achieved:

- Providing background information on the TTF-31 project and related initiatives, such as the UN Ocean Decade Tsunami Programme and the UNESCO-IOC Tsunami Ready Recognition Programme (TRRP).
- Getting to know each other and develop regional partnership arrangements.
- Discuss the establishment of National Working Groups on Tsunami Inundation modeling and mapping (NWG-TIMMs), which are proposed as a mechanism to subsequently

facilitate joint learning and national implementation of the project activities. National working groups should involve not only representatives from agencies, universities and research institutions, but also the local level, preferably from the community of the Pilot Areas to be involved in order to improve cooperation between science and application in the warning process. Representatives might therefore also be drawn from Provincial Disaster Management Organisations (PDMOs) and/or Local Disaster Management Organisations (LDMOs).

- Discussion and sharing of knowledge on principal concepts, methodologies and approaches for tsunami inundation modelling. Partner countries are invited to share their experiences and skills of tsunami inundation modeling and mapping.
- Presentation and discussion of the approach for a gap analysis in each of the five countries and preliminary results.
- Outlook on further activities to be undertaken under the framework of the project, including next steps towards building a common understanding and joint strategy for tsunami inundation modelling in the region and nationally.

OVERALL SCHEDULE

The workshop will run as a virtual regional meeting with a duration of 3 hours and 30 minutes.

ORGANISERS

The organisation of this regional meeting will be undertaken by the UNESCO-IOC/BMKG Indian Ocean Tsunami Information Center (IOTIC), UNESCO-IOC Secretariat of the Intergovernmental Coordination Group for Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS), and Project Team for the UNESCAP TTF-31 project with the support of the UNESCO-IOC Tsunami National Contacts (TNCs) from India, Iran, Oman, Pakistan and UAE.

PARTICIPANTS

The joint working process on tsunami inundation modelling and mapping in the TTF-31 project requires the establishment of a regional working group consisting of representatives from the five partner countries (India, Iran, Oman, Pakistan and UAE). This regional working group shall be composed of representatives from national agencies (e.g. National Tsunami Warning Centre), from universities and research organisations. It may also include representatives in other countries who are interested or involved in the topic.

EVENT WEBSITE

For further information on the workshop, please refer to the event website:
https://oceanexpert.org/event/3630 .

AGENDA

Time	Draft Agenda Item (Speaker/Lead)
0600 – 0630 UTC	**1. Opening** – Welcome remarks (Head of ICG/IOTWMS Secretariat, Mr. Rick Bailey) – Background: The TTF-31 Project (ICG/IOTWMS Secretariat, Ms. Nora Gale) – Context: The UN Ocean Decade Tsunami Programme (Mr. Rick Bailey) and the UNESCO-IOC Tsunami Ready Recognition Programme (Mr. Ardito Kodijat) – Objectives of the Workshop (Project Consultant, Mr. Jörn Lauterjung)
0630 – 0730 UTC	**2. Requirements for Inundation Mapping from the Tsunami Evacuation Planning (TEP) perspective** (Mr. Harald Spahn) **3. Preliminary Results of the Probabilistic Hazard Assessment** (Mr. Andrey Babeyko) **4. Identification of Pilot Areas in accordance with TEP** (Mr. Harald Spahn) **5. Discussion of items 2 – 4**
0730 - 0745	**Break**
0745 – 0845 UTC	**6. Country Presentations** – Introductions of members of the Regional Working Group on Tsunami Inundation Modelling and Mapping – Overview on previous experiences with tsunami inundation modelling and mapping and available input data (shallow water bathymetry, DEM's, development, computational resources, etc.
0845 – 0915 UTC	**7. Preparation of gap analysis** (Mr. Jörn Lauterjung) – Background and approach – The questionnaire – Timeline – Discussion
0915 - 0330 UTC	**8. Summary**, **Outlook** and **Closing remarks** (Mr. Ardito Kodijat, Ms. Nora Gale, Mr. Rick Bailey) – Project partnership arrangements involving National Working Groups and pilot areas – National online workshops to further help identify national gaps and capacities – Support by the project – Outlook on the further process (TTF-31 Project outlook), including development

Questionnaire

In preparation of the workshop and as basic information for a gap analysis for inundation modeling capabilities in the five countries India, Iran, Oman, Pakistan and UAE a questionnaire (see below) was prepared and send to the members of the ICG-IOTWS NWIO Task Group together with the request to nominate two scientists for the inundation working group.

Questionnaire for the assessment of capabilities of inundation modeling and mapping in the NWIO region

Input data for modeling/mapping	
Shallow Water Bathymetry	
Availability	
Resolution	
Resolution in pilot areas	
Digital Elevation Models (DEM) for coastal regions	
Availability	
Resolution	
Resolution in Pilot areas for evacuation mapping	
Digital land use information, development information, zoning maps	
Availability in pilot regions for evacuation mapping	
Hazard information for pilot regions	
Scenarios (available?)	
Worst case scenarios (available?)	
Probabilistic Hazard information (available?)	
Other relevant information	
Other Information	
Computational resources, please describe shortly	
Software tools, software packages	
Human resources	
Comments	

Short summary of presentations and gap analysis

After some general introduction talks to frame the project scope and the objectives of this workshop. A short contribution was given to define the challendes and requirements of evacuation planning and the respective expectations from inundation modeling (see Annex).

The foreseen presentation on the first results of the PTHA in the NWIO region was cancelled.

The next presentation introduced the state of discussions in the Tsunami Evacuation Planning (TEP) Group. See for this topic the chapter on pilot areas below.

The presentations for the countries followed the structure and topics of the questionnaire, answered the questions and in all cases examples of inundation modelling projects have been shown.

The results of the questionnaire are shown in the following table and demonstrate the heterogenities in the five countries preconditions. In the first row the type of shallow water bathymetric data and its lateral resolution are listed, row two gives information of the topographic data (Digital Elevation Model) and their horizontal resolution (SRTM = Shuttle Radar Topography Mission), row three gives information if any land use data or information is available (this might be important for evacuation planning), row four gives information on the software systems which have been used so far for inundation modeling projects and row five gives an indication what type of input scenario has been used (deterministic or probabilistic or both).

Shallow Water Bathymetry: For all countries we have the standard GEBCO dataset with 15 arcsec resolution. Many studies on inundation mapping have shown that this resolution is not sufficient for shallo water and that also interpolation approaches to produce finer grid near the coastline may miss structures and heterogenities which may influence the wave hight at the coastline. Therefore it is desirable to have shallow water bathymetry with a higher resolution especially for the pilot regions and other high risk regions. In some of the countries a few datasets are available, in some cases there might be some industry data available and we do not know exactly the availability of military data. In the case of shallow water bathymetry we have highly variable data and the largest gaps between the countries.

Digital Elevation Models: Here all countries have access to SRTM data, in one case we have also other satellite data. In this case the situation looks more homogenous compared to bathymetry. Nevertheless it was recommended to look for recent satellite data with higher resolution and to look especially on the vertical resolution of the data. In case of SRTM the data have to be calibrated by local GPS surveys.

Land Use Information: This information plays only a secondary role for inundation modeling as source of additional informtion. Accordingly this information is not used in most countries.

In the case of shallow water bathymetry we have highly variable data and the largest gaps between the countries.

Table: Results of the questionnaire

	India	Iran	Oman	Pakistan	UAE
Shallow Water Bathymetry	200 m Res. GEBCO	450 m Res. (15 arcsec GEBCO) Industry data	450 m Res. (15 arcsec GEBCO)?	Variable, 10 m in Pilot Regions	450 m Res. (15 arcsec GEBCO)
DEM	5-10m SRTM	30 m SRTM	SRTM	10 m SRTM	10 m High resolution Satellite Data
Land Use Information	Maps 1:5000	Not available	Not available	Not available	Basic map
Model Used	Tunami-N2 ADCIRC	ComMit GEOWAVE MIKE-21 Tunami-N2	COMCOT	GUITAR TOAST GeoClaw	ComMIT
Type of Studies	Deterministic	Deterministic/ Probabilistic	Deterministic/ Probabilistic	Deterministic	Deterministic

Pilotregions

The discussions in the first meeting of the Tsunami Evacuation Planning (TEP) group on 24. August 2022 resulted in some recommendations having direct impact to the work of this Tsunami Inundation Modeling and Mapping group.

1. The first recommendation is to initiate a close cooperation between the two working groups, this is especially important for the inundation modeling for evacuation planning as the requirements (e.g. the question what input scenarios for inundation modeling have to be selected) have to be in minimum co-defined by the TEP group.
2. The second recommendation of the TEP group is the initial concentration on pilot regions for evacuation planning. All five countries have been asked to appoint 1-3 pilot regions.

The pilot regions which ave been fixed after August 2022 are the following and displayed in the figure.

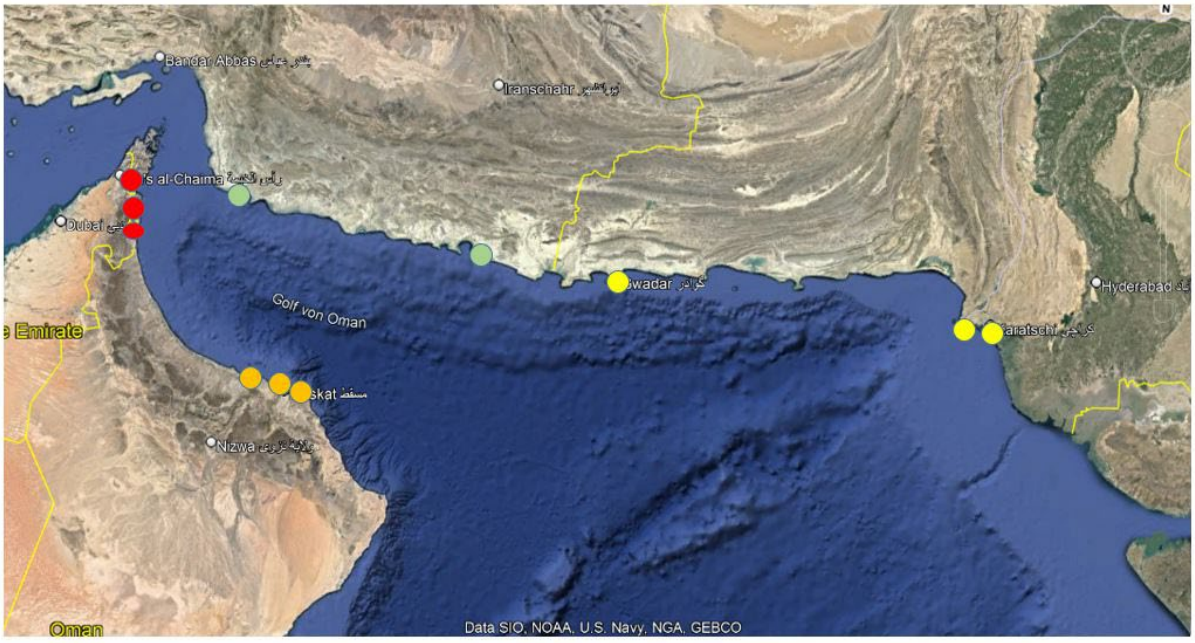
India: (1) Alappad (Kerala) (this is at the western coast of India very far in the south, therefore not displayed in the figure)

Iran: (1) Chabahar, (2) Jask

Oman: (1) Muscat, (2) Barka, (3) Sib

Pakistan: (1) Gwadar District, (2) Karachi: West-District (Keamari), (3) Karachi: Malir District

UAE: (1) Dibba, (2) Kalba, (3) Khor Fakkan.



Results, Recommendations and follow-up actions

As **results** of the workshop the following points can be listed:

- The regional group for Tsunami Inundation Modeling and Mapping (TIMM) has been established
- Close cooperation with the Tsunami Evacuation Planning (TEP) Group necessary
- Definition of pilot areas in the NWIO region for Tsunami Evacuation Planning (TEP) and Tsunami Inundation Modeling and Mapping (TIMM)
- First rough gap analysis through a questionnaire performed

Following **follow-up actions** have been discussed:

- Definition of the requirements to perform the respective inundation modeling in the pilot areas.
- Detailed gap analysis to be performed on the basis of the requirements.
- Discussion and definition of software tools for future harmonized and unified modeling approach
- Science Workshop with international experts and discussion of the results of the ongoing Probabilistic Tsunami Hazard Analysis (PTHA) planned for beginning of November 2022
- Discussion of strategies of inundation modeling for Tsunami Risk assessment with disaster managers and decision makers.

Recommendations

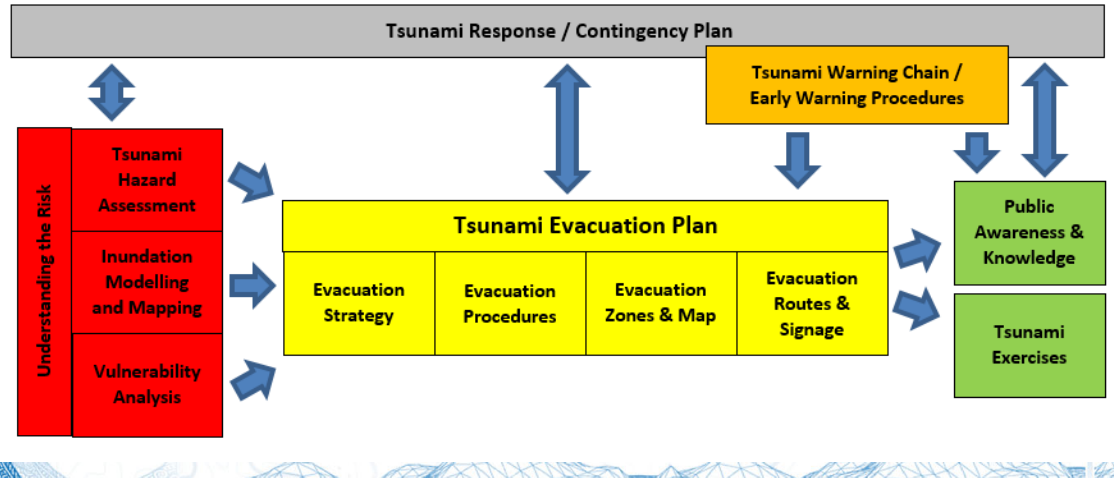
The participants of the workshop recommend that the regional working group on Tsunami Inundation Modeling and Mapping (TIMM) should be “officially” mandated by the Sub-regional Working Group for the North-West Indian Ocean of the UNESCO IOC ICG IOTWMS.

Annex

Requirements for Inundation Mapping from the Tsunami Evacuation Planning (TEP) perspective

Harald Spahn, International Consultant

Hazard Assessment and Inundation Maps are main references for TEP



Essential Hazard Information for TEP

- Location of **tsunami source areas**
- **Origin of tsunamis** which may affect the area
- **Minimum estimated arrival times (ETA_{min})** for different source areas
- **Wave height at coast** and / or **flow depth** on land
- **Multiple threat scenarios**, including worst case, most probable scenario, historical events

Requirements for Inundation Maps

Inundation Maps need to visualize **the entire area that can be inundated by all types of tsunamis and wavehights that may occur**. Differentiation is useful for different types of tsunami and source areas (if any and / or possible)

In case of a **single scenario map**, it should represent the **worst case** scenario

Preferred are inundation maps visualizing **multiple scenarios** indicating the **probability** of an area on land being inundated

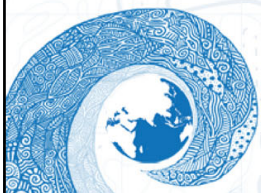
Maps should provide information on **ETA_{min}** for different types of tsunamis and source areas

Information on **flow depth** and / or **impact energy** of tsunamis on land can be helpful, but are not essential

Other Considerations

Regarding **accuracy / resolution** of inundation maps one must have in mind that the modelling of propagation on land involves usually considerable uncertainties due to the application of a single roughness factor to represent the natural or built environment. From therefore the maxim should be: “it is better to be roughly right than precisely wrong”

Replicability: the methodology for inundation mapping introduced and applied by the TTF-project in Pilot Areas should be replicable with own (national) resources for other areas in the partner country. Access to HPC technologies for inundation modelling is probably not realistic in most partner countries.



Inundation modelling and mapping “**on the fly**” is <u>not</u> required nor useful for TEP