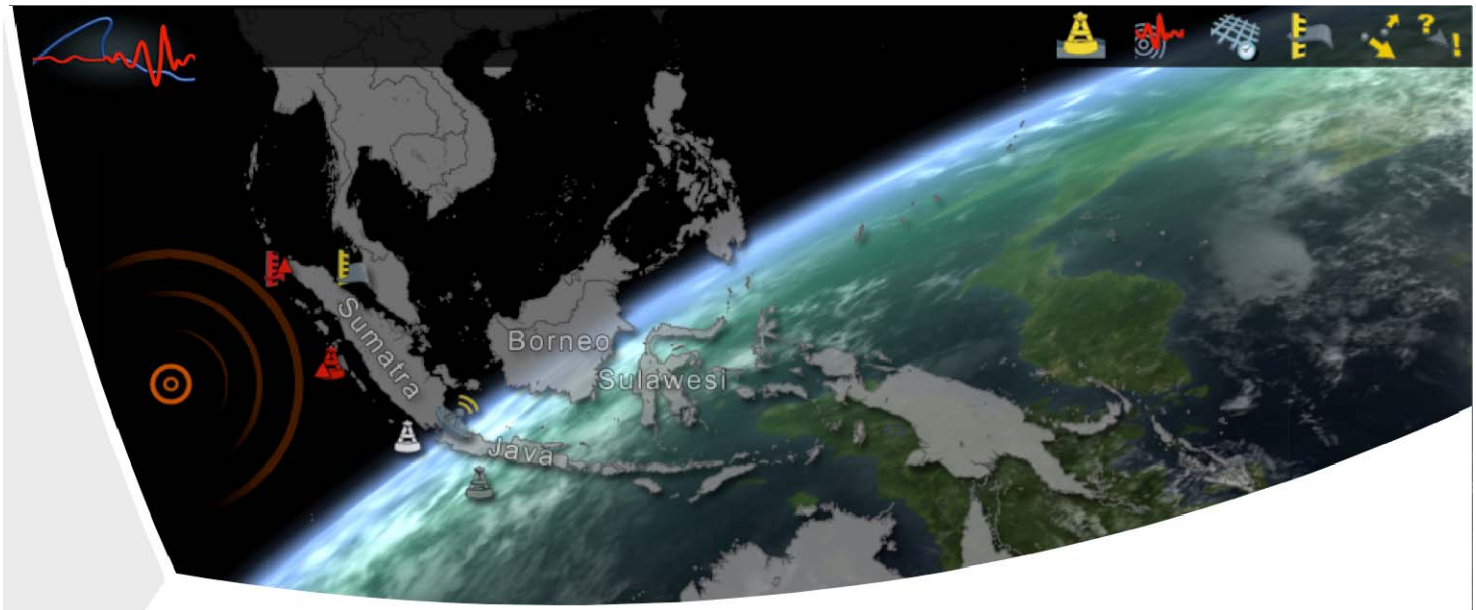


TECHNICAL GUIDELINE FOR TSUNAMI RISK ASSESSMENT IN INDONESIA

SCIENTIFIC PROPOSAL FOR PRACTITIONERS AND END USERS

Version 0.9 (March 2011)

Indonesian – German Working Group on Tsunami Risk Assessment

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

LIPI

RISTEK

Bundesministerium für Bildung und Forschung

GITEWS

Product of the Joint Indonesian-German Working Group on Tsunami Risk Assessment

Lead Authors (alphabethical order)
Herryal Anwar
Niklas Gebert
Matthias Mueck
Abdul Muhari
Joachim Post
Enrico Stein
Stephanie Wegscheider

Co Authors
Joern Birkmann
Hery Harjono
Torsten Riedlinger
Guenter Strunz

Proposed Citation:

LIPI / DLR / UNU-EHS (2011): TECHNICAL GUIDELINE FOR TSUNAMI RISK ASSESSMENT IN INDONESIA: SCIENTIFIC PROPOSAL FOR PRACTITIONERS AND END USERS. Provided by the Indonesian – German Working Group on Tsunami Risk Assessment. 126p.

Content

List of Tables

List of Figures

Technical Guideline

The technical guideline provides - based on the described concept, methods and products in the "Guideline for Tsunami Risk Assessment in Indonesia: Scientific proposal for practitioners and end user" - a step by step technical documentation to perform and replicate the overall assessment and the generation of risk products

1 Introduction and Structure

This technical documentation gives a detailed description of the processing and calculations of the risk and vulnerability assessment in the frame of the GITEWS project. The creation of the presented products – hazard, vulnerability and risk maps at different scales and risk information for decision support in the early warning process – as documented in the in the "Guideline for Tsunami Risk Assessment in Indonesia: Scientific proposal for practitioners and end user" is described in a step-by-step way.

1.1 Input data

All input data should be in an equal-area projection to be able to correctly calculate areas, e.g. Albers equal area conical projection for national level or UTM for local level.

In order to perform the processes described in the following chapters easily, the input data should meet the requirements listed in Table 2 and Table 1.

The (pre-)processing of these input data will be described in the following sections.

Table 1: Requirements for input raster

Raster	Pixel size	Content
Digital elevation model	30 m (national level) 5 m (local level)	At best: digital terrain model (DTM); if not available, digital surface model (DSM)

Table 2: Requirements for input shapefiles

Shapefile	Required fields (data type)	Comment
warning segments	WS_ID	ID number of warning segment
	area_sqm (double)	Size of warning segment [square meters]
Desa (administrative boundary)	ID2005	ID number of desa
	area_sqm (double)	Size of desa [square meters]
Hazard zone for warning and major warning respectively	ID (int)	Same value for all polygons (e.g. 1); must be different from value in temporary shelter area shapefile
Islands		Polygon shapefile of all islands of Indonesia
Temporary shelter areas for warning and major warning	ID (int)	Same value for all polygons (e.g. 2); must be different from value in hazard shapefile
Population density	Pij2007_d	Amount of people per polygon during daytime
	area_sqm (double)	Size of polygon [square meters]
Critical facilities	ESSENT_FAC (double)	Amount of essential facilities per polygon
	SUPPLY_FAC (double)	Amount of supply facilities per polygon
	HILOSS_FAC (double)	Amount of high loss facilities per polygon
	crit_fac_d (int)	Overall amount of critical facilities per polygon at daytime
	AREA_KM (double)	Size of polygon [square kilometre]
Land use / Land cover		Polygon shapefile with land use / land cover information
Road network		At best: polygon shapefile; otherwise line

		shapefile with information about road types
Hazard modeling results		Details see chapter 2
DSS key numbers		Prepared shapefile for hand-over of key numbers for ingestion into DSS
	WS_ID (int)	ID number of warning segment
	WS_name (string)	Name of warning segment
	People_WL2 (int)	Amount of people exposed at warning level
	People_WL3 (int)	Amount of people exposed at major warning level
	Crifac_WL2 (int)	Amount of critical facilities exposed at warning level
	Crifac_WL3 (int)	Amount of critical facilities exposed at major warning level
	Hlfac_WL2 (int)	Amount of high loss facilities exposed at warning level
	Hlfac_WL3 (int)	Amount of high loss facilities exposed at major warning level
	RI_WL2 (string)	Evacuation capability index at warning level
	RI_WL3 (string)	Evacuation capability index at major warning level
	Risk_WL2 (string)	Degree of risk at warning level
	Risk_WL3 (string)	Degree of risk at major warning level

1.2 Map template

A map template was developed to display the output of the risk and vulnerability assessments. It follows closely the official Bakosurtanal template in both layout and naming / numbering of the map sheets. Basically, the template is identical for each map type. The map elements are shown in Figure 1. The placement of the map information text and data sources as well as the additional small maps varies between the different map types.

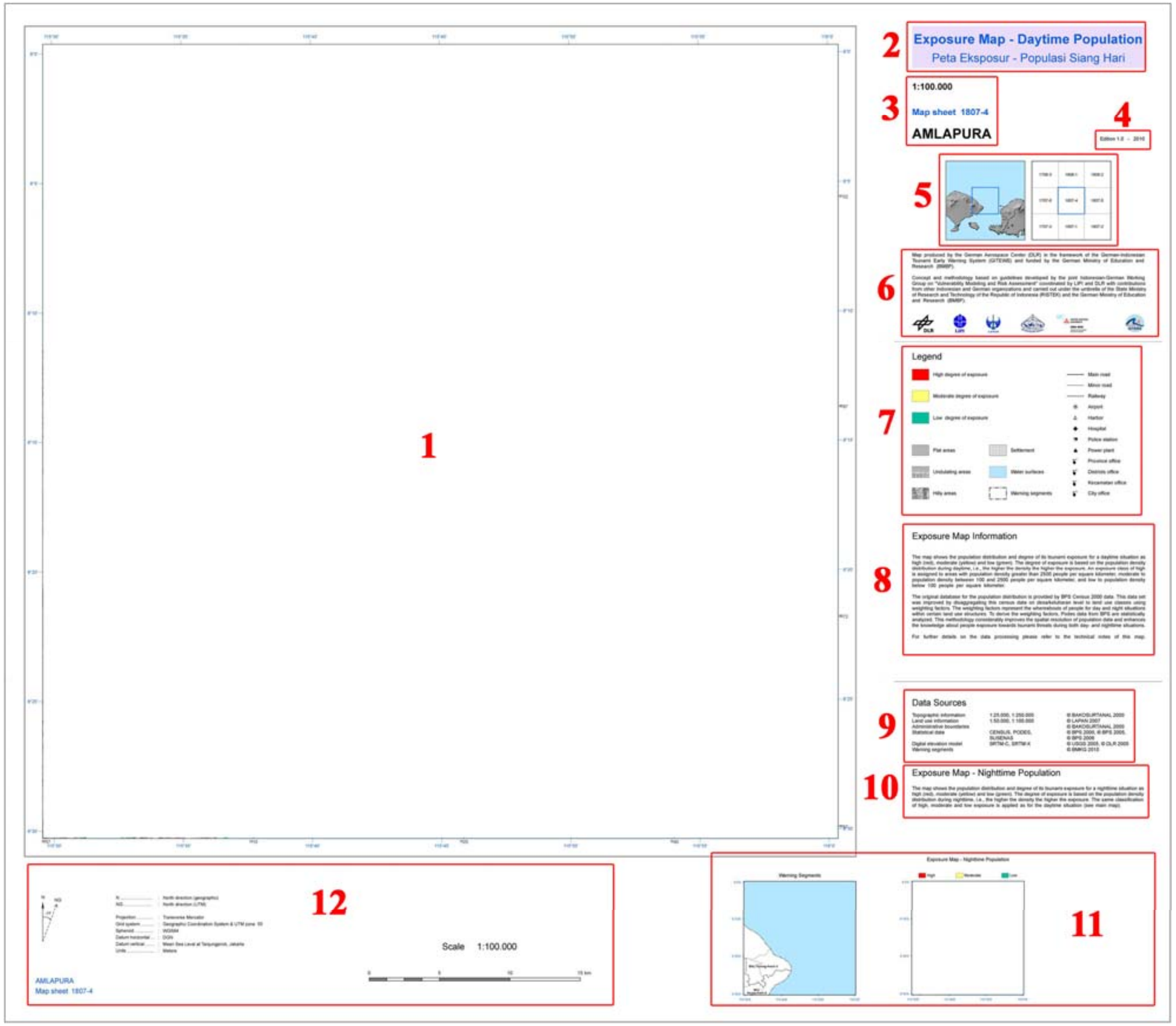


Figure 1: GITEWS map template

1	Main map frame
2	Title (English and Bahasa Indonesia) Color of title box depending on map type: - hazard (rgb 200 230 255) - vulnerability (rgb 235 220 250) - risk (rgb 255 190 200)
3	Scale, map sheet number and map sheet name
4	Edition and year of issue
5	Overview maps
6	Information about the producing entity and the GITEWS project; logos of involved organizations
7	Legend
8	Map information text
9	Data sources
10	Optional: additional information text for small maps below (see item 11)
11	Additional small maps (number varies between map types)
12	Scale bar, northing, projection

2 Hazard Assessment

The hypothetic question for all elements of the hazard assessment can be summarized by: How is the degree of impact on land?

For estimating the tsunami impacts on land, the hazard assessment is conducted by using numerical inundation modeling results, based one a presumed geological framework. At this in GITEWS a multi- scenario approach was used. This approach analyses the likelihood of tsunamis of various sizes (based on many scenarios) that can then be simplified into tsunami hazard zones.

The Tsunami modelling was realised at the sub-national (broad-scale) level and in three pilot areas (Padang, Cilacap and Bali).

The database for the broad-scale approach is based on about 1300 (1224) Tsunami Scenarios simulated with TsunAWI©, Version 18L by the Alfred Wegener Institute (AWI), Germany regarding the South West Coast of Indonesia. The model uses an unstructured grid with a resolution between 50 m and 500 m on land and near the shore. The scenarios cover about 300 tsunamigenic sources along the Sunda Trench which are calculated by a rupture generator provided by the GFZ, Germany. At the used tsunamigenic sources the tsunami origins are simulated with seven different earthquake moment magnitudes (Mw 7.5, Mw 7.7, Mw 8.0, Mw 8.2, Mw 8.5, Mw 8.7and Mw 9.0) for now. For the settings of the numerical Tsunami model bathymetric data are used from the GEBCO data set, augmented by C-Map data. Topographic data are derived from SRTM C- and X-band data sets.

The method used to produce detailed hazard maps for the pilot areas is the same as for the 1:100 000 hazard map series, but the used database is more detailed. For detailed inundation modelling the MIKE21 FM model from DHIWasy GmbH was used, and run-up modelling was performed by GKSS and DHIWasy. Initial bottom deformation and sea surface height as well as time series of water level elevation at the open boundaries were provided by AWI and GFZ in the frame of the GITEWS project. Spatial resolution used in modelling is between several hundreds of meters to ten meters, allowing for representation at a map scale of 1 : 25,000. The number of tsunami inundation scenarios used was 137 (Bali), 300 (Cilacap) and 90 (Padang) respectively, with moment magnitudes of 8.0, 8.5 and 9.0. The bathymetry is based on GEBCO data, C-Map data and echosounder measurements performed by BPPT and DHI-Wasy. The topography is based on digital surface model, street and building data, provided by DLR, and differential GPS measurements performed by DHI-Wasy.

2.1 Sub-national level

2.1.1 Ingestion of Modelling Scenario Shapefiles into the database

The computations (modelling) of the Hazard Assessment was performed in a database. Hereby the Oracle 10 g framework is used. For the integration of the modelling scenario shapefiles into the database following batch (with the Windows/DOS command) file is used to create ASCII files:

```
@prompt -$G

@echo Erzeuge *att.dat und *geom.dat ASCII-Dateien aus Shapefile-DBFs

@for %%f in (*.shp) do shp2sdo -r %%~nf

@for %%f in (SZ*att.dat) do @echo SEDding Filename | sed -i -T s/$/%%f/g
%%f

@for %%f in (SZ*att.dat) do sqlldr userid=username/password control=name of
the control file data=%%f log=%%f.log direct=TRUE
```

Remark: substitute correct username and password in last line.

The following sequence of steps is therefore required in order to ingest new data into the database:

1. A table to load data into must exist or must be created inside the database (load_into_szen_mw):

```
CREATE TABLE load_into_szen (
 point_id   NUMBER       NULL,
 topography NUMBER       NULL,
 arrivaltim NUMBER       NULL,
 ssh_max    NUMBER       NULL,
 vel_max    NUMBER       NULL,
 flux_max   NUMBER       NULL,
 uplift     NUMBER       NULL,
 sdo_gid    NUMBER       NULL,
 scen_id    VARCHAR2(45) NULL
 )
```

2. all shapefiles to be loaded are put into a directory containing no other shape files

3. a control file (*.ctl / shape_oracle_load_SZENARIEN.ctl) describing the structure of input data and their mapping to the database table must exist or be created (in the directory used for the shape file conversion)

3. an SQL-File which is used to write data from ASCII-Files to the database must exist or be created (inthe directory used for the shape file conversion)

4. the batch file (convert_and_load_to_OracleSDE.bat) (in the directory used for the shape file conversion)

5. User Access Rights must be created on the data if necessary

Remark: Data loading is quite memory and CPU intensive. The process of creating the spatial index and loading them into the database can take some hours (about 20 h for 200 szenarios).

2.1.2 Calculation of tsunami hazard probabilities

The calculation of the tsunami hazard probabilities requires the following information in the database:

1. tsunami-scenarios shapefiles (→ load_into_szen_MW; see above)

2. shapefile with the calculated probability of an earthquake with a specific magnitudeand at a specific location on the defined tsunamigenic sources along the Sunda trench (e.g. patches_eqprob)

3. shapefile with the predefined GRID-points (with an extent of about 100 m) for the coastal and land area (e.g. dlr_gridpoints_land; dlr_gridpoints_coast)

The fist step, the spatial data query, selects all scenarios from the tsunamigenic sources which at least inundate one point on land in the area of interest (especially a map sheet) for the seven different earthquake moment magnitudes (Mw 7.5 Mw 7.7, Mw 8.0, Mw 8.2, Mw 8.5, Mw 8.7 and Mw 9.0). The following PL/SQL-query shows it as an example for the earthquake moment magnitude 7.5:

```
CREATE OR REPLACE
PROCEDURE COMPUTE_PATCHFIELD_75 AS
BEGIN
EXECUTE IMMEDIATE'
      CREATE TABLE grid_szenarios75_points_maps AS
      SELECT a.point_id, a.shape, a.id_100k, a.nr_100k, a.name_100k,
      a.grid_north, a.utm_zone, b.ssh_max, b.scen_id
      FROM gridpoint_coast a INNER JOIN load_into_szen75 b ON
      a.point_id = b.point_id
      WHERE b.ssh_max>0.5';

EXECUTE IMMEDIATE'
      CREATE TABLE patch_rechnen_mag75 AS
      SELECT a.objectid, a.shape,a.prob75, b_lat AS lat, b_lon AS lon, mag,
      point_id, id_100k, nr_100k, name_100k, grid_north FROM
      (SELECT  point_id, id_100k, nr_100k, name_100k, grid_north, cast
      (SUBSTR(scen_id, 19,3) AS INT) AS b_lon, cast (SUBSTR(scen_id, 23,2)
      AS INT) AS b_lat, SUBSTR(scen_id, 28,3) AS mag
      FROM grid_szenarios75_points_maps)
      INNER JOIN patches_eqprob a ON a.i_1=b_lon and a.j_1=b_lat';

EXECUTE IMMEDIATE'
```

```
      ALTER TABLE patch_rechnen_mag75 ADD (SID NUMBER)';

EXECUTE IMMEDIATE'
      CREATE SEQUENCE TEMP_SEQ_ID_ssh
            MINVALUE 1
            MAXVALUE 99999999
            INCREMENT BY 1
            START WITH 1
            CACHE 20
            NOORDER
            NOCYCLE';

EXECUTE IMMEDIATE'
      UPDATE patch_rechnen_mag75 set SID=TEMP_seq_id_ssh.NEXTVAL';

EXECUTE IMMEDIATE'
      CREATE TABLE tab75_2 AS
      SELECT DISTINCT (lat || _ || lon) AS ll
      FROM patch_rechnen_mag75';

EXECUTE IMMEDIATE'
      CREATE TABLE punktIDs75_chip AS SELECT max(objectid) AS objectid,
      (lat || _ || lon)  AS mll, nr_100k, max (tab75_2.ll)   AS ll
      FROM patch_rechnen_mag75 t1, compute.tab75_2
      WHERE (lat || _ || lon) = ll
      GROUP BY nr_100k, (lat || _ || lon)
      ORDER BY nr_100k ASC';

BEGIN
DECLARE
      sql_stmt VARCHAR(650);
      my_mapnr VARCHAR2(50);
      mapid string(60);
      CURSOR maps_cursor IS
      SELECT DISTINCT(t1.nr_100k) AS map
      FROM patch_rechnen_mag75 t1, punktids75_chip t2,
      gitews.id_mapsheets_100k_ll_wgs84_si t3
      WHERE t1.objectid = t2.objectid AND t2.nr_100k = t3.nr_100k
      ORDER BY map ASC;
      map maps_cursor % rowtype;

BEGIN
      dbms_output.enable;
EXECUTE IMMEDIATE'
      TRUNCATE TABLE distinct_sources_75';

EXECUTE IMMEDIATE'
      ALTER TABLE distinct_sources_75 modify (objectid number(38))';
FOR map_record IN maps_cursor
      LOOP
            my_mapnr := map_record.map;

            EXECUTE IMMEDIATE'
            INSERT INTO distinct_sources_75 (shape, nr_100k, objectid,
            prob75, lat, lon)
            SELECT t1.shape, t1.nr_100k, t1.objectid, t1.prob75, t1.lat,
            t1.lon
            FROM patch_rechnen_mag75 t1,
            (SELECT objectid, count(objectid) as counter, min(sid) AS id
            FROM patch_rechnen_mag75
```

```
                  WHERE nr_100k =  || my_mapnr ||
                  having count(objectid) > 1
                  group by objectid
                  order by objected) t2
            WHERE t1.sid = t2.id';
      END LOOP;

/* delete Metadata */
      DELETE FROM user_sdo_geom_metadata
      WHERE LOWER(TABLE_NAME) = 'distinct_sources_75';

/* write Metadata ArcSDE-registration */
      INSERT INTO user_sdo_geom_metadata
      VALUES('distinct_sources_75', 'SHAPE',
      mdsys.sdo_dim_array(mdsys.sdo_dim_element('X', -180, 180, 0.0000005),
      mdsys.sdo_dim_element('Y', -90, 90, 0.0000005)), NULL);

/* Index fuer ArcSDE erzeugen (ohne laesst sich Layer nicht registrieren */
EXECUTE IMMEDIATE'
      CREATE INDEX idx_distinct_sources_75 on distinct_sources_75(shape)
      indextype is mdsys.spatial_index ';

EXECUTE IMMEDIATE'
      GRANT SELECT ON distinct_sources_75 TO map';
END;
END;
END COMPUTE_PATCHFIELD_75;
```

The next step is the calculation of the hazard-probabilities and the warning zones with the maximum generated impact on land with a wave height at coast under 3 m for each map sheet (scale 1:100.000).

Remark: The complete procedure takes about 14 days for all map sheets on sub-national level.

The following PL/SQL-query have to be performed:

```
CREATEOR REPLACE
PROCEDURE HAZARD_BROADSCALE AS
BEGIN
DECLARE
      sql_stmt VARCHAR(950);
      sql_stmt2 VARCHAR2(10);
      my_mapnr VARCHAR2(50);
      mapid string(60);
      v_day VARCHAR2 (2);
      v_month VARCHAR2 (2);
      v_year VARCHAR2 (4);
      v_date VARCHAR (10);

/*  mit diesem Cursor werden die Namen aller betroffen Karten ermittelt */
/* (indem ein Join der Kartenpunkte auf die Kartenblaetter gemacht wird) */
/* er versucht die maximale Erstreckung zu finden, indem die 9er Szenarien
verwendet werden */

CURSOR maps_cursor IS
```

```
      SELECT DISTINCT(t3.nr_100k) AS map
      FROM patch_rechnen_mag75 t1, punktids75_chip t2, id_maps_100k_ll_konv
      t3
      WHERE t1.objectid = t2.objectid AND t2.nr_100k = t3.nr_100k
/* for a query of one map sheet (e.g. 1308-3) use: AND t3.nr_100k LIKE
/*'1308-3'
      ORDER BY map DESC;
      map maps_cursor % rowtype;

BEGIN
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_75 PARALLEL (degree 12)';
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_77 PARALLEL (degree 12)';
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_80 PARALLEL (degree 12)';
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_82 PARALLEL (degree 12)';
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_85 PARALLEL (degree 12)';
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_87 PARALLEL (degree 12)';
EXECUTE IMMEDIATE 'ALTER TABLE distinct_sources_90 PARALLEL (degree 12)';

FOR map_record IN maps_cursor
  LOOP
      DBMS_OUTPUT.ENABLE(100000);
      my_mapnr := map_record.map;
      mapid := TO_NUMBER((SUBSTR(my_mapnr, INSTR(my_mapnr,'-')-4,4)
      || SUBSTR(my_mapnr, INSTR(my_mapnr,'-')+1,1)));
      DBMS_OUTPUT.PUT_LINE('Map: ' || my_mapnr || ' / mapid: ' ||
      mapid);
      v_day := to_char (Extract (DAY from sysdate));
      v_month := to_char (Extract (MONTH from sysdate));
      v_year := to_char (Extract (YEAR from sysdate));
      v_date := v_year||v_month||v_day;

/************************BEGIN MW 7.5******************** */
      sql_stmt := 'CREATE TABLE loadintoszen75_' || mapid || ' AS
      SELECT c.point_id, b.scen_id, c.nr_100k, a.objectid, a.prob75,c.shape
      FROM load_into_szen75 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
      c.point_id = b.point_id INNER JOIN compute.distinct_sources_75 a ON
      a.lat=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-3,2) AS INT)
      AND a.lon=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-7,3) AS INT)
      WHERE c.nr_100k LIKE || my_mapnr ||
      AND a.nr_100k LIKE || my_mapnr ||';
      EXECUTE IMMEDIATE sql_stmt;
      EXECUTE IMMEDIATE'
            ALTER TABLE loadintoszen75_' || mapid || ' PARALLEL  (degree
            12)';
      EXECUTE IMMEDIATE'
            CREATEINDEX idx_load75_' || mapid || ' ON loadintoszen75_' ||
            mapid || ' (point_id)
            PARALLEL 12';

/************************BEGIN MW 7.7******************** */
      sql_stmt := 'CREATE TABLE loadintoszen77_' || mapid || ' AS
      SELECT c.point_id, b.scen_id,c.nr_100k, a.objectid, a.prob77, c.shape
      FROM load_into_szen77 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
      c.point_id = b.point_id INNER JOIN compute.distinct_sources_77 a ON
      a.lat=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-3,2) AS INT)
      AND a.lon=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-7,3) AS INT)
      WHERE c.nr_100k LIKE || my_mapnr ||
      AND a.nr_100k LIKE || my_mapnr ||';
      EXECUTE IMMEDIATE sql_stmt;
      EXECUTE IMMEDIATE'
```

```
        ALTER TABLE loadintoszen77_' || mapid || ' PARALLEL  (degree
        12)';
    EXECUTE IMMEDIATE'
        CREATEINDEX idx_load77_' || mapid || ' ON loadintoszen77_' ||
        mapid || ' (point_id) PARALLEL 12';

/*************************BEGIN MW 8.0******************** */
    sql_stmt := 'CREATE TABLE loadintoszen80_' || mapid || ' AS
    SELECT c.point_id, b.scen_id, c.nr_100k, a.objectid, a.prob80,c.shape
    FROM load_into_szen80 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
    c.point_id = b.point_id INNER JOIN compute.distinct_sources_80 a ON
    a.lat=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-3,2) AS INT)
    AND a.lon=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-7,3) AS INT)
    WHERE c.nr_100k LIKE || my_mapnr ||
    AND a.nr_100k LIKE || my_mapnr ||';
    EXECUTE IMMEDIATE sql_stmt;
    EXECUTE IMMEDIATE'
        ALTER TABLE loadintoszen80_' || mapid || ' PARALLEL  (degree
        12)';
    EXECUTE IMMEDIATE'
        CREATEINDEX idx_load80_' || mapid || ' ON loadintoszen80_' ||
        mapid || ' (point_id) PARALLEL 12';

/*************************BEGIN MW 8.2******************** */
    sql_stmt := 'CREATE TABLE loadintoszen82_' || mapid || ' AS
    SELECT c.point_id, b.scen_id, c.nr_100k, a.objectid, a.prob82,c.shape
    FROM load_into_szen82 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
    c.point_id = b.point_id INNER JOIN compute.distinct_sources_82 a ON
    a.lat=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-3,2) AS INT)
    AND a.lon=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-7,3) AS INT)
    WHERE c.nr_100k LIKE || my_mapnr ||
    AND a.nr_100k LIKE || my_mapnr ||';
    EXECUTE IMMEDIATE sql_stmt;
    EXECUTE IMMEDIATE'
        ALTER TABLE loadintoszen82_' || mapid || ' PARALLEL  (degree
        12)';
    EXECUTE IMMEDIATE'
        CREATEINDEX idx_load82_' || mapid || ' ON loadintoszen82_' ||
        mapid || ' (point_id) PARALLEL 12';

/*************************BEGIN MW 8.5******************** */
    sql_stmt := 'CREATE TABLE loadintoszen85_' || mapid || ' AS
    SELECT c.point_id, b.scen_id, c.nr_100k, a.objectid, a.prob85,c.shape
    FROM load_into_szen85 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
    c.point_id = b.point_id INNER JOIN compute.distinct_sources_85 a ON
    a.lat=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-3,2) AS INT)
    AND a.lon=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-7,3) AS INT)
    WHERE c.nr_100k LIKE || my_mapnr ||
    AND a.nr_100k LIKE || my_mapnr ||';
    EXECUTE IMMEDIATE sql_stmt;
    EXECUTE IMMEDIATE'
        ALTER TABLE loadintoszen85_' || mapid || ' PARALLEL  (degree
        12)';
    EXECUTE IMMEDIATE'
        CREATEINDEX idx_load85_' || mapid || ' ON loadintoszen85_' ||
        mapid || ' (point_id) PARALLEL 12 ';

/*************************BEGIN MW 8.7******************** */
    sql_stmt := 'CREATE TABLE loadintoszen87_' || mapid || ' AS
    SELECT c.point_id, b.scen_id, c.nr_100k, a.objectid, a.prob87,c.shape
```

```
      FROM load_into_szen87 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
      c.point_id = b.point_id INNER JOIN compute.distinct_sources_87 a ON
      a.lat=cast(SUBSTR(scen_id, INSTR(scen_id, mw)-3,2) AS INT)
      AND a.lon=cast(SUBSTR(scen_id, INSTR(scen_id, mw)-7,3) AS INT)
      WHERE c.nr_100k LIKE || my_mapnr ||
      AND a.nr_100k LIKE || my_mapnr ||';
      EXECUTE IMMEDIATE sql_stmt;
      EXECUTE IMMEDIATE'
            ALTER TABLE loadintoszen87_' || mapid || ' PARALLEL  (degree
            12)';
      EXECUTE IMMEDIATE'
            CREATEINDEX idx_load87_' || mapid || ' ON loadintoszen87_' ||
            mapid || ' (point_id) PARALLEL 12';

/*************************BEGIN MW 9.0******************** */
      sql_stmt := 'CREATE TABLE loadintoszen9_' || mapid || ' AS
      SELECT c.point_id, b.scen_id,c.nr_100k, a.objectid, a.prob90, c.shape
      FROM load_into_szen90 b INNER JOIN compute.dlr_grid_v3_WS_map c ON
      c.point_id = b.point_id INNER JOIN compute.distinct_sources_90 a ON
      a.lat=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-3,2) AS INT)
      AND a.lon=cast(SUBSTR(b.scen_id, INSTR(b.scen_id, mw)-7,3) AS INT)
      WHERE c.nr_100k LIKE || my_mapnr ||
      AND a.nr_100k LIKE || my_mapnr ||';
      EXECUTE IMMEDIATE sql_stmt;
      EXECUTE IMMEDIATE'
            ALTER TABLE loadintoszen9_' || mapid || ' PARALLEL  (degree
            12)';
      EXECUTE IMMEDIATE'
            CREATEINDEX idx_load9_' || mapid || ' ON loadintoszen9_' ||
            mapid || ' (point_id) PARALLEL 12';


/*Calculation of the warning level zones for a waveheight (ssh) < 3m per
map sheet*********************** */
/***************** MAGNITUDE 7.5 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS SELECT a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen75_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS SELECT a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM  nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN75 b
      ON a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id';
EXECUTE IMMEDIATE'
```

```
      DELETE FROM nodes_broad_over_3m Where nodes_broad_over_3m < 5';
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
      SELECT scen_id FROM nodes_broad_coast_sshmax  Where scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
EXECUTE IMMEDIATE'CREATE TABLE Haz_WZ_broad75 (point_id) AS
      SELECT b.point_id
      FROM scens_broad_over_3ssh a, loadintoszen75_' ||mapid|| ' b
      WHERE a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad75 a WHERE a.rowid > ANY (SELECT b.rowid
      FROM  Haz_WZ_broad75 b
      WHERE a.point_id = b.point_id)';

EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad75 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad75
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATEINDEX idx_WZ_broad75 ON Haz_WZ_broad75 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen75_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';


/**************** MAGNITUDE 7.7 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS select a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen77_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS select a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN77 b
      ON a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id  ';
EXECUTE IMMEDIATE'
      CREATEINDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id';
EXECUTE IMMEDIATE'
```

```
      DELETE FROM nodes_broad_over_3m Where nodes_broad_over_3m < 5';
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
      SELECT scen_id FROM nodes_broad_coast_sshmax  Where scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad77 (point_id) AS
      Select b.point_id
      FROM scens_broad_over_3ssh a, loadintoszen77_' ||mapid|| ' b
      WHERE a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad77 a
      WHERE a.rowid > ANY (SELECT b.rowid FROM Haz_WZ_broad77 b
      WHERE a.point_id = b.point_id)';
EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad77 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad77
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATEINDEX idx_WZ_broad77 ON Haz_WZ_broad77 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen77_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';

/***************** MAGNITUDE 8.0 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS select a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen80_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS SELECT a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN80 b ON
      a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id  ';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id ';
EXECUTE IMMEDIATE'
      DELETE FROM nodes_broad_over_3m Where nodes_broad_over_3m < 5';
```

```
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
      SELECT scen_id FROM nodes_broad_coast_sshmax  Where scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad80 (point_id) AS SELECT b.point_id
      FROM scens_broad_over_3ssh a, loadintoszen80_' ||mapid|| ' b
      WHERE a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad80 a WHERE a.rowid > ANY
      (SELECT b.rowid FROM Haz_WZ_broad80 b
      WHERE a.point_id = b.point_id)';
EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad80 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad80
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_WZ_broad80 ON Haz_WZ_broad80 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen80_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';

/***************** MAGNITUDE 8.2 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS select a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen82_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS select a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN82 b
      ON a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT Count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id ';
EXECUTE IMMEDIATE'
      DELETE FROM nodes_broad_over_3m Where nodes_broad_over_3m < 5';
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
```

```
      SELECT scen_id FROM nodes_broad_coast_sshmax WHERE scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad82 (point_id) AS
      SELECT b.point_id FROM scens_broad_over_3ssh a, loadintoszen82_'
      ||mapid|| ' b Where a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad82 a WHERE a.rowid > ANY
      (SELECT b.rowid
      FROM Haz_WZ_broad82 b
      WHERE a.point_id = b.point_id )';
EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad82 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad82
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_WZ_broad82 ON Haz_WZ_broad82 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen82_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';

/***************** MAGNITUDE 8.5 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS select a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen85_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS select a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM  nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN85 b ON
      a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id  ';
EXECUTE IMMEDIATE'
      CREATEINDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id ';
EXECUTE IMMEDIATE'
      DELETE FROM nodes_broad_over_3m WHERE nodes_broad_over_3m < 5';
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
```

```
      SELECT scen_id FROM nodes_broad_coast_sshmax  WHERE scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad85 (point_id) AS
      SELECT b.point_id FROM scens_broad_over_3ssh a, loadintoszen85_'
      ||mapid|| ' b Where a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad85 a WHERE a.rowid > ANY
      (SELECT b.rowid FROM Haz_WZ_broad85 b
      WHERE a.point_id = b.point_id)';
EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad85 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad85
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_WZ_broad85 ON Haz_WZ_broad85 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen85_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';

/***************** MAGNITUDE 8.7 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS select a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen87_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS select a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN87 b ON
      a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id  ';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id ';
EXECUTE IMMEDIATE'
      DELETE FROM nodes_broad_over_3m WHERE nodes_broad_over_3m < 5';
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
      SELECT scen_id FROM nodes_broad_coast_sshmax WHERE scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
```

```
EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad87 (point_id) AS
      SELECT b.point_id From scens_broad_over_3ssh a, loadintoszen87_'
      ||mapid|| ' b Where a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad87 a WHERE a.rowid >  ANY
      (SELECT b.rowid FROM Haz_WZ_broad87 b
      WHERE a.point_id = b.point_id )';
EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad87 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad87
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_WZ_broad87 ON Haz_WZ_broad87 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen87_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';

/***************** MAGNITUDE 9.0 **********/
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast (
            point_id,
            shape,
            scen_id)
      AS select a. point_id, a.shape, b.scen_id FROM Dlr_gridpoints_coast a
      INNER JOIN loadintoszen9_' ||mapid|| ' b ON a.point_id=b.point_id';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_coast_sshmax (
            point_id,
            shape,
            scen_id,
            ssh_max)
      AS select a.point_id, a.shape, a.scen_id, b.ssh_max
      FROM nodes_broad_coast a INNER JOIN LOAD_INTO_SZEN90 b
      ON a.point_id=b.point_id Where ssh_max>0 AND a.scen_id=b.scen_id  ';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_coast_sshmax ON nodes_broad_coast_sshmax (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      CREATE TABLE nodes_broad_over_3m (nodes_broad_over_3m, scen_id) AS
      SELECT count (point_id) as nodes_broad_over_3m, scen_id
      FROM nodes_broad_coast_sshmax WHERE SSH_max > 3
      GROUP by scen_id ';
EXECUTE IMMEDIATE'
      DELETE FROM nodes_broad_over_3m Where nodes_broad_over_3m < 5';
EXECUTE IMMEDIATE'
      CREATE TABLE scens_broad_over_3ssh (scen_id) AS
      SELECT scen_id FROM nodes_broad_coast_sshmax  WHERE scen_id NOT IN
      (SELECT scen_id FROM nodes_broad_over_3m) group by scen_id';
EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad90 (point_id) AS
```

```
      SELECT b.point_id From scens_broad_over_3ssh a,  loadintoszen9_'
      ||mapid|| ' b Where a.scen_id = b.scen_id';
EXECUTE IMMEDIATE'
      DELETE FROM Haz_WZ_broad90 a WHERE a.rowid > ANY
      (SELECT b.rowid FROM Haz_WZ_broad90 b
      WHERE a.point_id = b.point_id)';
EXECUTE IMMEDIATE'
      ALTER TABLE Haz_WZ_broad90 ADD (inundation INTEGER)';
EXECUTE IMMEDIATE'
      Update Haz_WZ_broad90
      SET inundation = 1';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_WZ_broad90 ON Haz_WZ_broad90 (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE loadintoszen9_' ||mapid|| ' CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_coast_sshmax CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE nodes_broad_over_3m CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE scens_broad_over_3ssh CASCADE CONSTRAINTS PURGE';


/***************** Aggregatte the results of the warning level zones per
magnitude to an overall result **********/

EXECUTE IMMEDIATE'
      CREATE TABLE Haz_WZ_broad (point_id, inundation) AS
      SELECT point_id, inundation from haz_wz_broad75 UNION
      SELECT point_id, inundation from haz_wz_broad77 UNION
      SELECT point_id, inundation from haz_wz_broad80 UNION
      SELECT point_id, inundation from haz_wz_broad82 UNION
      SELECT point_id, inundation from haz_wz_broad85 UNION
      SELECT point_id, inundation from haz_wz_broad87 UNION
      SELECT point_id, inundation from haz_wz_broad90';
EXECUTE IMMEDIATE'
      CREATE INDEX idx_HAZ_WZ ON Haz_WZ_broad (point_id)
      Parallel (degree 12)';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad75 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad77 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad80 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad82 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad85 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad87 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      DROP TABLE haz_wz_broad90 CASCADE CONSTRAINTS PURGE';
EXECUTE IMMEDIATE'
      CREATE TABLE  TSH_'|| mapid ||'_'||v_date||'WZ AS
      SELECT b.objectid, b.point_id, b.shape, b.se_anno_cad_data ,
      a.inundation From Haz_WZ_broad a INNER JOIN
      GITEWS.dlr_grid_v3_ws_clean b ON a.point_id = b.point_id';
```

```
      INSERT INTO user_sdo_geom_metadata VALUES (
      'TSH_'|| mapid ||'_'||v_date||'WZ',
      'SHAPE',
      MDSYS.SDO_DIM_ARRAY(
      MDSYS.SDO_DIM_ELEMENT('X',-180,180,0.0000015),
      MDSYS.SDO_DIM_ELEMENT('Y',-90,90,0.0000005)
     ),
     NULL);
EXECUTE IMMEDIATE'
      CREATE INDEX idx_TSH' ||mapid|| 'shp ON TSH_'|| mapid
      ||'_'||v_date||'WZ (shape)
      indextype is mdsys.spatial_index';
/* **********************Anfang Registrierung der berechneten Tabelle für
die SDE und der Zuweisung des Koordinatensystems WSG84******************
*/
BEGIN
DECLARE
      v_JobName2 VARCHAR2(100);
      table_in2 VARCHAR(40) := 'TSH_'|| mapid ||'_'||v_date||'WZ';

BEGIN
      -- Registration
      v_JobName2 := DBMS_SCHEDULER.Generate_Job_Name; -- jobname
      DBMS_OUTPUT.ENABLE;
      DBMS_OUTPUT.PUT_LINE('Jobname is: '|| v_jobName2);
      DBMS_SCHEDULER.Create_Job(
      job_name => v_JobName2,
      job_type => 'EXECUTABLE',
      job_action => 'C:\WINDOWS\SYSTEM32\cmd.exe',
      number_of_arguments => 3,
      enabled => FALSE );

      -- CREATEJob
      DBMS_SCHEDULER.Set_Job_Argument_Value (
      job_name => v_JobName2,
      argument_position => 1,
      argument_value => '/q'
      );
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName2, 2, '/c');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName2, 3, 'sdelayer -o
      register -l '||table_in2||',shape -e npc -C OBJECTID -t sdo_geometry
      -u compute -P BASIC -p Compute');
      DBMS_Scheduler.enable(v_JobName2);

      -- add Projection
      v_JobName2 := DBMS_SCHEDULER.Generate_Job_Name; generieren
      DBMS_OUTPUT.ENABLE;
      DBMS_OUTPUT.PUT_LINE('Jobname ist: '|| v_jobName2);
      DBMS_SCHEDULER.Create_Job(
      job_name => v_JobName2,
      job_type => 'EXECUTABLE',
      job_action => 'C:\WINDOWS\SYSTEM32\cmd.exe',
      number_of_arguments => 3, --Parameteranzahl
      enabled => FALSE -- Job ist inaktiv);

      -- CREATEJob
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName2, 1, '/q');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName2, 2, '/c');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName2, 3, 'sdelayer -o
      alter -l '||table_in2||',shape -G 4326 -u compute -p Compute');
```

```
      DBMS_Scheduler.enable(v_JobName2);

      SDE_LAYER LOG FILE IN:
      --C:\*\giomgr_esri_sde.log

      DBMS_LOCK.Sleep(30);
      FOR i in (SELECT status, additional_info
      FROM all_scheduler_job_run_details
      WHERE (job_name = v_jobName2))
      LOOP
      DBMS_OUTPUT.PUT_LINE('Status: '|| i.status);
      DBMS_OUTPUT.PUT_LINE('Status: '|| i.additional_info);
  END loop; --for
END;
END;
END LOOP;
END;
END HAZARD_BROADSCALE;
```

The following two output files will be created:

- the hazard-probability layer (TSH_mapID_*date*) as a point-table and
- the associated warning zones (TSH_mapID_*date*_WZ).

2.1.3 Calculation of estimated times of arrival (ETA)

Every modeled scenario comprises an Estimated Time of Arrival (ETA) of the first disastrous Tsunami wave hitting the coast. The ETA can vary to a great extent for the various scenarios depending generally on the distance from the coast to the tsunamogenic source and the earthquake magnitude. To derive a valid value for the ETA from all available scenarios, two values are shown in the hazard map. The Min. ETA represents the minimum ETA which was found in all available scenarios, which is defined as 3 percentile. This is the worst case for the displayed point in the map. But this can be also a very rare event, so the Med. ETA is added to the point in the map. This value is the Median (50%-value) of the minimum ETAs of all relevant scenarios for the regarded region.

For the calculation based on the predefined POI's the following PL/SQL-query have to be performed:

```
CREATE OR REPLACE
PROCEDURE ETA_ALL AS
BEGIN
DECLARE
      v_day VARCHAR2 (2);
      v_month VARCHAR2 (2);
       v_year VARCHAR2 (4);
       v_date VARCHAR (10);

BEGIN
/*****************************************************************
 used to compute ETAs as the 3 Percent percentile of ETAs
 at points (POIs) stored in the table "ETAS_Selected_points"
*****************************************************************/
```

```
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_75 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN75 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN75 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_77 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN77 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN77 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_80 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN80 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN80 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_82 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN82 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN82 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_85 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN85 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN85 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_87 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN87 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN87 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAS_Selected_points_90 AS
SELECT /*+ PARALLEL (LOAD_INTO_SZEN90 16) */ a.ARRIVALTIM as ETA ,
a.POINT_ID FROM LOAD_INTO_SZEN90 a
INNER JOIN COMPUTE.ETAS_Selected_points b ON a.POINT_ID = b.POINT_ID';
EXECUTE IMMEDIATE'
CREATE TABLE ETAs_statistics_temp AS
SELECT  POINT_ID, MIN("Percentile_Disc_1") as Perzentil_1,
  MIN("Percentile_Disc_3") as Perzentil_3,
  MIN("Median") as Median,
  count("POINT_ID") AS cnt
  FROM
  (SELECT point_id,
    eta,
    round((PERCENTILE_DISC(0.01) WITHIN GROUP (ORDER BY eta ASC)
     OVER (PARTITION BY point_id))/60) "Percentile_Disc_1" ,
    round((PERCENTILE_DISC(0.03) WITHIN GROUP (ORDER BY eta ASC)
     OVER (PARTITION BY point_id))/60) "Percentile_Disc_3",
    round((PERCENTILE_DISC(0.5) WITHIN GROUP (ORDER BY eta ASC)
     OVER (PARTITION BY point_id))/60) "Median"
    FROM
    (SELECT * FROM ETAS_Selected_points_75 WHERE eta>0
    UNION
    SELECT * FROM ETAS_Selected_points_77 WHERE eta>0
    UNION
    SELECT * FROM ETAS_Selected_points_80 WHERE eta>0
    UNION
    SELECT * FROM ETAS_Selected_points_82 WHERE eta>0
    UNION
    SELECT * FROM ETAS_Selected_points_85 WHERE eta>0
```

```
    UNION
    SELECT * FROM ETAS_Selected_points_87 WHERE eta>0
    UNION
    SELECT * FROM ETAS_Selected_points_90 WHERE eta>0
    )
  )
  GROUP BY POINT_ID order by POINT_ID';
v_day := to_char (Extract (DAY from sysdate));
v_month := to_char (Extract (MONTH from sysdate));
v_year := to_char (Extract (YEAR from sysdate));
v_date := v_year||v_month||v_day;
EXECUTE IMMEDIATE'
CREATE TABLE ETA_STATISTIC_SHAPE_'||v_date||' AS
 SELECT
 a.point_id, a.ws_id,  b.Perzentil_1, b.perzentil_3,a.min_eta,
b.median,a.med_eta, b.cnt, a.scale, a.shape, a.se_anno_cad_data
 FROM
 COMPUTE.ETAS_Selected_points a,
 COMPUTE.ETAs_statistics_temp b
 WHERE (
 b.POINT_ID = a.POINT_ID
 ) ';

/*** Metadaten schreiben ***/

INSERT INTO user_sdo_geom_metadata VALUES (
     'ETA_STATISTIC_SHAPE_'||v_date||,
     'SHAPE',
     MDSYS.SDO_DIM_ARRAY(
     MDSYS.SDO_DIM_ELEMENT('X',-180,180,0.0000005),
     MDSYS.SDO_DIM_ELEMENT('Y',-90,90,0.0000005)
     ),
     NULL);

EXECUTE IMMEDIATE'
      CREATE INDEX idx_ETA_STATISTIC_SHAPE_'||v_date||'
     on ETA_STATISTIC_SHAPE_'||v_date||'(shape)
     indextype is mdsys.spatial_index
     PARALLEL 3' ;
/*** Klassifizierung der ETAs in 10 min Klassen
  für die Darstellung in den Karten           ***/
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <10 min
WHERE a.perzentil_3 <10 ';
      EXECUTE IMMEDIATE'
Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <20 min
      WHERE a.perzentil_3 <20 AND a.perzentil_3>=10';
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <30 min
      WHERE a.perzentil_3 <30 AND a.perzentil_3>=20';
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <40 min
      WHERE a.perzentil_3 <40 AND a.perzentil_3>=30';
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <50 min
      WHERE a.perzentil_3 <50 AND a.perzentil_3>=40';
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <60 min
      WHERE a.perzentil_3 <60 AND a.perzentil_3>=50';
EXECUTE IMMEDIATE'
```

```
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <70 min
       WHERE a.perzentil_3 <70 AND a.perzentil_3>=60';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <80 min
       WHERE a.perzentil_3 <80 AND a.perzentil_3>=70';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <90 min
       WHERE a.perzentil_3 <90 AND a.perzentil_3>=80';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <100 min
       WHERE a.perzentil_3 <100 AND a.perzentil_3>=90';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <110 min
       WHERE a.perzentil_3 <110 AND a.perzentil_3>=100';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <120 min
       WHERE a.perzentil_3 <120 AND a.perzentil_3>=110';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MIN_ETA = <130 min
       WHERE a.perzentil_3 <130 AND a.perzentil_3>=120';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <10 min
       WHERE a.median <10 ';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <20 min
       WHERE a.median <20 AND a.median>=10';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <30 min
       WHERE a.median <30 AND a.median>=20';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <40 min
       WHERE a.median <40 AND a.median>=30';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <50 min
       WHERE a.median <50 AND a.median>=40';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <60 min
       WHERE a.median <60 AND a.median>=50';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <70 min
       WHERE a.median <70 AND a.median>=60';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <80 min
       WHERE a.median <80 AND a.median>=70';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <90 min
       WHERE a.median <90 AND a.median>=80';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <100 min
       WHERE a.median <100 AND a.median>=90';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <110 min
       WHERE a.median <110 AND a.median>=100';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <120 min
       WHERE a.median <120 AND a.median>=110';
EXECUTE IMMEDIATE'
       Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <130 min
       WHERE a.median <130 AND a.median>=120';
EXECUTE IMMEDIATE'
```

```
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <140 min
      WHERE a.median <140 AND a.median>=130';
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <150 min
      WHERE a.median <150 AND a.median>=140';
EXECUTE IMMEDIATE'
      Update ETA_STATISTIC_SHAPE_'||v_date||' a SET a.MED_ETA = <160 min
      WHERE a.median <160 AND a.median>=150';

/************************Anfang Registrierung der berechneten Tabelle für
die SDE und der Zuweisung des Koordinatensystems WSG84******************
*/
BEGIN
DECLARE
      v_JobName VARCHAR2(100);
      table_in VARCHAR(40) := 'ETA_STATISTIC_SHAPE_'||v_date||;

BEGIN
      -- Registration
      v_JobName := DBMS_SCHEDULER.Generate_Job_Name;
      DBMS_OUTPUT.ENABLE;
      DBMS_OUTPUT.PUT_LINE('Jobname ist: '|| v_jobName);
      DBMS_SCHEDULER.Create_Job(
      job_name => v_JobName,
      job_type => 'EXECUTABLE',
      job_action => 'C:\WINDOWS\SYSTEM32\cmd.exe',
      number_of_arguments => 3,
      enabled => FALSE);

      DBMS_SCHEDULER.Set_Job_Argument_Value (
      job_name => v_JobName,
      argument_position => 1,
      argument_value => '/q');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName, 2, '/c');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName, 3, 'sdelayer -o
      register -l '||table_in||',shape -e npc -C OBJECTID -t sdo_geometry -
      u compute -P BASIC -p Compute');
      DBMS_Scheduler.enable(v_JobName);

      -- SDE_LAYER LOG FILE IN: C:\*\giomgr_esri_sde.log

      DBMS_LOCK.Sleep(30);
      -- add Projection
      v_JobName := DBMS_SCHEDULER.Generate_Job_Name;
      DBMS_OUTPUT.ENABLE;
      DBMS_OUTPUT.PUT_LINE('Jobname ist: '|| v_jobName);
      DBMS_SCHEDULER.Create_Job(
      job_name => v_JobName,
      job_type => 'EXECUTABLE',
      job_action => 'C:\WINDOWS\SYSTEM32\cmd.exe',
      number_of_arguments => 3,
      enabled => FALSE);
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName, 1, '/q');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName, 2, '/c');
      DBMS_SCHEDULER.Set_Job_Argument_Value (v_JobName, 3, 'sdelayer -o
      alter -l '||table_in||',shape -G 4326 -u compute -p Compute');
      DBMS_Scheduler.enable(v_JobName);

      -- SDE_LAYER LOG FILE IN:
      C:\* \giomgr_esri_sde.log
```

```
      DBMS_LOCK.Sleep(30);

END;
END;
END;
END ETA_ALL;
```

For the ETA-calculation based on the warning-zones the following PL/SQL-query ETA_PER_WZ have to be performed. The associated points of the DLR_Gridpoints_coastclip will assigned to the specific warning-segment (ETA_Points_Coast_WS):

```
CREATE OR REPLACE
PROCEDURE ETA_PER_WZ AS
BEGIN
DECLARE
        v_day VARCHAR2 (2);
        v_month VARCHAR2 (2);
        v_year VARCHAR2 (4);
        v_date VARCHAR (10);
BEGIN

        v_day := to_char (Extract (DAY from sysdate));
        v_month := to_char (Extract (MONTH from sysdate));
        v_year := to_char (Extract (YEAR from sysdate));
        v_date := v_year||v_month||v_day;

/****************************************************************
 used to compute ETAs as the 3 Percent percentile of ETAs
 at points (POIs) stored in the table "ETA_COAST_WS"
***************************************************************/
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_75 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN75 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_77 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN77 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_80 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN80 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_82 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN82 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
```

```
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_85 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN85 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_87 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN87 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETAS_COAST_WS_90 AS
        SELECT a.ARRIVALTIM as ETA, a.POINT_ID, b.WS_ID FROM
        LOAD_INTO_SZEN90 a
        INNER JOIN COMPUTE.ETA_POINTS_COAST_WS b ON a.POINT_ID =
        b.POINT_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETAs_statistics_WS_temp AS
        SELECT  WS_ID, MIN("Percentile_Disc_1") as Perzentil_1,
        MIN("Percentile_Disc_3") as Perzentil_3,
        MIN("Median") as Median,
        count("WS_ID") AS cnt
        FROM
        (SELECT WS_id, eta,
        round((PERCENTILE_DISC(0.01) WITHIN GROUP (ORDER BY eta ASC)
        OVER (PARTITION BY WS_id))/60) "Percentile_Disc_1" ,
        round((PERCENTILE_DISC(0.03) WITHIN GROUP (ORDER BY eta ASC)
        OVER (PARTITION BY WS_id))/60) "Percentile_Disc_3",
        round((PERCENTILE_DISC(0.5) WITHIN GROUP (ORDER BY eta ASC)
        OVER (PARTITION BY WS_id))/60) "Median"
        FROM
        (SELECT * FROM ETAS_COAST_WS_75 WHERE eta>0
        UNION
        SELECT * FROM ETAS_COAST_WS_77 WHERE eta>0
        UNION
        SELECT * FROM ETAS_COAST_WS_80 WHERE eta>0
        UNION
        SELECT * FROM ETAS_COAST_WS_82 WHERE eta>0
        UNION
        SELECT * FROM ETAS_COAST_WS_85 WHERE eta>0
        UNION
        SELECT * FROM ETAS_COAST_WS_87 WHERE eta>0
        UNION
        SELECT * FROM ETAS_COAST_WS_90 WHERE eta>0
        ))
        GROUP BY WS_ID order by WS_ID';
EXECUTE IMMEDIATE'
        CREATE TABLE ETA_STATISTIC_WS_temp2 AS
        SELECT b.ws_id, b.Perzentil_3 ,a.min_eta, b.median, a.med_eta,
        b.cnt, a.shape, a.se_anno_cad_data
        FROM COMPUTE.ETAs_statistics_WS_temp b,
        COMPUTE.ETA_points_coast_ws a
        WHERE (b.WS_ID = a.WS_ID)  ';

EXECUTE IMMEDIATE'
        CREATE TABLE ETA_STATISTIC_WS_'||v_date||' AS
        SELECT
        distinct(ws_id), Perzentil_3 ,min_eta, median, med_eta, cnt
```

```
        FROM  ETA_STATISTIC_WS_temp2';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_ETA_STATISTIC_WS_'||v_date||' ON
        ETA_STATISTIC_WS_'||v_date||' (ws_id)
        PARALLEL 12';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <10 min
        WHERE a.perzentil_3 <10 ';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <20 min
        WHERE a.perzentil_3 <20 AND a.perzentil_3>=10';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <30 min
        WHERE a.perzentil_3 <30 AND a.perzentil_3>=20';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <40 min
        WHERE a.perzentil_3 <40 AND a.perzentil_3>=30';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <50 min
        WHERE a.perzentil_3 <50 AND a.perzentil_3>=40';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <60 min
        WHERE a.perzentil_3 <60 AND a.perzentil_3>=50';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <70 min
        WHERE a.perzentil_3 <70 AND a.perzentil_3>=60';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <80 min
        WHERE a.perzentil_3 <80 AND a.perzentil_3>=70';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <90 min
        WHERE a.perzentil_3 <90 AND a.perzentil_3>=80';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <100 min
        WHERE a.perzentil_3 <100 AND a.perzentil_3>=90';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <110 min
        WHERE a.perzentil_3 <110 AND a.perzentil_3>=100';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <120 min
        WHERE a.perzentil_3 <120 AND a.perzentil_3>=110';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MIN_ETA = <130 min
        WHERE a.perzentil_3 <130 AND a.perzentil_3>=120';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <10 min
        WHERE a.median <10 ';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <20 min
        WHERE a.median <20 AND a.median>=10';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <30 min
        WHERE a.median <30 AND a.median>=20';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <40 min
        WHERE a.median <40 AND a.median>=30';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <50 min
        WHERE a.median <50 AND a.median>=40';
```

```
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <60 min
        WHERE a.median <60 AND a.median>=50';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <70 min
        WHERE a.median <70 AND a.median>=60';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <80 min
        WHERE a.median <80 AND a.median>=70';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <90 min
        WHERE a.median <90 AND a.median>=80';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <100 min
        WHERE a.median <100 AND a.median>=90';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <110 min
        WHERE a.median <110 AND a.median>=100';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <120 min
        WHERE a.median <120 AND a.median>=110';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <130 min
        WHERE a.median <130 AND a.median>=120';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <140 min
        WHERE a.median <140 AND a.median>=130';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <150 min
        WHERE a.median <150 AND a.median>=140';
EXECUTE IMMEDIATE'
        UPDATE ETA_STATISTIC_WS_'||v_date||' a SET a.MED_ETA = <160 min
        WHERE a.median <160 AND a.median>=150';

END;
END ETA_PER_WZ;
```

2.1.4 Converting from point-shape to raster-file

The last step is the union of the discrete points in the map sheets. For the displaying of the calculated probabilities the area-information was transform to a raster-file. Herby a computation model was prepared with the ArcMap Model-Builders.

In the following Model-Builder (Figure 2) the hazard-probabilities were interpolated and simplified to a ca. 30 - 50 m raster:

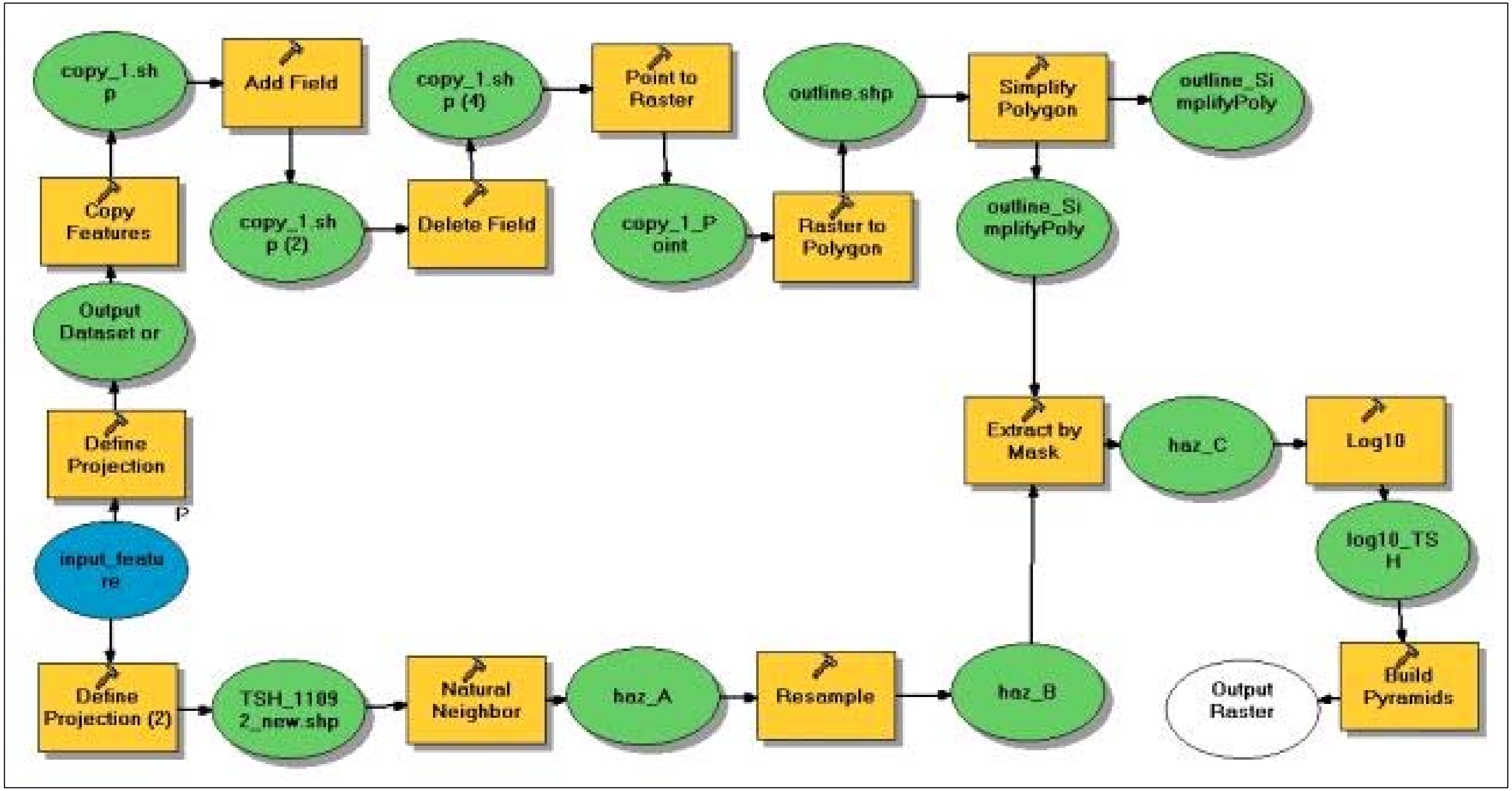


Figure 2: Workflow of the convertion from point-shape to raster-file in ArcGis Modelbuilder (DLR 2009)

2.2 Local level

2.2.1 Calculation of tsunami hazard probabilities

The method used to produce detailed hazard maps for the GITEWS pilot areas is the same as for the 1:100 000 hazard map series, but the used database is more detailed.

The calculation of the tsunami hazard probabilities based, instead on GRID-points on more detailed polygon-areas (elements). The number of tsunami inundation scenarios used was 137, with moment magnitudes of 8.0, 8.5 and 9.0. The results of the calculation have to joint to the polygons-shapes (elements) in ArcGIS. Furthermore a registration inner the ArcSDE have to be performed manually, because an automatically registration with SQL/PL isn't given.

The following PL/SQL-query have to be performed:

```
CREATE OR REPLACE PROCEDURE COMPUTE_HAZARD_PILOT AS

BEGIN

DECLARE sql_stmt VARCHAR(950);
sql_stmt2 VARCHAR2(10);
my_mapnr1 VARCHAR2(50);
my_mapnr2 VARCHAR2(50);
mapid string(60);

  /* Cursor to define the concerned mapsheets */
        CURSOR maps_cursor IS
        SELECT
        DISTINCT(t3.nr_100k) AS  map
        FROM patch_rechnen_mag77 t1, punktids77_chip t2,
        compute.gitews_id_maps_100k_ll_konv t3
        WHERE t1.objectid = t2.objectid AND t2.nr_100k = t3.nr_100k
        ORDER BY map DESC;

BEGIN
-- FOR map_record IN maps_cursor
-- LOOP
-- DBMS_OUTPUT.ENABLE(100000);
-- mapid := TO_NUMBER((SUBSTR(my_mapnr, INSTR(my_mapnr,'-')-4,4) ||
SUBSTR(my_mapnr, INSTR(my_mapnr,'-')+1,1)));
        my_mapnr1 := '1308-3';
        my_mapnr2 := '1308-2';
        mapid := 'CILACAP';

DBMS_OUTPUT.PUT_LINE('Map: ' || my_mapnr || ' / mapid: ' || mapid);

/* *********************** BEGIN MW 8.0 ******************** */
sql_stmt :='
        CREATE TABLE loadintoszen80_' || mapid || ' AS
        SELECT b.scen_id, b.ssh_max, a.objectid, a.prob, a.nr_100k,
        cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-7,3) AS INT) as I_lat,
```

```
        cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-3,2) AS INT) AS J_lon,
        SUBSTR(scen_Id, INSTR(scen_id, ''mw'')+2,3)AS mw,
        b.element AS point_id
        FROM load_into_prio_sshmax_cilacap b
        INNER JOIN
        compute.distinct_sources_80_spatialJ a ON
        a.i=cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-7,3) AS INT)
        AND
        a.j=cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-3,2) AS INT)
        WHERE a.nr_100k LIKE '''|| my_mapnr1 ||''' AND SUBSTR(scen_Id,
        INSTR(scen_id, ''mw'')+2,3) LIKE ''800''
        AND b.ssh_max > 0.01
        OR a.nr_100k like '''|| my_mapnr2 ||'''
        AND SUBSTR(scen_Id, INSTR(scen_id, ''mw'')+2,3) LIKE ''800''
        AND b.ssh_max > 0.01
        ';

EXECUTE IMMEDIATE sql_stmt;

EXECUTE IMMEDIATE'
        ALTER TABLE loadintoszen80_' || mapid || ' PARALLEL  (degree 12)
        ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_loadszen80_' || mapid || '_pid ON loadintoszen80_'
        || mapid || '(point_id) PARALLEL 16
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE sum_perpoint_map80_' || mapid || ' AS
        SELECT /*+ PARALLEL COMPUTE.LOADINTOSZEN80_' || mapid || ' 12 */
        point_id, sum(prob) as sumprob
        FROM COMPUTE.LOADINTOSZEN80_' || mapid || '
        GROUP BY point_id
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE scens_per_map80_' || mapid || ' AS
        SELECT /*+ PARALLEL COMPUTE.LOADINTOSZEN80_' || mapid || ' 12 */
        count(distinct(scen_id)) as cnt
        FROM COMPUTE.LOADINTOSZEN80_' || mapid || '
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE probs80_' || mapid || ' AS
        SELECT a.point_id, a.sumprob/b.cnt AS hit_ratio
        FROM
        sum_perpoint_map80_' || mapid || ' a,
        scens_per_map80_' || mapid || ' b
        ';

EXECUTE IMMEDIATE '
        CREATE TABLE allprobs_' || mapid || ' AS
        SELECT point_id,hit_ratio FROM
        probs80_' || mapid || '
        ';

EXECUTE IMMEDIATE '
        DROP table probs80_' || mapid || '
        ';
```

```
/* *********************** END MW 8.0************************** */

/* *********************** BEGIN MW 8.5******************** */
sql_stmt := '
        CREATE TABLE loadintoszen85_' || mapid || ' AS
        SELECT /*+ PARALLEL(load_into_prio_sshmax_cilacap 12) */
        b.scen_id, b.ssh_max,
        a.objectid, a.prob, a.nr_100k,
        cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-7,3) AS INT) as I_lat,
        cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-3,2) AS INT) AS J_lon,
        SUBSTR(scen_Id, INSTR(scen_id, ''mw'')+2,3)AS mw,
        b.element AS point_id
        FROM load_into_prio_sshmax_cilacap b
        INNER JOIN
        Compute.distinct_sources_85_spatialJ a ON
        a.i=cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-7,3) AS INT)
        AND
        a.j=cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-3,2) AS INT)
        WHERE (a.nr_100k LIKE '''|| my_mapnr1 ||'''AND SUBSTR(scen_Id,
        INSTR(scen_id, ''mw'')+2,3) LIKE ''850''
        AND b.ssh_max > 0.01)
        OR (a.nr_100k like '''|| my_mapnr2 ||'''
        AND SUBSTR(scen_Id, INSTR(scen_id, ''mw'')+2,3) LIKE ''850''
        AND b.ssh_max > 0.1)
        ';

EXECUTE IMMEDIATE sql_stmt;

EXECUTE IMMEDIATE'
        ALTER TABLE loadintoszen85_' || mapid || ' PARALLEL  (degree 12)
        ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_loadszen85_' || mapid || '_pid ON loadintoszen85_'
        || mapid || '(point_id) PARALLEL 12
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE sum_perpoint_map85_' || mapid || ' AS
        SELECT /*+ PARALLEL COMPUTE.LOADINTOSZEN85_' || mapid || ' 12 */
        point_id, sum(prob) as sumprob
        FROM COMPUTE.LOADINTOSZEN85_' || mapid || '
        GROUP BY point_id
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE scens_per_map85_' || mapid || ' AS
        SELECT /*+ PARALLEL COMPUTE.LOADINTOSZEN85_' || mapid || ' 12 */
        count(distinct(scen_id)) as cnt
        FROM COMPUTE.LOADINTOSZEN85_' || mapid || '
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE probs85_' || mapid || ' AS
        SELECT a.point_id, a.sumprob/b.cnt AS hit_ratio
        FROM
        sum_perpoint_map85_' || mapid || ' a,
        scens_per_map85_' || mapid || ' b
        ';
```

```
EXECUTE IMMEDIATE'
        INSERT INTO allprobs_' || mapid || '
        SELECT point_id,hit_ratio FROM
        probs85_' || mapid || '
        ';

EXECUTE IMMEDIATE'
        DROP table probs85_' || mapid || '
        ';
/* *********************** END MW 8.5 ************************** */

/* *********************** BEGIN MW 9    ******************** */
sql_stmt := 'CREATE TABLE loadintoszen9_' || mapid || ' AS
        SELECT /*+ PARALLEL(load_into_prio_sshmax_cilacap 12) */
        b.scen_id, b.ssh_max,
        a.objectid, a.prob, a.nr_100k,
        cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-7,3) AS INT) as I_lat,
        cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-3,2) AS INT) AS J_lon,
        SUBSTR(scen_Id, INSTR(scen_id, ''mw'')+2,3)AS mw,
        b.element AS point_id
        FROM load_into_prio_sshmax_cilacap b
        INNER JOIN
        compute.distinct_sources_9_spatialJo a ON
        a.i=cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-7,3) AS INT)
        AND a.j=cast(SUBSTR(scen_id, INSTR(scen_id, ''mw'')-3,2) AS INT)
        WHERE (a.nr_100k LIKE '''|| my_mapnr1 ||'''AND SUBSTR(scen_Id,
        INSTR(scen_id, ''mw'')+2,3) LIKE ''900''
        AND b.ssh_max > 0.01)
        OR a.nr_100k like '''|| my_mapnr2 ||'''
        AND SUBSTR(scen_Id, INSTR(scen_id, ''mw'')+2,3) LIKE ''900''
        AND b.ssh_max > 0.1
        ';
EXECUTE IMMEDIATE sql_stmt;

EXECUTE IMMEDIATE'
        CREATE INDEX idx_loadszen9_' || mapid || '_pid ON loadintoszen9_'
        || mapid || '(point_id)
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE sum_perpoint_map9_' || mapid || ' AS
        SELECT point_id, sum(prob) as sumprob
        FROM COMPUTE.LOADINTOSZEN9_' || mapid || '
        GROUP BY point_id
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE scens_per_map9_' || mapid || ' AS
        SELECT count(distinct(scen_id)) as cnt
        FROM COMPUTE.LOADINTOSZEN9_' || mapid || '
        ';

EXECUTE IMMEDIATE'
        CREATE TABLE probs9_' || mapid || ' AS
        SELECT a.point_id, a.sumprob/b.cnt AS hit_ratio
        FROM sum_perpoint_map9_' || mapid || ' a,
        scens_per_map9_' || mapid || ' b
        ';
```

```
EXECUTE IMMEDIATE'
        INSERT INTO allprobs_' || mapid || '
        SELECT point_id,hit_ratio FROM
        probs9_' || mapid || '
        ';

EXECUTE IMMEDIATE'
        DROP table probs9_' || mapid || '
        ';
/* *********************** END MW 9 ************************** */

EXECUTE IMMEDIATE'
        CREATE TABLE ALLPROBS_' || mapid || '_SUM
        AS
        SELECT point_id, sum(hit_ratio) AS sumprob
        FROM ALLPROBS_' || mapid || ' GROUP BY point_id
        ';

/* ********************** END Metadata one mapsheet***************** */
END;
END COMPUTE_HAZARD_PILOT;
```

The next step is the calculation of the hazard-probabilities according to the warning zones with the maximum generated impact on land with a wave height at coast under 3 m.

The following PL/SQL-query have to be performed:

```
CREATE OR REPLACE PROCEDURE HAZARD_WARNINGZONE_PRIO AS
BEGIN

/* Erzeugen der Anfangstabelle mit der ID für die Elemente und der Scenario
ID auf die später die selektierten Scenarios wieder gejoint werden */

EXECUTE IMMEDIATE'
        CREATE TABLE nodes_Prio_sshmax (element_id, shape, ssh_max,
        scen_id )
        AS select a.element AS element_id, a.shape, b.ssh_max, b.scen_id
        FROM cilacap_hazardelements a INNER JOIN
        load_into_prio_sshmax_cilacap b ON a.element=b.element WHERE
        ssh_max>0
        ';

/* Erzeugen der Tabelle nur mit Elementen vor der Küste für die Abfrage der
Wellenhöhen an der Küste */

EXECUTE IMMEDIATE'
        CREATE TABLE nodes_Prio_sshmax_coast (element_id, ssh_max, scen_id)
        AS select a.element AS element_id, b.ssh_max, b.scen_id FROM
        cilacap_hazard_element_coast a INNER JOIN
        load_into_prio_sshmax_cilacap b ON a.element=b.element WHERE
        ssh_max> 0
        ';

/*Erzeuge eine Tabelle mit der Anzahl der Elemente an der Küste an denen
die Wellenhöhe über 3 m sind pro scenario*/

EXECUTE IMMEDIATE'
        CREATE TABLE nodes_Prio_over_3m (nodes_Prio_over_3m, scen_id) AS
```

```
        SELECT count(element_id) as nodes_Prio_over_3m, scen_id
        FROM nodes_Prio_sshmax_coast WHERE SSH_max> 3
        GROUP by scen_id
        ';

/*Erzeuge eine Tabelle mit der Gesamtanzahl an Elementen an der Küste an
pro Scenario zur Berechnung des prozentualen Anteils an Wellenhöhen über
oder gleich 3m an der Küste*/

EXECUTE IMMEDIATE'
        CREATE TABLE nodes_Prio_coast_sum AS
        SELECT scen_id, count(element_id) nodes_Prio_coast_sum
        FROM nodes_Prio_sshmax_coast group by scen_id
        ';

/* Erzeuge eine gemeinsame Tabelle mit den Inhalten aus den vorherigen
Tabellen nodes_Prio_under_3m und nodes_Prio_coast_sum */

EXECUTE IMMEDIATE'
        CREATE TABLE count_Prio_waves_coast (scen_id, nodes_prio_coast_sum,
        nodes_Prio_over_3m)  AS
        SELECT n.scen_id, n.nodes_prio_coast_sum, NVL(d.nodes_Prio_over_3m,
        0) as nodes_Prio_over_3m
        FROM nodes_Prio_coast_sum n, nodes_Prio_over_3m d
        WHERE n.scen_id = d.scen_id (+)
        ORDER BY n.scen_id
        ';

/* Erzeuge eine Tabelle mit den prozentualen Anteilen der Elemente unter
oder gleich 3m Wellenhöhe an der Küste pro Szenario"*/

EXECUTE IMMEDIATE'
        CREATE Table scens_Prio_over_3ssh (scen_id, perc3) AS
        SELECT scen_id, perc3
        FROM(
         SELECT scen_id,
         (nodes_Prio_over_3m/nodes_Prio_coast_sum) AS perc3,
        nodes_Prio_over_3m FROM count_Prio_waves_coast)
        WHERE perc3 <= 0.01
        ';

EXECUTE IMMEDIATE' UPDATE scens_Prio_over_3ssh SET perc3 = 1';

EXECUTE IMMEDIATE'COMMIT';

/*Erzeuge eine Tabelle mit den ausgewählten Szenarien aus der Tabelle
scens_prio_underequal_3ssh mit dem join auf die einzelnen Elemente*/

EXECUTE IMMEDIATE'
        CREATE Table Haz_WZ_Prio_cilacap (element_id, inundate)
        AS Select b.element_id, perc3 as inundate
        FROM scens_Prio_over_3ssh a, nodes_prio_sshmax b WHERE a.scen_id =
        b.scen_id';

/* Entfernen von Element_id die mehrmals in der TAbelle vorkommen, da sie
in mehreren Szenarien bei einer Wellenhöhe unter 3m betroffen sind */

EXECUTE IMMEDIATE'
        DELETE FROM Haz_WZ_Prio_cilacap A WHERE A.rowid >ANY
        (SELECT B.rowid FROM Haz_WZ_Prio_cilacap B
```

```
        WHERE A.element_id = B.element_id
        )';

/* Index for GIS-Prozcedure*/
EXECUTE IMMEDIATE 'CREATE INDEX idx_Haz_WZ_Prio_ci ON Haz_WZ_Prio_cilacap
(element_id)';

/* ***********************Shape file aus Tabelle
erzeugen******************** */
/*

EXECUTE IMMEDIATE 'CREATE TABLE Haz_WZ_Prio_Kuta_end AS
    SELECT
    a.SHAPE, a.element_id, b.inundate
    FROM
    KUTA_ELEMENTS a,
    Haz_WZ_Prio_Kuta_2 b
    WHERE (
    b.ELEMENT_ID = a.ELEMENT
    )
';

INSERT INTO user_sdo_geom_metadata VALUES (
                 'Haz_WZ_Prio_Kuta_end',
                 'SHAPE',
                 MDSYS.SDO_DIM_ARRAY(
                 MDSYS.SDO_DIM_ELEMENT('X',-180,180,0.0000005),
                 MDSYS.SDO_DIM_ELEMENT('Y',-90,90,0.0000005)
                 ),
                 NULL
              );

  EXECUTE IMMEDIATE '
    create index idx_Allprobs_idx_Haz_WZ_Prio_Kuta_end
                 on Haz_WZ_Prio_Kuta_end(shape)
                 indextype is mdsys.spatial_index
                 PARALLEL 3
   ' ;
*/
/* *************Alternative 1 um die Punkt-Duplikate beim Join zu
eliminieren*****************  */
/*
EXECUTE IMMEDIATE'
DELETE FROM Haz_WZ_Prio_Kuta5
WHERE rowid IN
 (
  SELECT rowid
  FROM
   (
    SELECT rowid, row_number()
    OVER (PARTITION BY element_id, scen_id ORDER BY element_id) dup
    FROM Haz_WZ_Prio_Kuta5
   )
  WHERE dup > 1
 )
 ';
*/
END HAZARD_WARNINGZONE_PRIO_NEW;
```

2.2.2 Calculation of the flux-values

The hazard impact zones can be derived by using the modeling results water depth above land surface (flow depth) and the water velocity. In the simplest way the flow depth can be used as criteria generating impact zones, e.g. by proposing hazard zones labelled as high, moderate and low with certain thresholds. In a more complex way, the water flux, as a function of flow depth and flow velocity, can be used to estimate the force impacting people, buildings or other objects. There might be the case that a lower flow depth inhibits higher water flux than a higher flow depth. The flux values of all scenarios were therefore statistically analysed and spatially classified into three classes representing zones of potential stability and instability of persons and buildings (see Table 3).

Table 3: Flux classes and stability of persons and buildings (Sources: Jonkman and Vrijling 2008, RESCDAM 2000, CDIT 2009)

Flux (m^2/s)	Effect on persons	Effect on buildings
<1	stable	stable
1–7	unstable	possibly partial damage
>7	unstable	destruction

For the calculation the following PL/SQL-query have to be performed:

```
create or replace PROCEDURE CREATE_HAZARD_PRIO_FLUX AS
BEGIN
EXECUTE IMMEDIATE'
        CREATE TABLE padang_flux (element, twdmax, velmax, flux, scen_id)
        AS select a.element,a.twd_max, b.vel_max, (a.twd_max*b.vel_max)
        AS flux, a.scen_id
        FROM  GITEWS.load_into_prio_TWDMAX_PADANG a
        full outer join gitews.load_into_prio_velmax_padang b ON a.element
        = b.element Where (SUBSTR(a.scen_id, 23)=SUBSTR(b.scen_id, 23))
        ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_padang_flux ON padang_twd_vel (element)
        PARALLEL 12
        ';

/**************************************testneu******/

EXECUTE IMMEDIATE'
        CREATE TABLE padang_fluxmax (element, twdmax, fluxmax)
        AS select /*+ PARALLEL (padang_flux, 12) */
        element, max(twdmax), max(flux) as fluxmax from padang_fluxmax
        group by (element)
        ';

/*************************** FLUX over 7  ****************************/
/*
EXECUTE IMMEDIATE'
```

```
        CREATE TABLE load_padang_flux_over1 (element, flux)
        AS Select /*+ PARALLEL (load_padang_flux, 12)
        element_id as element, flux FROM load_padang_flux  WHERE (flux >1)
        ';
/*

EXECUTE IMMEDIATE'
        CREATE INDEX idx_load_padang_flux_over1 ON
        load_padang_flux_over1(element)
        PARALLEL 12
        ';

EXECUTE IMMEDIATE'
        DELETE FROM load_padang_flux_over1 A
        WHERE A.rowid >
        ANY (SELECT B.rowid
        FROM load_padang_flux_over1 B
        WHERE A.element = B.element
        )';

EXECUTE IMMEDIATE'
        CREATE Table padang_FLUX_1 (element, flux) AS
        Select element, object_id as flux from padang_element Where element
        NOT IN (Select element from load_padang_flux_over1)
        ';
EXECUTE IMMEDIATE'
        Update padang_FLUX_1
        SET flux =1 where flux>0 ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_padang_FLUX_1 ON padang_FLUX_1(element)
        PARALLEL 12
        ';

/*************************** FLUX over 3  ****************************/

EXECUTE IMMEDIATE'
        CREATE TABLE load_padang_flux_under3 (element_id, flux, scen_id)
        AS Select
        element_id, flux, scen_id FROM load_padang_flux  WHERE flux<3 and
        flux>0
        ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_load_padang_flux_over3 ON
        load_padang_flux_under3(element_id)PARALLEL 12
        ';
/*
EXECUTE IMMEDIATE'DELETE FROM load_padang_flux_under3 A
        WHERE A.rowid > ANY (SELECT B.rowid
        FROM load_padang_flux_under3 B
        WHERE A.element_id = B.element_id
        AND A.scen_id=B.scen_id
        )';

EXECUTE IMMEDIATE'
        CREATE Table padang_FLUX_3 (element, flux) AS
        Select b.element, NVL(a.flux,0)
        FROM load_padang_flux_under3 a full outer join padang_element b On
        a.element_id = b.element
```

```
        ';

EXECUTE IMMEDIATE'
        Update padang_FLUX_3
        SET flux =1 where flux>0';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_padang_FLUX_3 ON padang_FLUX_3(element)
        PARALLEL 12
        ';

/*************************** FLUX over 1  *****************************/
EXECUTE IMMEDIATE'
        CREATE TABLE load_padang_flux_under1 (element_id, flux, scen_id)
        AS Select /*+ PARALLEL (load_padang_flux, 12) */
        element_id, flux, scen_id FROM load_padang_flux  WHERE flux<1 and
        flux>0
        ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_load_padang_flux_under1 ON
        load_padang_flux_under1(element_id) PARALLEL 12
        ';

EXECUTE IMMEDIATE'
        DELETE FROM load_padang_flux_under1 A
        WHERE A.rowid >
        ANY (SELECT B.rowid
        FROM load_padang_flux_under1 B
        WHERE A.element_id = B.element_id
        AND A.scen_id=B.scen_id
        )';

EXECUTE IMMEDIATE'
        CREATE Table padang_FLUX_1 (element, flux) AS
        Select b.element, NVL(a.flux,0)
        FROM load_padang_flux_under1 a full outer join padang_element b On
        a.element_id = b.element
        ';

EXECUTE IMMEDIATE'
        Update padang_FLUX_1 SET flux =1 where flux>0 ';

EXECUTE IMMEDIATE'
        CREATE INDEX idx_padang_FLUX_1 ON padang_FLUX_1(element)
        PARALLEL 12
        ';

/* ************************Shape file ******************* */
EXECUTE IMMEDIATE'
        CREATE TABLE padang_FLUX_3_end AS
        SELECT a.SHAPE, a.element, b.flux
        FROM padang_ELEMENTS a, padang_FLUX_3 b
        WHERE (b.ELEMENT = a.ELEMENT)
        ';

INSERT INTO user_sdo_geom_metadata VALUES (
                'padang_FLUX_3_end',
                'SHAPE',
                MDSYS.SDO_DIM_ARRAY(
```

```
                MDSYS.SDO_DIM_ELEMENT('X',-180,180,0.0000005),
                MDSYS.SDO_DIM_ELEMENT('Y',-90,90,0.0000005)
                ),
                NULL
             );

EXECUTE IMMEDIATE'
        CREATE INDEX idx_sp_padang_FLUX_3_end ON padang_FLUX_3_end(shape)
        indextype is mdsys.spatial_index PARALLEL 3
        ';
EXECUTE IMMEDIATE'
        CREATE INDEX idx_padang_FLUX_1_end ON padang_FLUX_1_end
        (element_id)
        ';

END CREATE_HAZARD_PRIO_FLUX;
```

2.3 Hazard map products

Hazard Maps are available at two scales: 1:100.000 for the southern and western coast of Sumatra, Java and Bali (in total 138 map sheets) and 1:25.000 and 1:30.000 respectively for three pilot areas (Padang, Cilacap and Kuta/Bali).

The coarse assessment was based on scenarios provided by the Alfred Wegener Institute (AWI). The available modeling results (as of February 2011) comprise in total 1224 scenarios of moment magnitudes 7.5, 7.7., 8.0, 8.2, 8.5, 8.7 and 9.0 with a spatial resolution between 100 and 500 m.

The modeling results for the pilot regions were provided by DHI-WASY and GKSS. The modeling comprises moment magnitudes of 8.0, 8.5 and 9.0 and have a spatial resolution between several hundred and 10 m. For Padang, 97 scenarios were available, for Cilacap 300, and for Bali 137.

The hazard probabilities and ETA calculated as described above are displayed in the maps (see “Guideline for Tsunami Risk Assessment in Indonesia: Scientific proposal for practitioners and end user” for description).

2.4 Hazard products for early warning

In the Decision Support System in the Tsunami Early Warning Center in Jakarta, hazard information is implemented as maps.

To be displayed as maps, the hazard information has to be prepared in three different scales (as shapefiles) and for both warning and major warning case: detailed scale (1:100k), aggregation to desa level (1:1M) and aggregation to warning segment level (1:3M).

A) Detailed scale

For the detailed scale, the hazard impact zone is displayed. The only process to be done is to add an attribute field called '*impact*' which takes one of three values:

- Affected area
- Temporary shelter area
- Area not suitable as temporary shelter area

As this is the only level of detail where temporary shelter areas are displayed, the result is one file each for warning and major warning covering two themes (hazard impact and temporary shelter areas). The criteria for temporary shelter areas are described in chapter 3.5.1.1.)

The following steps have to be performed:

- identity hazard zone shapefile with island shapefile (see Table 2)
- identity this result with temporary shelter area shapefile (see Table 2)
- add field 'impact'
- classify polygons into three classes (see above) according to fields 'ID' (corresponds to hazard shapefile) and 'ID_1' (corresponds to shelter area shapefile)
- delete all fields except 'impact'
- re-project result to geographic coordinate system WGS84

B) Desa aggregation

For the aggregation on desa level, the degree of hazard impact is determined by the proportion of affected area respective the total area of each desa. There are five classes: low – moderate – high – no hazard impact – no data.

C) Warning segment aggregation

For the aggregation on warning segment level, the degree of hazard impact is determined by the proportion of affected area respective the total area of each warning segment. There are five classes: low – moderate – high – no hazard impact – no data.

For the aggregation to desas (B) and warning segments (C) the following steps have to be performed with a GIS software like ArcMap by ESRI, each for warning and major warning case:

- intersect hazard zone shapefile and warning segments (desa) shapefile
- calculate areas (new field 'F_AREA' is created automatically)
- dissolve to warning segment ID (desa ID) with summing up F_AREA
- add field 'perc_hzimp'
- calculate for this field percentage affected area of area of whole warning segment (desa)

- identity with warning segment (desa) shapefile and dissolve again to warning segment ID (desa ID)
- add field ‘impact’
- classify warning segments (desas) into five classes (no – low – moderate – high impact – no data) according to the following thresholds:
- 0% affected area: No impact
- 0 - 10% affected area: Low impact
- 10 - 25 % affected area: Moderate impact
- 25 % affected area: High impact
- Where no modeling results are available: No data
- Re-project result to geographic coordinate system WGS84

3 Vulnerability Assessment

Within the vulnerability assessment, six components were considered in the frame of the GITEWS project: building vulnerability, exposure of population and critical facilities, people's access to warning, evacuation preparedness and evacuation time.

3.1 Building Vulnerability

The identification of buildings suitable for vertical evacuation requires in-situ assessments. Assisted by remote sensing imagery, sample buildings were pre-selected and the survey was limited to these buildings.

The assessment was conducted using the survey results sample buildings. In Padang and Cilacap 500 buildings were surveyed and 150 in southern Bali. The used methodology is splits the survey questions in different categories.

The following questionnaire was used in the survey:

14. Column of building :

[1] Available [2] Not Available

15. If available, the dimension of column of the building :

[1] 60 cm × 60 cm
[2] 50 cm × 50 cm
[3] 40 cm × 40 cm
[4] 30 cm × 30 cm
[5] .... cm × .... cm

Question **16 until 21 ONLY FILLED OUT**, if use ***"FERRO-SCAN"*** device.

16. Steel bar (longitude) of the column of building :

[1] Available [2] Not Available

17. If available, steel bar diameter of the column: .... mm

[1] More than Ø22 [4] Ø12 – D16
[2] Ø19 – Ø22 [5] Ø10 – Ø12
[3] Ø16 – Ø19 [6] Less Ø10

18. Number of steel bar of the column of building: ....

[1] More than 12 [4] 6 – 8
[2] 10 – 12 [5] 4 – 6
[3] 8 – 10

19. Stirrup of the column of building :

[1] Available [2] Not Available

20. If available, the diameter of stirrup of column of building :

[1] Ø 12 atau Ø 13 [4] Ø 6
[2] Ø 10 [5] ....
[3] Ø 8

21. Distance between stirrup of column of building :

[1] Less than 12 cm [3] 15-20 cm
[2] 12-15 cm [4] More than 20 cm

Question **22 until 23 ONLY FILL OUT** if use ***"HAMMER TEST"*** device.

22. Value of ***Hammer Test*** of the column of building (N/mm^2) :

[1] .... [7] ....
[2] .... [8] ....
[3] .... [9] ....
[4] .... [10] ....
[5] .... [11] ....
[6] .... [12] ....

23. Average value of ***Hammer Test*** of the column of building (N/mm^2) : .... N/mm^2

[1] More than 43 N/mm^2 (> K300)
[2] 35 N/mm^2 – 43 N/mm^2 (K250 – K300)
[3] 31 N/mm^2 – 35 N/mm^2 (K225 – K250)
[4] 22 N/mm^2 – 31 N/mm^2 (K175 – K225)
[5] 13 N/mm^2 – 22 N/mm^2 (K125 – K175)
[6] Less than 13 N/mm^2 (< K125)

24. Practical column of building :

[1] Available [2] Not available

25. Primary beam of building (for high rise building) :

[1] Available [2] Not available

26. If available, dimension of primary beam of building (for high rise building) :

[1] 40 cm × 60 cm or more
[2] 30 cm × 60 cm
[3] 30 cm × 50 cm
[4] 30 cm × 40 cm
[5] 25 cm × 50 cm
[6] 25 cm × 40 cm
[7] 20 cm × 40 cm
[8] 20 cm × 30 cm
[9] .... cm × .... cm

27. Perimeter Beam of building :

[1] Available [2] Not available

– 2 / 4 –

28. Type of material and color of roof of the building :

Roof material type	Colour
1 Concrete dak	....
2 Concrete tile	....
3 Ceramic tile	....
4 Clay tile	....
5 Metal tile	....
6 Zinc	....
7 Asbestos	....

29. Damage of building effect of earthquake which have happened :

- 1 Undamage
- 3 Medium damage
- 2 Lightly damage
- 4 Heavy damage
- 5 Never happen earthquake

30. Damage of building effect of tsunami which have happened:

- 1 Not destroy
- 3 Middlely destroy
- 2 Lightly destroy
- 4 Weight destroy
- 5 Never happen tsunami

31. Developer/executor of building :

- 1 Contractor/ Developer (PT/CV)
- 2 Skill worker
- 3 Built alone

32. Year of building built: ....

- 1 < 5 year
- 4 10 – 15 year
- 2 5 – 10 year
- 5 > 15 year

33. *Susceptibility Class of Building to Tsunami* :

- 1 Kelas A (*High Susceptibility*, 1 m *Wave Height*)
- 2 Kelas B (*Medium Susceptibility*, 3 m *Wave Height*)
- 3 Kelas C (*Low Susceptibility*, 5 m *Wave Height*)
- 4 Kelas VE (*Vertical Evacuation*, 10 m *Wave Height*)

34. Photo's code :

- 1 .... (Identify)
- 2 .... (Perspective,Ext)
- 3 .... (See front)
- 4 .... (column/wall)
- 5 .... (Beam)
- 6 .... (Sloof/Foundation
- 7 .... (Perspective,Int.)
- 8 .... (Roof)
- 9 .... (Hammer Test)
- 10 .... (Ferro Scan)

35. Amount of dweller in the building :

- 1 .... People (Morning)
- 2 .... People (Afternoon)
- 3 .... People (Night)

36. Amount of officer staff residing in the building (except the house) :

- 1 .... People (Morning)
- 2 .... People (Afternoon)
- 3 .... People (Night)

37. Percentage of the mean dwelling (just for hotel) :

- 1 .... % (Jan)
- 7 .... % (Jul)
- 2 .... % (Feb)
- 6 .... % (Aug)
- 3 .... % (Mar)
- 7 .... % (Sep)
- 4 .... % (Apr)
- 10 .... % (Okt)
- 5 .... % (Mei)
- 11 .... % (Nov)
- 6 .... % (Jun)
- 12 .... % (Des)

38. Width the primary road around the building : .... m

- 1 More than 7 m
- 3 3 m – 5 m
- 2 5 m – 7 m
- 4 Less than 3 m

39. Access to the building :

- 1 All way
- 3 2 ways
- 2 3 ways
- 4 1 ways

– 3 / 4 –

40. Did the building can be entered anytime :

- [1] Yes, anytime
- [3] Yes, only nighttime
- [2] Yes, only day time
- [4] No

41. Easy to receive the dangerous signal/warning of tsunami from all direction :

- [1] Yes
- [2] No

42. Did dweller of building have had the plan of tsunami evacuation :

- [1] Yes
- [2] Not yet

43. The availability of temporary room to evacuate after disaster:

- [1] Available
- [2] Not available

44. If available, in what floor that the emergency room :

- [1] Floor 1
- [4] Floor 4
- [2] Floor 2
- [5] Floor 5
- [3] Floor 3
- [6] ....

45. Access can be used to reach the evacuated room:

- [1] Main stairs
- [4] Lift
- [2] Emergency Stair
- [5] ....
- [3] Escalator

46. Price of land along with building at the moment: .... million

- [1] > 500 million
- [4] 200 - 300 million
- [2] 400 - 500 million
- [5] 100 - 200 million
- [3] 300 - 400 million
- [5] < 100 million

47. Land use around the building :

- [1] office
- [4] Perumnas
- [2] shop
- [5] Personal house
- [3] Housing
- [6] ....

SURVEY HAS BEEN EXECUTED:

Day : ....

Date : ....

ASSESMENT BUILDING SURVEYOR:

Full Name	Signature
1.	....
2.	....
3.	....
4.	....
5.	....
6.	....

HAMMER TEST OPERATOR:

Full Name	Signature
1.	....
2.	....
2.	....
4.	....

FERRO-SCAN TEST OPERATOR:

Full Name	Signature
1.	....
2.	....
3.	....
4.	....

– 4 / 4 –

The used categories are:

(1) **Structural stability components** (see Table 4)

(2) **Liquefaction components** (see Table 5)

(3) **Real tsunami components** (see Table 6)

(4) **Accessibility components** (see Table 7)

The relevant questions for each component with the corresponding parameter weightings and thresholds are listed below.

Table 4: Structural stability components

Criteria	**Weighting**	**Threshold**
Building height	4	4
Material of the main structural element	10	2
Material type of the wall	2	4
The foundation of main structures	5	3
Underground tie beam	7	1
Main column of the building	8	1
Dimension of the main column	5	5
Main reinforcement (Longitudinal bar) of the main column	8	1
Diameter of the reinforcement of the main column	2	5
Number of reinforcement of the main column	2	4
Stirrup of the main column	5	1
Stirrup diameter of the main column	2	4
Spacing of the stirrup of the main column	2	3
Average value of the Hammer test of the main column	12	2
Practical (Complimentary) column	2	1
Main beam of the building (for storey building)	4	1
Dimension of the main beam	2	8
Perimeter (ring) beam	6	1
Material of the roof	2	3
Damage due to previous earthquake	4	2
Type of the builder	6	2

Table 5: Liquefaction components

Criteria	Weighting	Threshold
Soil type under the Building	55	2
The depth of ground water table	45	(4)

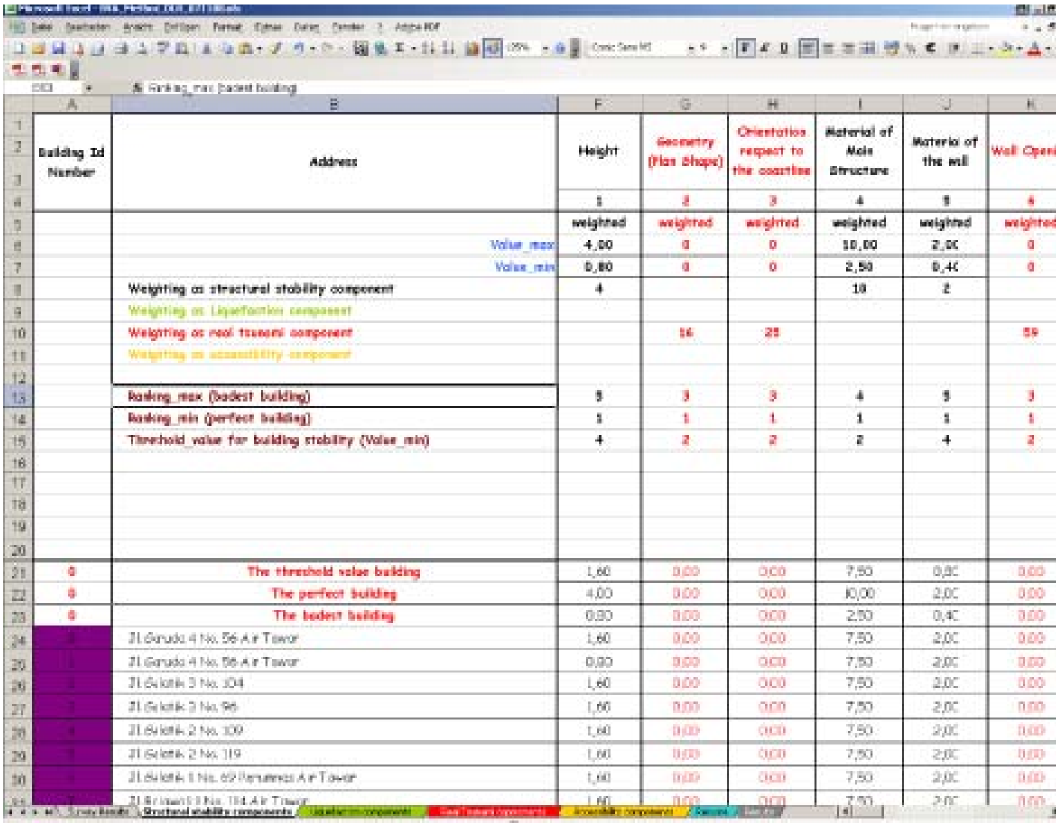
Table 6: Real tsunami components

Criteria	Weighting	Threshold
Orientation respect to the coastline	25	2
Opening on the ground surface wall	59	2
Damage due to last tsunami	0	2
Geometry of the plan	16	2

Table 7: Accessibility components

Criteria	Weighting	Threshold
The width of the main street around the building	11	3
Access to the building	11	3
Time to access the building	7	3
Is there any tsunami evacuation planning in the building	5	1
Is there any evacuation room in the building	22	1
If there is any evacuation room, what floor is the room provided	22	4
The access way to get to the evacuation room	22	2

A value was calculated for each parameter and building. Summarizing all these values leads to a total value for each building including all component categories. Subsequently the buildings are classified in group A and B. Class A buildings reach a defined total threshold value for each main component, Class B buildings don't reach the requirements of a main component.



	Building Id Number	Address	Height	Geometry (Plan Shape)	Orientation respect to the coastline	Material of Main Structure	Material of the wall	Wall Openi
4			1	2	3	4	5	6
5			weighted	weighted	weighted	weighted	weighted	weighted
6		Value_max	4,00	0	0	10,00	2,00	0
7		Value_min	0,80	0	0	2,50	0,40	0
8		Weighting as structural stability component	4			10	2	
9		Weighting as Liquefaction component						
10		Weighting as real tsunami component		16	25			59
11		Weighting as accessibility component						
13		Ranking_max (badest building)	5	3	3	4	5	3
14		Ranking_min (perfect building)	1	1	1	1	1	1
15		Threshold_value for building stability (Value_min)	4	2	2	2	4	2
21	0	The threshold value building	1,60	0,00	0,00	7,50	0,80	0,00
22	0	The perfect building	4,00	0,00	0,00	10,00	2,00	0,00
23	0	The badest building	0,80	0,00	0,00	2,50	0,40	0,00
24	[illegible]	Jl Garuda 4 No. 56 Air Tower	1,60	0,00	0,00	7,50	2,00	0,00
25	[illegible]	Jl Garuda 4 No. 56 Air Tower	0,80	0,00	0,00	7,50	2,00	0,00
26	[illegible]	Jl Gelatik 3 No. 104	1,60	0,00	0,00	7,50	2,00	0,00
27	[illegible]	Jl Gelatik 3 No. 96	1,60	0,00	0,00	7,50	2,00	0,00
28	[illegible]	Jl Gelatik 2 No. 109	1,60	0,00	0,00	7,50	2,00	0,00
29	[illegible]	Jl Gelatik 2 No. 119	1,60	0,00	0,00	7,50	2,00	0,00
30	[illegible]	Jl Gelatik 1 No. 69 Renatinea Air Tower	1,60	0,00	0,00	7,50	2,00	0,00
31	[illegible]	Jl [illegible] No. 114 Air Tower	1,60	0,00	0,00	7,50	2,00	0,00

Figure 3: Example of a building categorization table

To derive the physical vulnerability of a building and to define buildings which can be used for vertical evacuation, a new decision tree (see Figure 4) was developed.

Buildings suitable for vertical evacuation have to fulfil the criteria of each main component (defined by a threshold value) which is shown as YES and NO. The component order in the structure above is not random but chosen regarding the importance of each component. That means, for example, if a building is reaching the total threshold value of the “Structural stability component”, “Tsunami component” and “Liquefaction component” but not for the “Accessibility component”, the building only reach the requirements of Class C.

In Table 8 the results of the building survey are shown, using the decision tree of Figure 4

Table 8: Results of the building survey in Padang

Assessment Type		Results of Assessment	
		Class	Number
no component threshold fulfilled		A	374
Structural stability	(S)	B	115
Structural stability and Tsunami	(S) + (T)	C	17
Structural stability, Tsunami and Accessibility	(S) + (T) + (A)	C1	6
Structural stability, Tsunami, Accessibility and Liquefaction	(S) + (T) + (A) + (L)	VE	2

In addition further requirements for buildings were defined which are suitable for vertical evacuation:

(1) no buildings inside a 200m buffer from the coast are considered

(2) inside a 500m buffer from the coast, only buildings with at least 3 storeys are considered

(3) only public buildings are considered (no houses, Rukos, etc.)

(4) no buildings inside a 100m buffer from a river are considered

Buildings which are not reaching the threshold value for the "Liquefaction component" and respectively are defined as C1 buildings, could also be suitable for vertical evacuation, provided that they are not damaged by liquefaction.

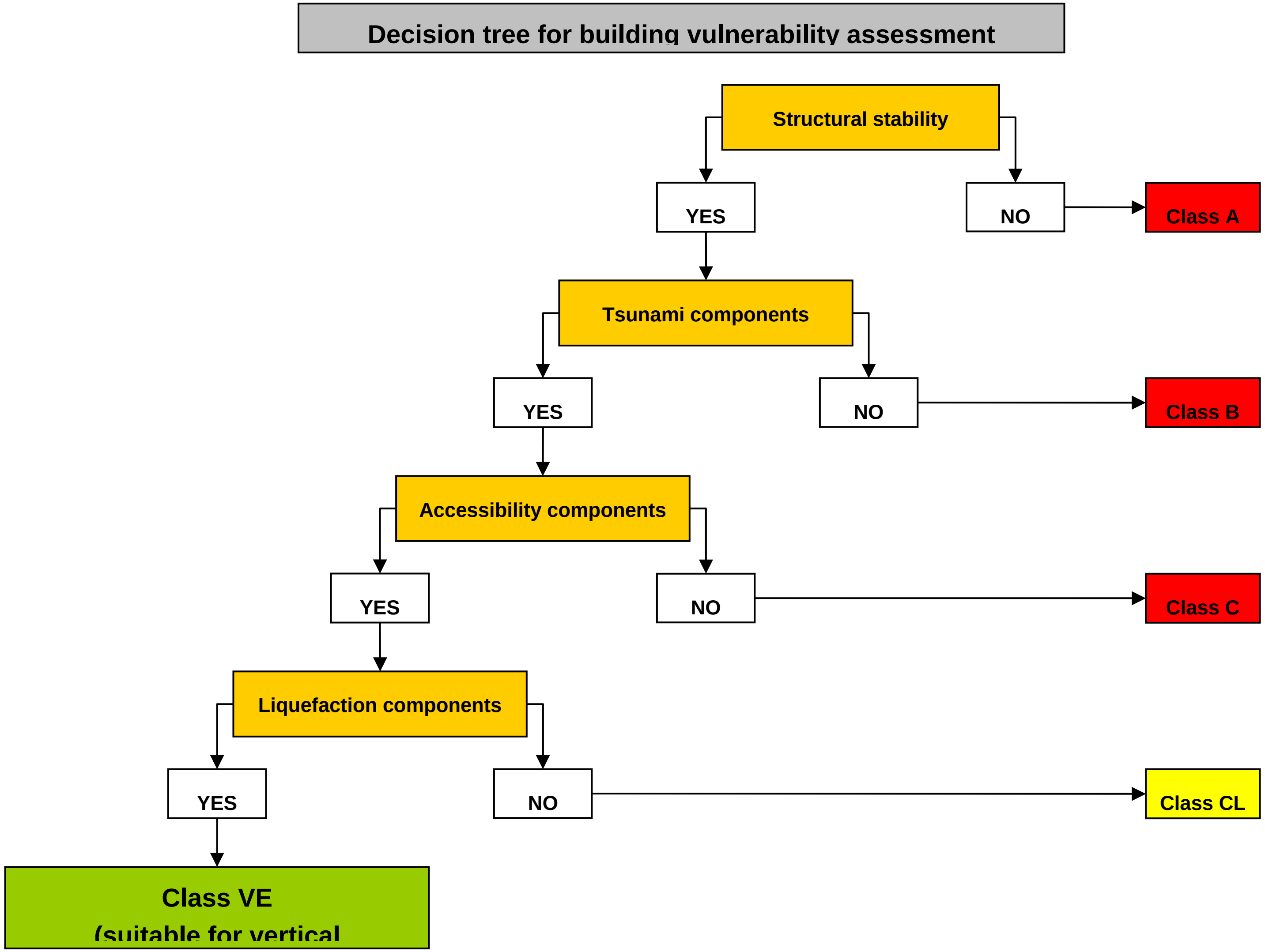


Figure 4: Decision tree for building vulnerability assessment

3.2 Exposure

To calculate this aspect it is essential to quantify the spatial spreading of the probable maximum inundation zone. Subsequently, with the population, critical facilities and lifelines distribution at hand one can average the number of people, critical facilities or lifelines exposed for each defined coastal zone.

3.2.1 Population

3.2.1.1 Population distribution modeling

The BPS Census 2000 data provides population figures on the level of the administrative unit of a *desa/kelurahan*, i.e. on community level. One desa/kelurahan often includes large uninhabited areas like e.g. swamp areas. The amount of people is distributed homogenously within each administrative unit, even in the part of uninhabited areas like lakes, forest, swamps, or areas with high slopes. The resulting people distribution and people density derived from census data on this level is not consistent with reality and hence too coarse for the usage for early warning issues.

For this reason, the population distribution was modeled using landuse data and weighting factors. To obtain a landuse data set as detailed as possible, a “best of” data set was created for Sumatra, Java and Bali. The landuse data available at different scales (1:10.000 to 1:250.000) was combined using the largest available scale in each case. This improved data set provided the basis for the population distribution modeling.

The concept of the people distribution modeling is based on a combination of census data and land use shown in Figure 5.

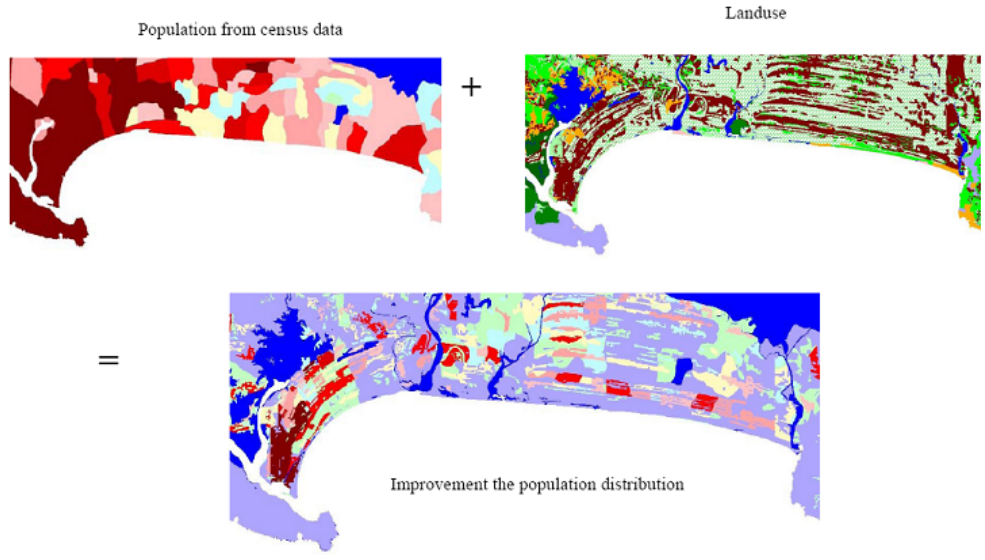


Figure 5: Concept of the people distribution modeling

The weighting factors concerning the presence of people in areas of different types of landuse were derived from statistical data by BPS. Here, several differentiations were made, each for day- and nighttime. The weighting factors can be updated if additional information will be available.

The weighting factor derivation is the critical value in this people distribution analysis. The percentages of weighting indicate the amount of people staying in a particular kind of landuse. People’s activities in urban, rural, coastal, and non-coastal areas are different causing different weighting factors for the same kind of landuse in each of these surroundings.

The weighting factor is the value of proportion to distribute the population number in the different land use polygons within one administrative unit. The sum of all weighting factors in one administrative unit is 100%. If an administrative unit (e.g. village) contains only one type of land use the spatial improvement is, of course, not possible, respectively not necessary. The weighting factors depend on the functional land use for human activities. For example, for the land use class “settlement” it is expected to have a high weighting factor because most of the human activities take place in the settlement area. But for classes like “forest”, “swamp”, and “water body”, the weighting factor is nearly zero because of very rare human activities there. To determine the weighting factor for each land use class, statistical data was analysed.

The data source for the population distribution is BPS Census 2000. This data set contains the population per desa. The population density distribution was further improved (upscaling) by DLR by using landuse data (from topographic maps by BAKOSURTANAL, and LAPAN) as well as BPS PODES data to obtain weighting factors to remodel the population distribution based on the various presence of people in different kind of land uses.

The disaggregation of the population from CENSUS data to land use classes is the core of this analysis. Statistical analysis of the activities of the people is used to allocate weights for the disaggregation. Figure 6 points out the influence of the weighting factors by the disaggregation method.

The modeled population density is also an indirect input parameter for the evacuation modeling (for details about the evacuation modeling please refer to the respective technical document). For the evacuation modeling, amongst other parameters, an average evacuation speed is needed to calculate the needed evacuation time and hence the capability to response to a tsunami warning. On the assumption that in areas with high population density the evacuation speed decreases (e.g. crowded streets in cities) the population density is used to assign according speed values (see chapter 3.5 for details).

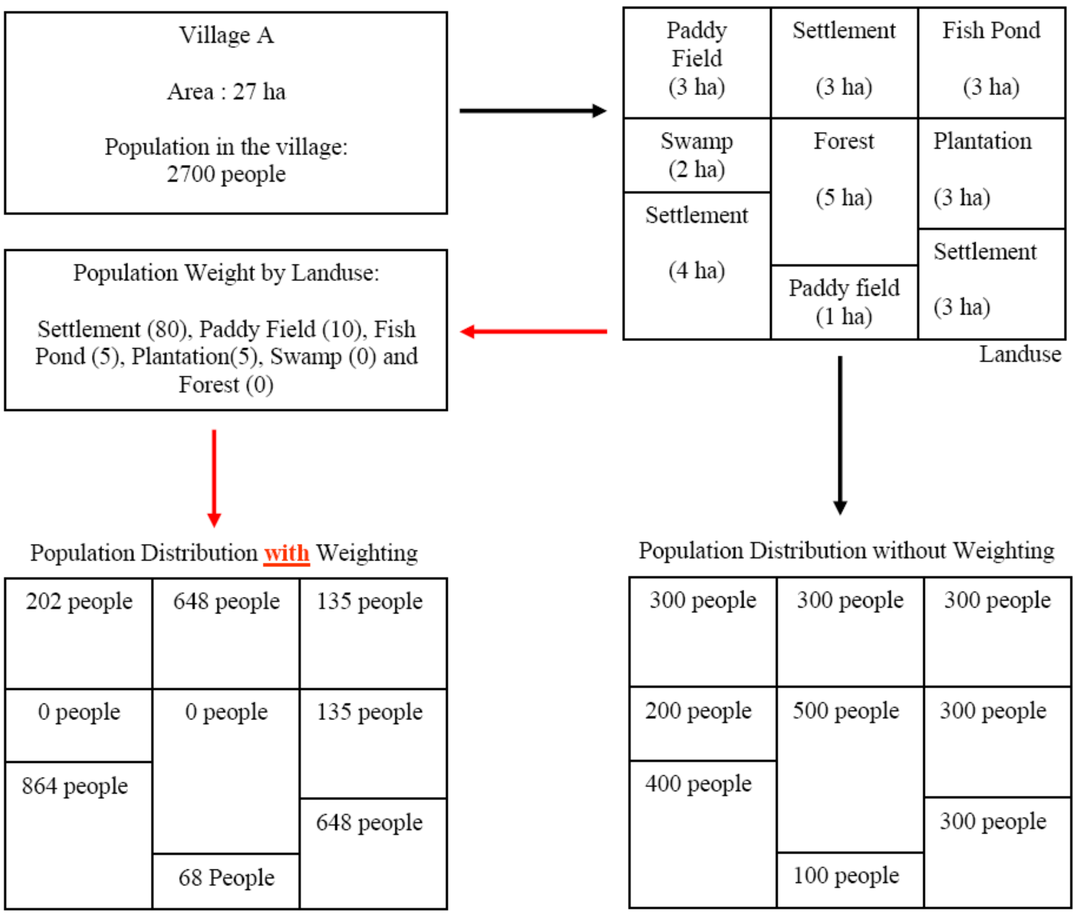


Figure 6: Used disaggregation method to improve the spatial population data

The formula for population disaggregation is given below:

(1) $X_d = \sum_{i=1}^{n} P_i$

(2) $P_i = \sum_{i=1}^{n} P_{ij}$

(3) $P_{ij} = \frac{S_{ij}}{\sum_{i,j=1}^{n} S_{ij}} . W_i . X_d$

where:

X_d = Number of people in administrative unit

P_i = Number of people in land use i

P_{ij} = Number of people in polygon j in land use i

S_{ij} = Size of polygon j in land use i

W_i = Weighting of land use i,

$\sum_{i=1}^{n} W_i = 100\%$

These formulas explain the distribution of the population from one administrative unit to the several land use polygons inside that administrative boundary (Eq. (1)). The population number of one certain land use is the accumulation from several polygons that have the same land use in the administrative boundary (Eq. (2)). For instance, one land use (for example settlement) could have more than one polygon with different sizes inside an administrative boundary. Eq. (3) takes this in consideration by also using the area size of the polygons for a weighting. Besides the areal weighting, every polygon is weighted depending on the people activity which characterises a land use class (Wi).

The weighting determination is developed by using Potential village (PODES) by Berau of Statistic Indonesia (BPS) and Population Census (BPS). PODES data is used for making differences between village categories such as urban and rural, coastal and non coastal, and also the differences between Sumatera, Jawa, and Bali. In the urban area for example, the main source of income is agriculture but the agricultural sector is less present than in the rural area. In urban areas people spread more in the business area (settlement) and less in the agricultural area. Also, most people in the coastal area are doing activities in the fisheries area, and less in the paddy field.

The weighting is not differentiated in island categories because the characteristics of main sources of income are mostly the same in Sumatera, Java, and Bali.

The base for the different characteristics of urban, rural, coastal, and non-coastal areas was extracted from PODES data and is shown in Figure 7.

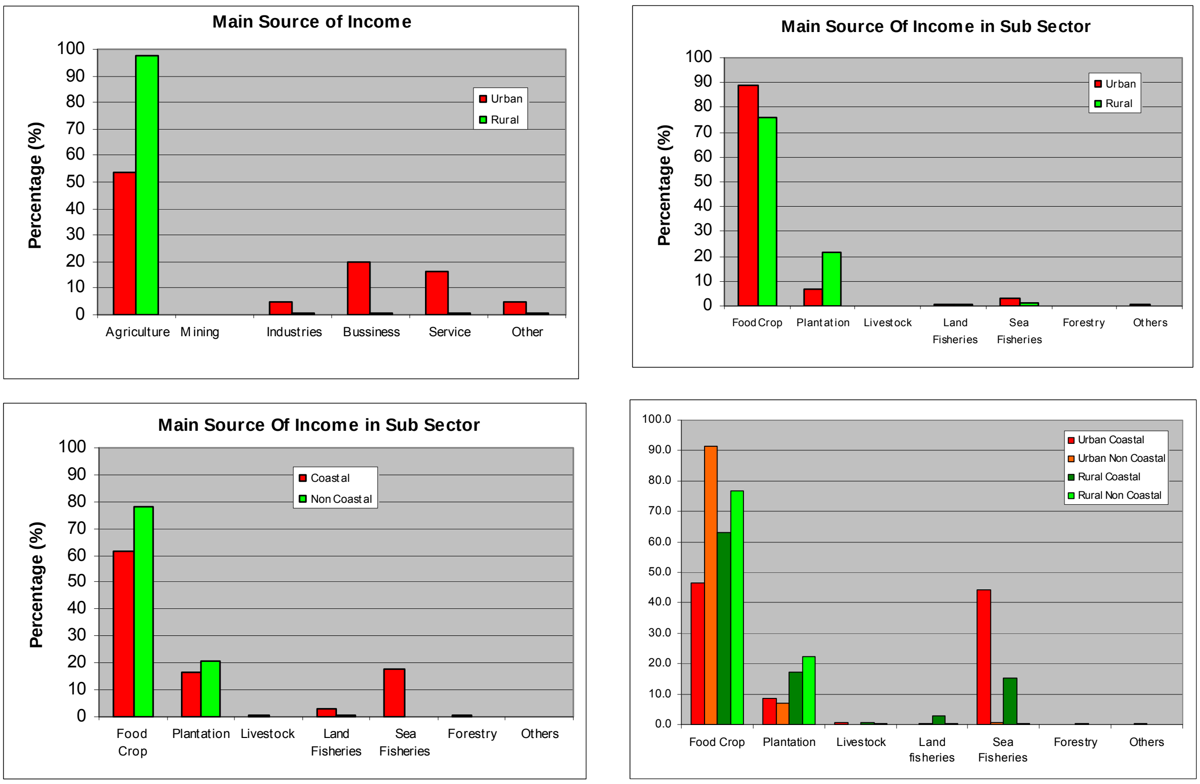
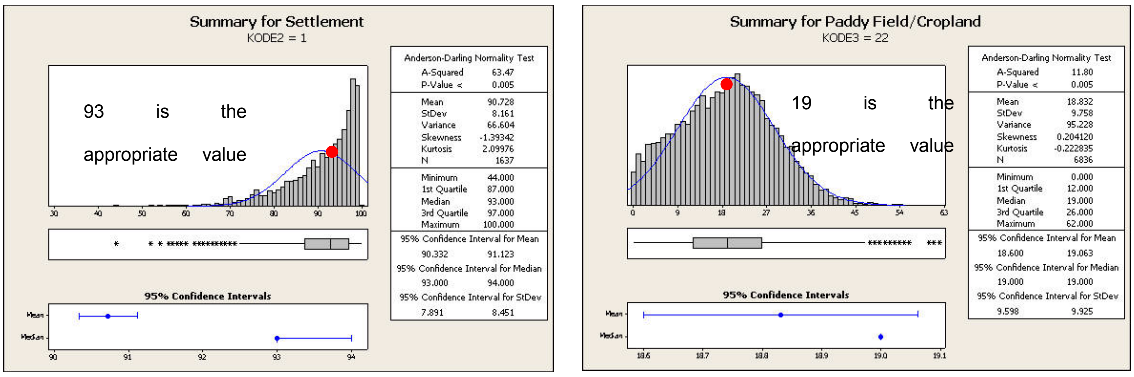


Figure 7: The differences of percentage of main sector and sub sector income in urban, rural, coastal, and non-coastal areas

The decision on a weighting factor is determined by the frequency distribution of people potentially staying in a certain land use (percentage of overall population in one administrative unit). The calculation of that distribution is based on the proportional allotment of occupations which is contained in the population census data for west coast of Sumatera, Jawa, and Bali. The median value of that distribution is the appropriate value for the weighting factor, and the standard deviation of the distribution indicates the range of values for the weighting factors that could be used for an uncertainty analysis. The uncertainty analysis is a method to describe the quality of a result. Figure 8 shows how the appropriate values of weighting factors were chosen. The figure shows on the left side the distribution of people who potentially stay in settlement areas in urban surroundings and the appropriate weighting factor derived out of it (a) and on the right side the equivalent for agricultural areas in rural surroundings (b). Figure 8 is only an example, all other combinations of land use types and different surrounding have also been analyzed. The resulting weighting factors can be seen in Figure 9 and Figure 10 for day- and nighttime situation. Those weighting factors are then used to perform the people distribution disaggregation.



(a) (b)

Figure 8: Histograms of people potentially staying in a certain land use, here exemplarily in settlement of urban (a) and in agriculture of rural areas (b)

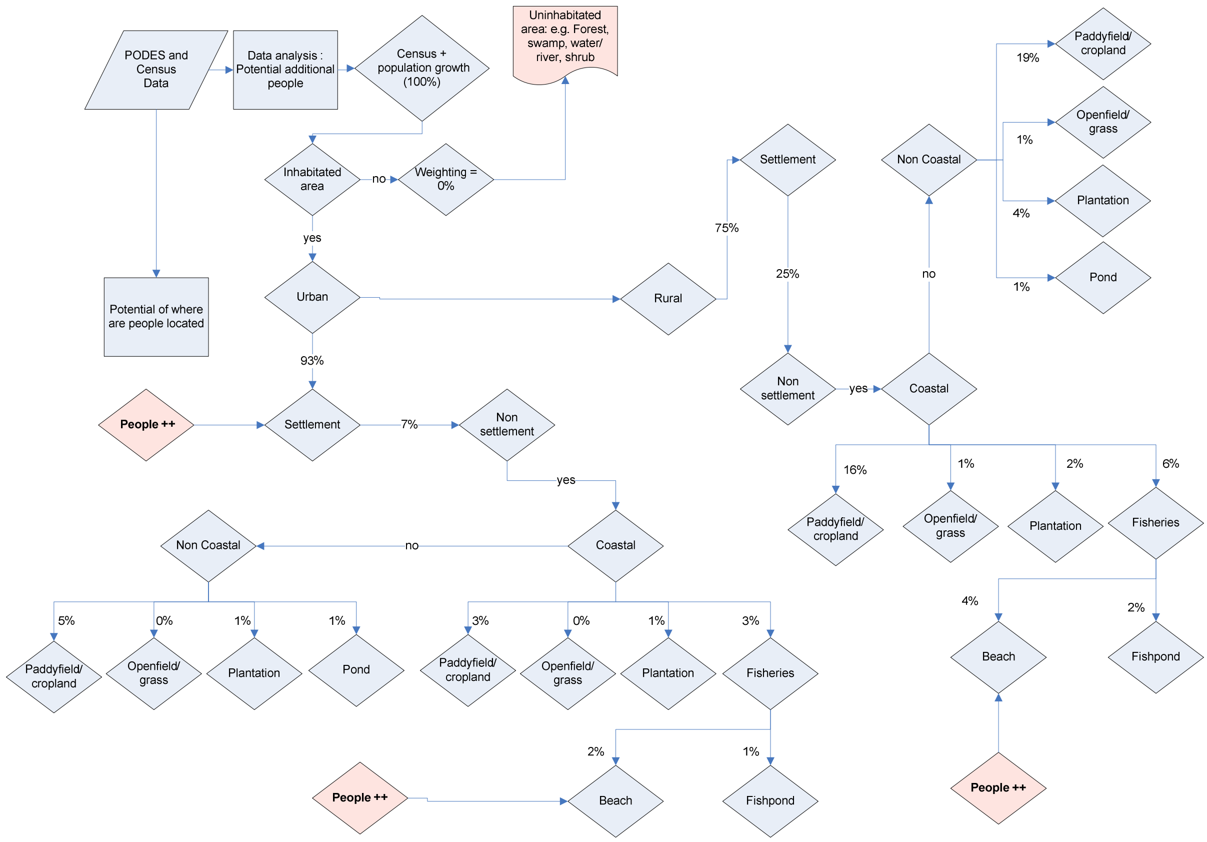


Figure 9: Weighting for people distribution at daytime

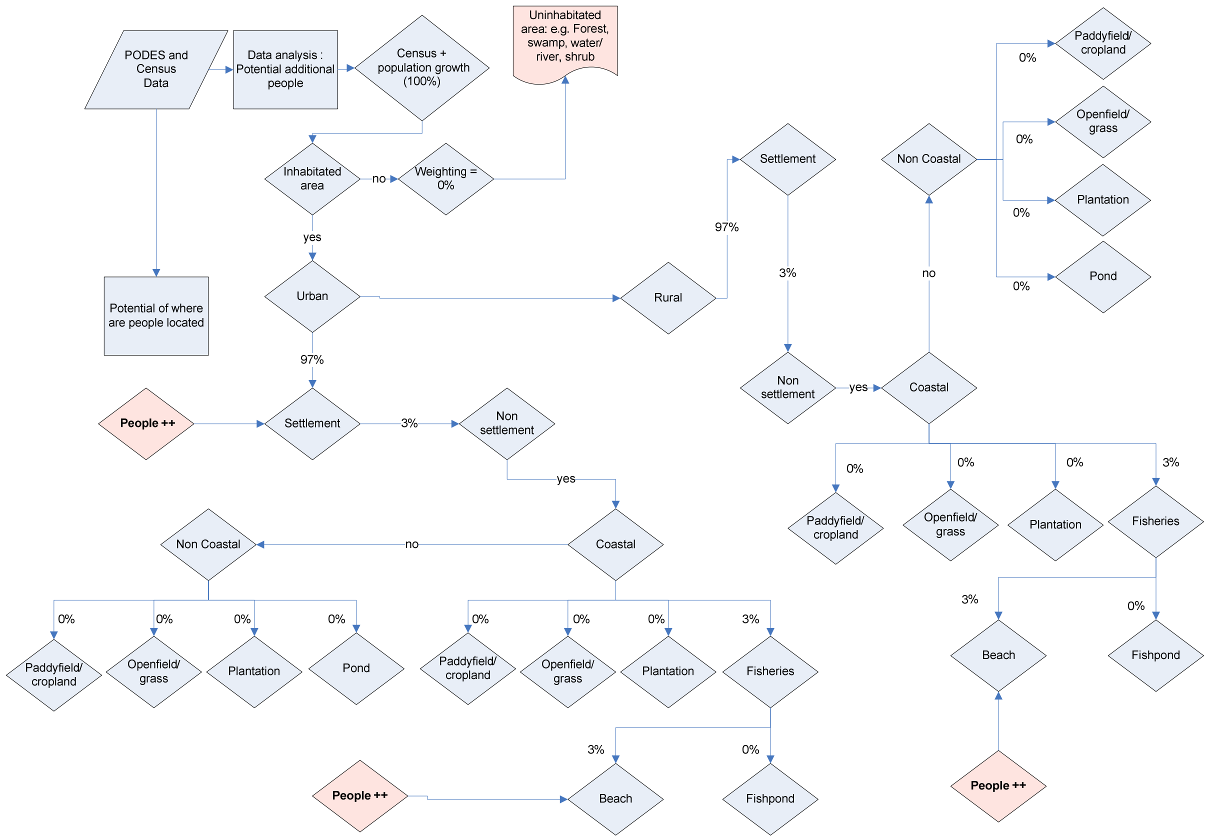


Figure 10: Weighting for people distribution at nighttime

The addition people in the orange box are calculated based on the number of tourists per day at village level. Because of the limitation of data the number of tourists per day is calculated using the number of hotels which is stated in the PODES data. The positive correlation between the number of hotels and tourists per day has been investigated and the coefficient determination is 88%.

This enhanced people density distribution (people per square kilometers at day- and nighttime) was used as input for the risk assessment.

3.2.1.2 Population exposure map products

The population density was classified into five classes. The following thresholds were applied: very low exposure (up to 100 persons/km², highly sparse), low exposure (100 – 1000 persons/km², sparse), moderate exposure (1000 – 2500 persons/km², quite dense), high exposure (2500 – 5000 persons/km², dense) and very high exposure (more than 5000 persons/km², highly dense).

The population densities at day- and nighttime calculated as described above are displayed in the maps in three classes (rgb values: 255-0-0 (high) – 255-255-115 (moderate) – 0-168-132 (low degree of exposure)).

3.2.1.3 Population exposure products for early warning

In the Decision Support System in the Tsunami Early Warning Center in Jakarta, population exposure information is implemented as maps and as tabular data.

To be displayed as maps, the population exposure information has to be prepared in three different scales (as shapefiles) and for both warning and major warning case: detailed scale (1:100k), aggregation to desa level (1:1M) and aggregation to warning segment level (1:3M).

Basis for both the tabular data and the maps are the results of the population distribution modeling.

In the DSS map of exposed people there are five classes:

- low degree of exposure (< 100 persons/km²)
- moderate degree of exposure (100 - 2500 persons/km²)
- high degree of exposure (> 2500 persons/km²)
- no exposure (areas not affected by any modeled tsunami hazard scenario)
- and no data (no or not enough population data available).

<u>A) Detailed scale</u>

For the map layer in the highest level of detail, the following steps have to be performed:

clip the population shapefile to the hazard zone shapefile

- calculate the areas of all polygons (in ArcMap new field will be named ‘F_AREA’, unit according to projection)
- add several fields named ‘perc_narea’, ‘people_new’, ‘pop_rd’, ‘pop_sqkm’, and ‘vuln_pop’
- calculate these fields: percentage affected area of the whole aggregation unit, percentage amount of people in each polygon according to the percentage of affected area, round the resulting number to a whole number, people density per km², and classify probabilities into five classes according as mentioned above
- delete irrelevant fields
- re-project result to geographic coordinate system WGS84

<u>B) Desa aggregation</u>

The degree of population exposure is calculated for each desa There are five classes: low – moderate – high – no hazard impact – no data.

<u>C) Warning segment aggregation</u>

The degree of population exposure is calculated for each warning segment There are five classes: low – moderate – high – no hazard impact – no data.

For the aggregation to desas (B) and warning segments (C) the following steps have to be performed with a GIS software like ArcMap by ESRI, each for warning and major warning case:

- clip the population shapefile to the hazard zone shapefile
- calculate the areas of all polygons (in ArcMap new field will be named ‘F_AREA’, unit according to projection)
- add several fields named ‘perc_narea’, ‘people_new’ and ‘pop_rd’
- calculate those fields: percentage affected area of the whole aggregation unit, percentage amount of people in each polygon according to the percentage of affected area, and round the resulting number to a whole number
- intersect this interim result with the warning segments (desa) shapefile and dissolve to the warning segment ID (desa ID) with summing up the rounded amount of people and the area
- calculate the people density per km² for each warning segment (desa)
- compute a geometric intersection of the warning segment (desa) shapefile and the interim result and dissolve again to warning segment ID (desa ID) with summarizing the prior calculated affected area, the rounded number of exposed people and the calculated people density
- classify into five classes (no data, no exposure, low – moderate – high exposure) as mentioned above
- re-project result to geographic coordinate system WGS84

The tabular data of population exposure contains the total number of exposed people in a warning segment depending on the currently announced warning level for each segment. As the number of exposed people was calculated during the preparation of the map layer aggregated to warning segments (see above) it is only necessary to perform three steps:

- join the result file from warning segment aggregation to the key number shapefile (joining field is warning segment ID)
- copy the value of the field ‘sum_people’ to the corresponding field (people_WL2 for warning and people_WL3 for major warning)
- remove join

3.2.2 Critical Facilities

3.2.2.1 Critical facility classification

The parameters and indicators describing the components in the risk assessment framework are dependent on scale and objective. This means that within the sub-national assessment the focus concentrates on national and sub-national early warning purposes whereas at pilot area level (local level) the focus concerns parameters and indicators related to the purposes of disaster management. Additionally, the parameters and indicators selected are a matter of data availability at the respective scale considered.

Following the definition issued by the German Ministry of the Interior, critical infrastructures are organizations and facilities having high relevance for the national community whose disturbance or failure would have lasting effects on supply, considerable disruptions of public safety, or other significant adverse impacts (e.g. high rate of loss of life).

This definition corresponds to the Indonesian terminology of SARANA and PRASARANA, i.e. a classification into critical facilities and lifelines. Using this differentiation of critical infrastructures, the classes can be further subdivided into:

a) SARANA - critical facilities

- All critical facilities are characterized by their importance for an efficient society and by their high exposure to a tsunami. They are further subdivided to:

  → essential facilities (Facilities featuring particularly endangered people (young, old, ill, disabled))

  → supply facilities (Facilities which are important in providing supply functions

  → high loss facilities (Facilities with high danger in causing negative effects for people and environment (secondary hazards like fire, oil spill)).

b) PRASARANA – Lifelines

- Transportation Systems (Lifelines having transportation characteristics like roads, railways, etc.
- Utility systems (Lifelines used for resource provision, e.g. water pipes, electricity network, communication)

3.2.2.2 Critical facility exposure products for early warning

In the Decision Support System in the Tsunami Early Warning Center in Jakarta, critical facility exposure information is implemented as maps and as tabular data.

To be displayed as maps, the critical facility exposure information has to be prepared in two different scales (as shapefiles) and for both warning and major warning case: aggregation to desa level (1:1M) and aggregation to warning segment level (1:3M). Basis for both the tabular data and the maps are BPS Podes 2006 data.

Critical facilities can be subdivided into three subgroups:

- **essential facilities**: facilities which hold particularly endangered groups of persons like very young or elderly persons (currently available data allows to consider hospitals, kindergartens and primary schools)
- **supply facilities**: facilities which are important due to their supply functions (currently, it comprises harbors and airports)
- **high loss facilities**: facilities which may cause secondary hazards with negative effects for people and environment like fire or oil spill (currently available data allows to consider power plants, oil tanks and industry facilities)

In the display as maps in the DSS there is no distinction between the three subgroups. All facilities are included with equal weighting. In the DSS map of exposed facilities there are five classes:

- low degree of exposure (< 0.01 facilities/ha)
- moderate degree of exposure (0.01 - 0.03 facilities/ha)
- high degree of exposure (> 0.03 facilities/ha)
- no exposure (areas not affected by any modeled tsunami hazard scenario)
- and no data (no or not enough critical facility data available).

To calculate the degree of exposure, first die amount of critical facilities present inside the hazard zone and the facility density is calculated. For being able to calculate areas correctly it should be made sure that all input files have an equal-area projection. For the aggregation to warning segments and desas the following steps have to be performed with a GIS software like ArcMap by ESRI, each for warning and major warning case:

- intersect the critical facility shapefile with the hazard zone shapefile
- add several fields named ‘perc_narea’, ‘cf_new’, ‘ef_new’, ‘hlf_new’, ‘cf_rd’, ‘ef_rd’ and ‘hlf_rd’
- calculate those fields: percentage affected area of the whole aggregation unit, percentage amount of critical (cf) / essential (ef)/ high loss (hlf) facilities in each polygon according to the percentage of affected area, and round (_rd) the resulting numbers to a whole number
- intersect this interim result with the warning segments (desa) shapefile and dissolve to the warning segment ID (desa ID) with summing up the rounded amount of facilities and the area
- calculate the facility density per hectare for each warning segment (desa)
- compute a geometric intersection of the warning segment (desa) shapefile and the interim result and dissolve again to warning segment ID (desa ID) with summarizing the prior calculated affected area, the rounded numbers of exposed facilities and the calculated facility density
- classify into five classes as mentioned above

- re-project result to geographic coordinate system WGS84

The tabular data of critical facility exposure consists of two columns containing information about exposed critical facilities. The naming of those columns does not follow completely the above noted subgroups.

Instead, there are the columns:

- ‘Crit. Facilities’ representing the amount of essential facilities (i.e. hospitals, kindergartens and primary schools)
- ‘H.I.Facilities’ representing the amount of supply and high loss facilities (i.e. harbors, airports, power plants, oil tanks and industry facilities)

Both columns contain the total number of the particular type of facilities in a warning segment depending on the currently announced warning levels for each segment.

As the number of exposed facilities was calculated during the preparation of the map layer aggregated to warning segments it is only necessary to perform four steps:

- join the result file from warning segment aggregation to the key number shapefile (joining field is warning segment ID)
- copy the value of the field ‘sum_ef’ to the corresponding field (crifac_WL2 for warning and crifac_WL3 for major warning)
- copy the value of the field ‘sum_hlf’ to the corresponding field (hlfac_WL2 for warning and hlfac_WL3 for major warning)
- remove join

3.3 Access to Warning Infrastructure

The methodology presented here covers the access of households to indoor and outdoor mass notification infrastructure. Thereby,

- Indoor warning infrastructure relates to those warning dissemination devices that households have access to. These are regular communication devices: TV, Mobile phone, and radio.
- Outdoor warning infrastructure relates to those warning dissemination devices that cover great areas, such as sirens and any kind of institutionalized loudspeaker facilities.

Assessing and mapping these and their coverage area is described in this chapter.

3.3.1 Calculation of Household Level Access to Indoor Warning Infrastructure

The data for calculating the information layers were derived from a household survey conducted in all three pilot areas in selected coastal villages. The variables captured for each household were: Radio, TV, Mobile.

From the data two information layers were calculated:

1. Single device availability: The share of households in a village possessing a radio, or a TV or a mobile phone (in %), Method: descriptive analysis aggregated at the village level (desa) as the reference unit for deriving relative values (%).
2. Device diversity: Share of households (%) in a village having no, one, two and all three devices.

Table 9 shows the results.

Table 9: Calculation of access to indoor mass notification devices aggregated for the village level in the district of Cilacap, Central Java

	Access to devices in HH (%)			Device diversity in HH (%)			
Village	**Radio**	**TV**	**Mobile**	**No device**	**1 device**	**2 devices**	**3 devices**
Tambakreja	53	79	60	0	19,5	26,8	53,7
Tegalkatilayu	46	76	60	3,7	13,4	40,2	42,7
Mertasinga	48	71	71	2,5	30,5	39	48
Karangkandiri	53	80	61	3,2	24,5	35,1	37,2
Adipala	68	68	47	0	16,9	33,7	48,2
Widarapayung Wetan	48	69	55	7,3	17	34,1	41,5

Generally speaking, for all villages in Cilacap the share of households / individuals having TV at home is higher (up to 80%) compared to radio and mobile (up to 70%), whereby the availability of mobile phones (mean 59%) in households is higher than of radios (mean 51%). Very little households have no communication devices at all; in contrary the share of households possessing three devices is higher than those having only two or even one device.

3.3.2 Calculation of Outdoor Warning Dissemination Infrastructure

Two information layers were calculated that assess the current status of communities equipped with outdoor mass notification infrastructure:

1. Area in a village covered by sirens (only Bali and Padang);
2. Area in a village covered by mosque loudspeaker (only Cilacap and Padang). Utilizing mosques as warning dissemination channels has been discussed in various areas, amongst them in Padang and Cilacap.

Two criteria determine by concept the size of the area covered by a mosque speaker, sirens or other forms of outdoor mass notification.

- Average city noise: Sound level (measured in db) at which a siren cannot be heard anymore: This is 80db (Federal Signal Cooperation, 2005)
- Output level of the speaker of a siren / mosque / any other system.

Thereby, the term “area covered” relates to the area where not only sound can be noticed, but where also e.g. guidance messages can still be understood.

Two steps need to be followed for calculating coverage areas of mass notification systems:

1. System’s inventory: Compiling GPS information for of all locations of mass notification speakers from any kind of mass notification system that exists within the tsunami exposed area.
2. Estimation of the area that notifications disseminated through a speaker and can be heard by exposed populations: The geometric form applied for calculating siren and mosque speaker spatial coverage are circles. For mapping them in the urban and rural environment in the three pilot areas the buffer function in ArcGIS9.3 has been applied.

Remark: It shall be noticed that any kind of mass notification system to be installed can be assessed using the same methodology.

3.3.2.1 Siren coverage calculation

Estimations of the area that exposed populations can properly hear a specific siren are based on sound projection measurements published by the Federal Signal Cooperation (2005). Figure 11 illustrates the maximum radius for sirens in an urban environment. The data tell that sirens become ineffective at 80db (average surrounding noise level).

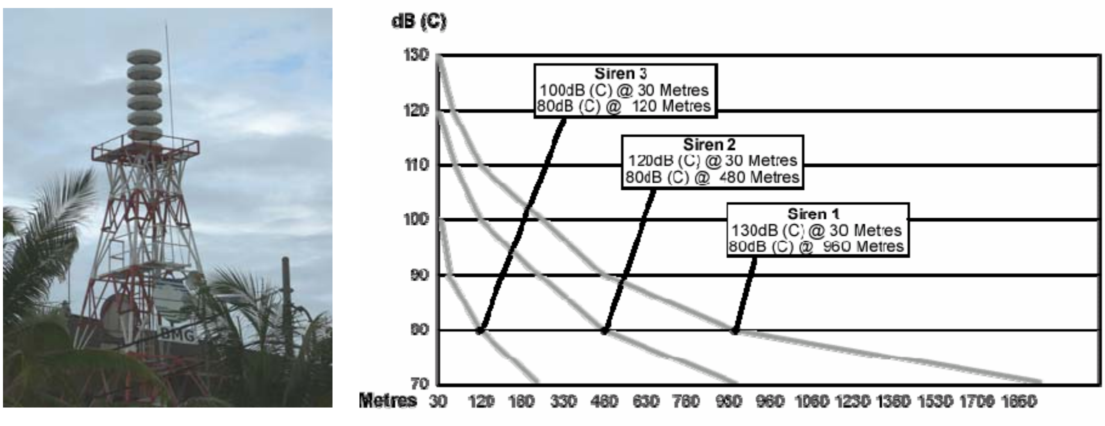


Figure 11: Sound projection for three sirens with different output power. Source: Federal Signal Corporation (2005): Modular Series Speaker Arrays. Illinois

Respectively, by using different siren output levels, three categories of siren coverage radius can be estimated and mapped:

- 100dB siren output = 120m coverage radius;
- 120dB siren output = 480m coverage radius;
- 130dB siren output = 960m coverage radius.

3.3.2.2 Mosque coverage calculation

If authorities regard mosques as a suitable warning dissemination system mapping their coverage area is needed. Inventories of mosques exist already in many statistics. Also data on GPS exists in some areas. When they are missing they have to be compiled. This is also true for measuring mosque speakers' output levels. Each mosque loudspeaker has different output levels, which could not be assessed. Instead a 150 m radius has been used and mapped for each mosque surveyed using the *Buffer* technique in ESRI ArcGIS, explained above.

3.3.3 Access to warning infrastructure map product

The access to warning infrastructure map has been produced using ESRI ArcGIS Three information layers have been produced:

(1) Hazard information *to identify the spatial entity that requires warning dissemination infrastructure equipment*

The calculation of hazard inundation is explained in chapter 2.2. For the access to warning map product the maximum inundation area (major warning) in all three pilot areas has been used.

(2) Exposure information *to identify those areas where masses of populations need to warned, during day and night time*

The calculation of exposure is explained in chapter 3.2.1.Although, to be utilized for warning infrastructure planning it is important to know the highest and lowest exposure levels for both, day and night. Thus, day and night time exposure information has been merged, by selecting only the highest exposure values from either day or night exposure data.

(3) Information on the current situation of access to warning infrastructure *that indicates the existing gaps of warning coverage and provides the knowledge base to identify the most efficient path of warning dissemination.*

1. *Outdoor mass notification infrastructure: Sirens and mosques coverage area*
2. *Indoor mass notification infrastructure; Device diversity: Share of households (%) within a village possessing at the same time radio, TV and mobile phone*

3.4 Evacuation Readiness

The overall methodological challenge is to

- Statistically identify the factors of evacuation readiness of exposed individuals (based on a logistic regression analysis),
- To develop an end-user friendly product that allows for getting an overview about the degree of evacuation preparedness of the population at the village level (index construction, tabular data and index mapping) (Figure 12).

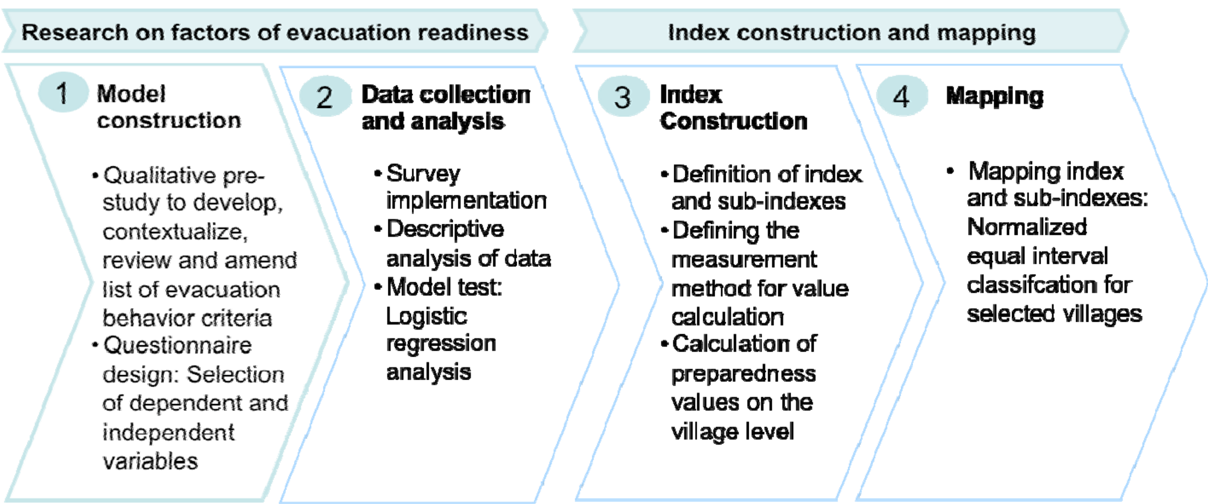


Figure 12: Methodological flowchart for constructing and mapping the evacuation readiness index

3.4.1 Identification of Factors of Evacuation Readiness

This chapter explains the methods applied to identify those factors that shape individuals evacuation readiness. Thus, conducting a social science based analysis of evacuation readiness factors includes the following steps:

- Construction of a multivariate statistical analysis model (example here is given for the logistic regression);
- Household questionnaire design;
- Data collection;
- Data analysis: Regression analysis;
- Results interpretation (Model fit measures and variable discussion).

3.4.1.1 Logistic Regression Model Construction

For this research the logistic regression analysis tool has been the method identified to be most appropriate because it is designed to predict the probability of the occurrence of an event (anticipated evacuation yes, or no) by fitting data (set of variables influencing evacuation preparedness) to a logic curve. This means the model aims at discovering those key factors (independent variables) that according to theory, qualitative analysis and expert judgement are assumed to influence individuals' decision and speed to commence evacuation after receiving a tsunami warning. The logistic regression is a generalized linear model applied for binominal regression (binominal dependent variables). Like many forms of regression analysis, it makes use of several predictor variables that may be either numerical or / and categorical.

Constructing a social science based model for logistic regression includes the following steps:

- Selection and preparation of a dependent variable
- Selection and preparation of a set of predictor variables.

Selection and preparation of a dependent variable

In order to apply the logistic regression, binominal / categorical dependent variables (0 and 1) need to be developed. The questionnaire provides the basic set of variables for the development of the dependent variables:

"What would you do in the case you receive a tsunami warning?"

8 response options were provided in the questionnaire that shall allow respondents to precisely reflect on, imagine and judge on their hypothetical *anticipated action after receipt of a tsunami warning alert*. In order to use these variables for the as dependent variables in the logistic regression analysis they were transformed / recoded into a "quick" and "slow / no" warning alert response variable (compare Table 10).

Table 10: Dependent variables in the household questionnaire: List of hypothetical actions after receiving a tsunami warning

Question: Directly after having received a tsunami warning: What would you do immediately?	
Quick	I would immediately run to a safe place myself
Quick	I would gather my family members and then run to a safe place
Slow / no	I would listen to the radio or TV and wait for further instruction
Slow / no	I would find more guidance from RT/RW / Mosque
Slow / no	I would go away from the beach
Slow / no	I would immediately run to the coast to observe and confirm
Slow / no	I would immediately inform and find confirmation with my neighbours and friends around
Slow / no	I would follow what others do

This approach (asking close to reality hypothetical questions and then recoding into a dependent variable) yields a more robust database on people's anticipated response to tsunami warnings, then directly designing a binominal variable, that only allows for posing very generalized questions to respondents on their anticipated warning response behaviour.

Definition and selection of a set of independent (predictor) variables

What are the variables that are assumed to influence / predict people's response behaviour to tsunami alerts? The variables included in the quantitative questionnaire were developed and selected based on the following analytical steps:

- Pre-selection of variables based on theory: The theoretical background for the preliminary variable selection is the Protective Motivation Theory from Rogers (1983) that assumes that cognitive processes are mediating individual and collective behavior;
- Qualitative pre-study; contextualization of theory based variables:

  - Defining evacuation behaviour requirements according to threat and EWS specifications in Indonesia,

  - Semi-Structured Interviews (SSI) with exposed households and stakeholder consultations (workshops of the German-Indonesian Working Group on Risk and Vulnerability Modelling).

Finally, 35 predictor variables (independent variables) were selected for the logistic regression that are assumed to represent those cognitive processes that shape individuals response to tsunami warnings for the case of Indonesia (Table 11).

Table 11: Overview of the survey parameters assumed (according to theory) to regulate people's response behaviour to tsunami warnings.

No	Variables for the regression analysis
1	Correct tsunami definition
2	Correct knowledge of natural tsunami indications
3	Correct knowledge of estimated time of tsunami arrival (ETA)
4	Perception on the determinants of the harm of tsunami: Sins by the society/politics
5	Perception on the determinants of the harm of tsunami: Many people live in the exposed area
6	Perception on the determinants of the harm of tsunami: People don't have enough protection and preparedness
7	Generally I am very worried because tsunami can strike anytime
8	I feel worried that my own home will be seriously damaged
9	I feel worried that myself or my loved ones will be hurt
10	I am not afraid of tsunami
11	Your most concern: Income insecurity
12	Your most concern: Tsunami
13	Have you ever experienced a tsunami in your area in your lifetime?
14	Implications for action of received tsunami warning: people must immediately evacuate wherever they are.
15	Perception on tsunami warning: Sure that tsunami will occur
16	Have you ever received information about tsunami occurrence from any kind of source after a strong earthquake?
17	Implications for action of received tsunami warning: people must be in alert and ready to evacuate to save place
18	Perceived safe place: Relatives living at higher ground
19	I know high buildings suitable for evacuation close to home/workplace/school
20	I know higher ground close to home/workplace/ school
21	I know and understand evacuation signs placed along the street
22	Disadvantage of evacuation (if tsunami did not occur): possibility of looting
23	Disadvantage of evacuation (if tsunami did not occur): troubling friends/relatives while staying at their house
24	I don't know any evacuation route
25	Have you ever participated in tsunami simulation/socialization?
26	Location too faraway. What are the constraints of successful evacuation?
27	I and my household members will manage to successfully find a safe place before the tsunami hits
28	Gathering my family members and still appropriately evacuate together to a safe place
29	Time to reach the nearest evacuation place from home
30	Education
31	Junior High School completed
32	Household income
33	Sector of employment
34	Activity (employed, looking for work, school, others)
35	Age
36	Household size
37	Distance to the coast
38	Respondent having children (yes / no)

3.4.1.2 Household Questionnaire Design

Quantitative household surveys are the key instrument for data collection. It is advised to develop and manage household surveys in close cooperation with universities to insure quality control and representative results. Also BPS has a significant competence to assist. BPS can also provide guidelines on questionnaire design, including layout. According to the research topic and data needs, questionnaires differ in terms of questions and variable metrics and size of the questionnaire.

Questions

Three types of data sets shall be included in the quantitative household questionnaire, if a multivariate analysis is desired:

1) Baseline socio-economic parameters of households an individuals: age, gender, household size, income, employment sector, education etc.
2) Independent variables: How at best can anticipated and hypothetical reaction to warning alerts be captured, what are the variables? Here, it was chosen to design parameters and question that respondents can easily associate with, when dealing with options after receiving a tsunami warning alert (compare Table 10)
3) Dependent variables: All possible and by theory assumed variables (compare Table 11) shall be included in the questionnaire. In the statistical analysis some of them may turn out to be not significant and thus not suitable to be used for logistic regression.

The following questionnaire was used in the survey:

QUESTIONNAIRE FOR MEASURING EVACUATION PREPAREDNESS

This questionnaire is designed to be applied by authorities and organizations involved in socialization campaigns of the population on tsunami threat and evacuation preparedness.
It includes a set of questions related to the different topics and factors of evacuation readiness identified by research, documented in the associated guideline.

The questionnaire can be applied for any individual that is exposed to tsunami threat. Thus, to design a survey to apply the questionnaire it is recommended to first use the hazard and exposure map and then to decide in which areas to conduct the questionnaire. Specific areas to investigate on individuals' evacuation readiness is in residential areas and at workplaces.

The goal of the data analysis, once the survey is finished, is to apply the scoring system. The proposed values for each answer category or option is attached to each of the questionnaire questions. By calculating e.g. mean values for all scores values within each Sub-index, a single sub-index score value can be calculated. Using the scoring system allows for making visible those groups of people who would behave correctly after an tsunami warning alert then others. The scoring method is explained in this guideline.

1. General information of the interview

ID of the questionnaire	
Date of interview	
Time of interview	
Interviewer ID	
Name of Editor	
Name of the respondent	
Kelurahan	
RT /RW	
Kecamatan	

2. Social data of the respondent

Age (years)	_______________(years)
Sex	Male =1 Female =2
Religion	Islam =1 Catholic = 2 Kristen = 3 Hindu = 4 Budism = 5 Others____
Ethnicity	Minang =1 Jawa =2 Batak = 3 Cina = 4 Nias = 5 Others____
How long has the respondent stayed in the Kelurahan?	_______________(years)
How long has the respondent stayed in this Kecamatan?	_______________(years)
Attained education	0. Never went to school 1. Not attained SD 2. Attained SD 3. Attained SMP 4. Attained SMA/SMK 5. Diploma and Bachelor 6. Graduate/PhD 77. < 5 years old
Household size	_________________(number)

EVACUATION PREPAREDNESS VARIABLES

Key Variables Hypothetical question on intended, anticipated behavior after having received a tsuami warning?			
1	**What would you do in case of a tsunami warning?**	**Select**	**Score**
	a. I will immediately run to the coast to observe the sea to confirm		**-0.5**
	b. I will first wait and find more information: Radio, TV, RW / RT staff, Mosque		**0**
	c. I will go in opposite direction of the beach		**0.5**
	d. I will immediately run to a safe place myself		**1**
1	**Participation in any tsunami socialization programme**	**Select**	**Score**
	a. Evacuation drill		**1**
	b. Workshops on household level preparedness for tsunami		**1**
	c. Awareness activities at work, at school		**1**

INDEX COMPONENTS

Sub Index A: Tsunami Knowledge How much do you know about tsunami characteristics in Indonesia?			
1	**Tsunami definition: What is "tsunami"?**	**Select**	**Score**
	a. Big flood due to rain		**0**
	b. High sea waves due to storm occurring regularly		**0**
	c. High sea waves caused by earthquake in sea		**1**
	d. Earthquake		**0.5**
2	**What are the signs that a tsunami might arrive in a short time?**	**Select**	**Score**
	a. Earthquake on land		**-0.5**
	b. Big earthquake in the sea and receeding of water from the coast		**1**
	c. Animal's unusual habits (e.g. birds)		**0.5**
	d. Sins by society		**0**
3	**How long will after the natural signs tsunami will occur?**	**Select**	**Score**
	a. < 5 min		**-0.5**
	b. 5 – 20 min		**1**
	c. 20 – 45 min		**0.5**
	d. > 45 min		**0**

Sub Index B: Vulnerability Perception What are your personal worries with regard to possible tsunami impacts in your living area and their associated reasons?			
1	**I live in the danger zone, and people will die, if they don't evacuate!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**

	c) agree		**0.5**
	d) strongly agree		**1**
2	**In case of tsunami happens here, I feel worried that my own home will be seriously damaged or destroyed!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
3	**Generally speaking, communities are able to get prepared for tsunami and to prevent the loss of life!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
4	**From all worries about different kinds of hazards** (earthquake, storm, flooding, traffic accident, neighborhood security, income insecurity), **tsunami worries me most!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**

	Sub Index C: Warning Perception What is your knowledge on the tsunami warning system in place and do you believe that tsunami warnings can safe your life?		
1	**If a tsunami warning is issued, I would clearly hear the warning signal and message from a siren or mosque or other system!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
2	**The Tsunami Early Warning System can predict very accurately the occurrence of a tsunami!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
3	**A tsunami warning means automatically that residents must immediately start evacuation!**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
4	**I always trust in tsunami warnings, I would always directly commence evacuation!**	**Select**	**Score**

	a) strongly disagree		- 0.5
	b) disagree		0
	c) agree		0.5
	d) strongly agree		1

Sub Index D: Evacuation Perception What is your knowledge about warning infrastructure in the area where you live and do you think you can manage evacuation successfully?			
1	**I know high buildings suitable for evacuation close to home/workplace/school**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
2	**I know safe hilly areas (if the case: designated as evacuation places by government/authorities)**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
3	**I know evacuation routes given by the government**	**Select**	**Score**
	a) strongly disagree		**- 0.5**
	b) disagree		**0**
	c) agree		**0.5**
	d) strongly agree		**1**
4	**I can gather my family members and still successfully evacuate to a safe place in due time**	**Select**	**Score**
	e) strongly disagree		**- 0.5**
	f) disagree		**0**
	g) agree		**0.5**
	h) strongly agree		**1**

Variable metrics

Apart from typical *bi-variate* and *nominal* categories the metrics of the quantitative questionnaire was developed based on the following considerations:

- Perception and judgment analysis of individuals: For the investigation on socio-psychological conditions of individuals binominal metrics are to coarse. To get a more differentiated picture of individual's values and perceptions the *Likert-Scale is best to be applied (*four level response classification: e.g. 4 very appropriate - 3 appropriate – 2 inappropriate - 1 very inappropriate; common scale for socio-psychological research questions);
- Capturing different priorities of individuals for different judgment options applying ranking methods.

Option: If multivariate analysis is not required the variable metrics shall fulfill the following two criteria:

- Consider the complexity of the topics: e.g. Likert scale vs. binominal scales
- Apply only one scale for all variables to derive a coherent ranking matrix for index construction

3.4.1.3 Data Collection and Survey Sampling

To define the survey sample locations and size it is necessary to define the product goal and output desired. Here, measuring evacuation readiness and developing decision support products for awareness rising and sensitization aims at developing indicators whose values are representative for decision makers' geographic territory of political power.

Thus, the survey sampling definition is based on the following steps:

1. Definition of the representative unit of analysis
2. Sample size selection
3. Sample location selection
4. Household selection

Each of the different steps is explained in the following in detail. Thereby, the method applied for the product developed will be described, but also options for utilizing a different approach are presented.

(1) Definition of the representative unit of analysis

The guideline presents the evacuation preparedness assessment results representative at the village level. This scale has been chosen because it allows for a spatial analysis of evacuation readiness at different exposure levels. In addition, it allows for prioritizing and designing village specific socialization campaigns, depending on the level of evacuation preparedness within a village.

(2) Sample size

For the assessment to be representative at the village level, the sample size needs to be selected according to the social structure and its heterogeneity within a village. Generally speaking, the higher the heterogeneity the higher the sample size. In this case the sample size for each village ranges from 60 – 90 households. Depending on how many villages shall be selected the total sample size varies. Here in total 2000 households have been surveyed in 24 villages.

Options: If the village level shall not be the representative unit of the assessment, the sample size can be much smaller, which also lowers the resources necessary. But also defining the sample size e.g. to be representative for the district level, shall take into account the social structure of the population. Enough samples shall be generated for each social group, e.g. defined according to gender, age and income.

(3) Household Selection: Stratified sampling

Due to the lack of precise socio-economic sampling data for different villages / city wards, the household samples were selected based on remote sensing analysis of the physical urban structure of residential areas (building type, density and size, rural/urban area). Thereby, it is assumed that the physical structure corresponds with the socio-economic structure of the household entities residing in the respective building. Thus, in order to include all sub-groups of the population an equal share of the different residential building types that exist within a village was selected randomly. The precise remote-sensing based pre-selection of single households was only possible in urban Padang and Cilacap due to the availability of high-resolution Ikonos satellite imagery. For the more rural areas and for Badung (Bali) simple random sampling has been conducted.

Options: Depending on the available information of the social structure of an area other means of stratified sampling is possible. E.g. the census block information from BPS can be used, and can be obtained in the local BPS office.

(4) Village Selection

Due to limited financial resources of the research in this guideline only a few villages in the pilot areas could be covered. Therefore, also the product developed shall act as an example how evacuation preparedness can be measured. For the product developed in this guideline the criteria ‘coastal / hazard exposed’ and ‘regional / developmental difference’ were the two main criteria applied for selecting the villages of interest for the study. In the case of Cilacap all villages selected are coastal, whereby two are urban (Tambakreja, Tegalkatilayu), two semi-urban (Mertasinga, Karangkandiri) and two rural (Adipala, Widarapayung Wetan).

Also in the study area of South Bali, the villages selected are all coastal representing the most touristic area on the island, except for Tibubeneng, whose structures are still in transition from rural / agricultural to solely tourism based ones. In Padang, due to available resources twelve city wards could be surveyed.

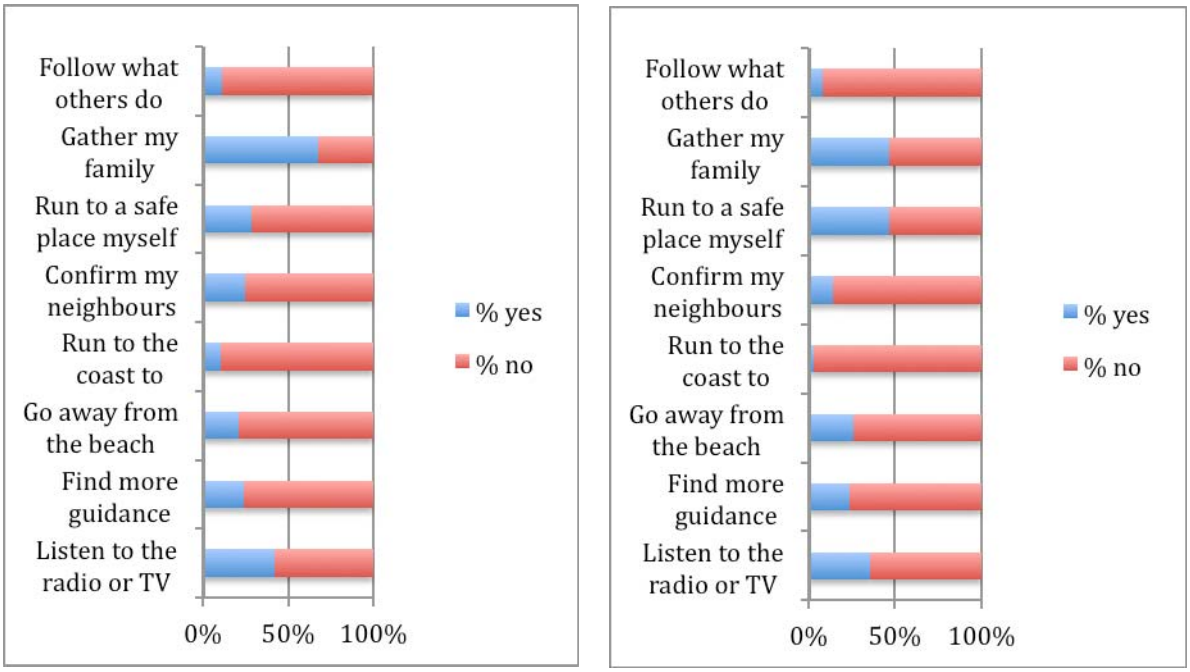
Options: To get a full picture of the degree of evacuation preparedness of all coastal villages more villages need to be covered. Based on hazard inundation maps exposed villages can identified and entirely surveyed.

3.4.1.4 Data Analysis: Conducting logistic regression using SPSS 17

The data analysis is at best conducted with SPSS (Statistical Package for Social Science). Before conducting the multivariate analysis, descriptive analysis of the data is important. With such information at hand, one can judge whether the data are good enough to be utilized for further analysis.

(1) Example: Descriptive analysis of the dependent variables

The results for the dependent variables descriptive data analysis of Cilacap and Bali shows that there is a diversity of anticipated responses to tsunami warnings amongst the test group (Figure 17).



Cilacap Bali

Figure 13: Survey results, respondents anticipated response to tsunami warning in Cilacap and Bali

Although a large proportion of the respondents indicate that they either would run to a safe place themselves or gather their family members first and then run to a safe place (quick response) there is a significant amount of respondents preferring to conduct other activities prior to evacuation. Amongst them are to wait for further instructions or confirmation on tsunami occurrence from the radio, TV, the mosques or even friends and neighbours. Even 10 % of the respondents in Cilacap chose to get direct confirmation by observing changes in sea water levels. Obviously, the respondents have subjective reasons for not responding to tsunami warnings and its associated threat. The results show clearly that the social response to technological systems is non-linear. This is an expected result that is of less use for the development of contextual socialization measures and preparedness strategies when not knowing the underlying factors that shape a specific behaviour pattern during an alarming event.

(2) Running the logistic regression

In a first step a logistic regression model was developed that included all variables identified in the survey (Table 5) assumed to be relevant by theory and context. The so-called "*full model*" (38 variables) was employed to distil those variables that can significantly predict the probability of households belonging to the quick response group. In a second step another regression, the so-called *"top model"* was conducted using only the significant variables from the *"full model"* in order to achieve an even more accurate prediction. The models were performed separately for each pilot area (Cilacap, Bali and Padang) considering the fact that those variables showing strong influence do not have to be the same ones because of location specific differences.

Nowadays it is easy to conduct complex statistical analysis using computer software such as SPSS. The real challenge is then to interpret the results, e.g. the modelfit measures. Applying the logistic regression the dependent variable must be "nominal" the independents: "nominal" and / or "scale". In this analysis both scales were used. Figure 14 illustrates the location of the logistic regression analysis tool in SPSS.

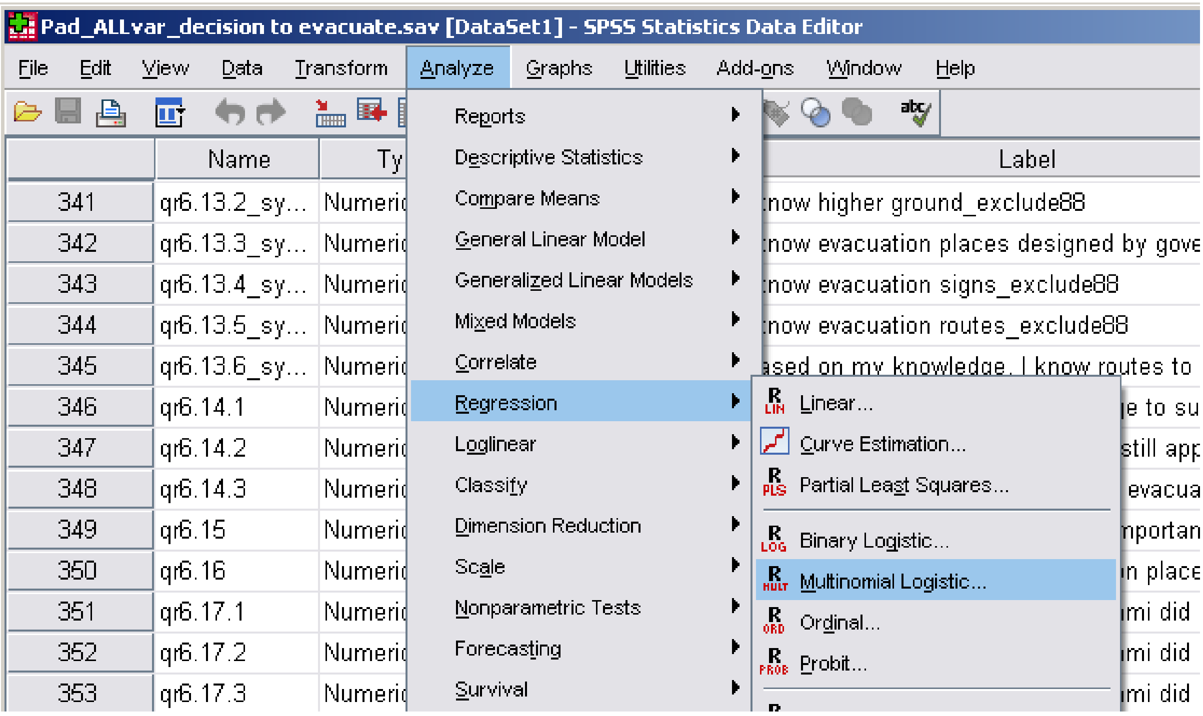


Figure 14: How to find the logistic regression analysis tool in SPSS

When the dialogue box has been opened the following actions need to be conducted:

- Put the dependent variable developed to item "Dependent"

- Put independent scale and (0/1)-variables to “Covariate(s)”, put independent multinomial variables to “Factor(s)”.
- Selection of output measures for model interpretation: There are different options e.g. under “Model”, “Statistics…”,… - Suggestion: under “Statistics…” chose additionally “Classification table” and “Goodness-of-fit”.

In the following a few selected measurements shall be included in the output:

- Table Model Fitting Information, “Sig.”: should be close to zero.
- Table Goodness-of-Fit, “Sig.”: both values should NOT be too close to zero.
- Pseudo R-Square: between 0 and 1. The closer to 1, the better the adjustment of the model.
- Table Parameter Estimates: note: interpretation with respect to the chosen reference category!
    - B: coefficients, interpretation: positive value increases the probability for the considered category compared to the reference category
    - Exp(B): Odds ratio, interpretation: between 0 and 1 -> negative influence, over 1 -> positive influence
    - Sig.: significance of the variables, should be close to 0.
- Table Classification: the overall percentage correct should be higher than the highest percentage of the classes of the dependent variable.

3.4.1.5 Logistic Regression Results: Model Fit Measures

Table 12 shows for all pilot areas those variables that were identified in the *“full model”* as being significant (**P>|z|** = close to 0, values can be between 0 and 1). Thereby, out of 38 variables 22 were identified to possess a statistically significant impact on individuals’ response to tsunami warnings.

Table 12: Significant variables of the “full model“ to be employed for the “top model“ for all three pilot areas

Variables significant in the „full model“	Padang	Cilacap	Bali
Correct definition of tsunami	X		
Correct knowledge of natural signs of tsunami occurrence	X		
Correct knowledge of Estimated Time of Tsunami Arrival (ETA)		X	
Hazard occurrence perception: Tsunami can strike anytime	X		
Perception on the determinants of the harm of tsunami: People don't have enough protection and preparedness	X		
Perception on the determinants of the harm of tsunami: Sins by the society/politics			X
Implications of tsunami occurrence: Home will be destroyed (exposure perception)	X		
Implications of tsunami occurrence: Myself or loved ones will be hurt/ killed (exposure perception)			X
Fear of tsunami: yes		X	
Perceived most concern in everyday life: Priority is tsunami		X	X

What to do in case of warning: Residents must be aware and wait for further instructions		X	
Implications of warnings: Sure that tsunami will happen	X		X
What to do in case of warning: People must evacuate immediately		X	X
Perceived safe place: Relatives living at higher ground		X	X
Evacuation buildings knowledge: yes		X	
Evacuation signs knowledge: yes	X		X
Evacuation routes knowledge: No knowledge	X	X	
Evacuation manageability: Gathering my family members and still appropriately evacuate together to a safe place	X		
Household's distance to the coast	X		
High Income		X	
Age	X		
Household size			X

But, before getting an understanding of how to interpret the single variables' statistical "behaviour" in the model, its validity and accuracy needs to be proven.

(1) Interpretation of model fit measures

The interpretation of the logistic regression results is based on two steps:

1. A set of model fit measures explains the accuracy of the "top model": LR chi2 test, Pseudo-R square, Hosmer-Lemeshow test, classification table
2. A set of measures provides information on how to interpret each of the variables in the model

For an overview the key model fit measures for all pilot areas are shown in Table 13.

Table 13: Model fit measures for Cilacap, Bali, Padang

	p-value for LR chi² test	**p-value for Hosmer-Lemeshow test**	**Pseudo-R squared**
Padang (N=933)	0.000	0.430	0.110
Cilacap (N=505)	0.000	0.685	0.142
Bali (N=501)	0.000	0.981	0.145

The following detailed presentation and explanation of the model results is based on the example of Cilacap:

a) LR chi2 (Likelihood ratio chi²) test: Prob > chi2= 0.000

The LR chi2 tests the 0-hypotheses that the independent variables do not contribute to the explanation of the variance of the dependent variables.

If the p-value (=Prob > chi2) is close to zero, it can be assumed that at least one of the variables contributes to the explanation of the variance of the dependent variables. The results show that we can prove that the variables selected in the "*top model*" are to be acknowledged as important factors that influence a household's reaction pattern to tsunami warnings.

b) Pseudo-R square: 0.19

This measure explains how much of the variance of the observed dependent variables can be explained through the predicted variance. The values of the Pseudo-R square measure are always fluctuating between 0 and 1, the higher the value the more of the variance is explained. In the case of Cilacap 19% of the variance of the observed dependent variables can be explained. The rest of the variance is assumed to be a non-linear relationship between the dependent and independent variables which cannot be captured through this measure. Thus, although this measure seems to be important, it has been developed for engineering science and not for social science. The complexity of interrelationships between variables in social science and cognitive models cannot be revealed by the Pseudo-R square measure alone.

c) Hosmer-Lemeshow test: p-value: 0,68

This measure explains the probability that the predicted and observed frequencies of the dependent variables (fast and slow response group) match. The higher the value the better the model fit. A p-value of 0.5 is regarded as the starting point for accepting a certain accuracy of the model, but values around 0.5 need to be treated carefully. A value of 0.7 is considered as good. Judging the values for Cilacap (0,685) and Bali (0.981) against these scientifically accepted benchmarks, the model can be considered as quite good, whereas the model for Padang is not as good (0.43).

d) Classification table as model fit measure: Correctly classified 80.00%

In the classification process one of the two predicted dependent variable values will be classified into each empirically observed case, 0 or 1 (slow and quick response group). Normally, a value of 1 will be classified into an observed value if the model predicts a probability of above 0.5, whereas if the probability is below 0.5, a value of 0 will be attributed to the observed value. The classified values of the dependent variable are typically displayed in a classification table. The table is a simple cross tabulation of the classified values with the empirically observed values (See Table 14).

Table 14: Observed and classified sample cases for Cilacap

	True / observed cases		
Classified / predicted	Quick resp.	Slow resp.	Total
Quick resp.	371	93	464
Slow resp.	13	28	41
Total	384	121	505

As can be seen from Table 8, in the case of Cilacap, 464 cases were predicted and classified in the quick response group, but only 371 of those were classified correctly and 93 were wrong. On behalf of the slow response group, 41 were predicted and classified in the slow response group of which 28 were correctly classified and 13 were not.

Thus the percentage of correctly predicted / classified overall values are calculated as follows:

r count = (371 + 28) / 505 * 100 = 79,00 %

The value is quite good showing that the prediction of a household to belong to a quick response group can be roughly approximated through assessing household or individual hazard knowledge, vulnerability perception, warning perception, evacuation perception, social indicators, and the average distance of a household to the sea.

(2) Interpretation of the results for single variables

A standard coefficient for single variable interpretation is the *odds ratio*: It determines the direction of the influence of the variable: The higher the value is above 1 the more likely the respondent belongs to a fast response group and vice versa.

Table 15: Model fit measures for top model variables in Cilacap

Variables that influence the probability to belong to the quick response group	**Odds Ratio**	**Std. Err**	**z**	**P>|z|**	**95% Conf. Interval**	
Correct knowledge of "Estimated Time of Tsunami Arrival" (ETA)	**1.67**	0.10	-3.45	0.001	0.29	0.71
Fear of tsunami: yes	**1.45**	0.21	2.52	0.012	1.09	1.93
Perceived most concern in everyday life: Priority is tsunami	**1.23**	0.17	1.51	0.132	0.94	1.60
What to do in case of tsunami warning: Residents must be aware and wait for further instructions	**0.58**	0.11	-2.85	0.004	0.39	0.84
What to do in case of warning: People must evacuate immediately	**1.24**	0.21	1.29	0.198	0.89	1.72
Perceived safe place: Relatives living at higher ground	**8.53**	6.49	2.82	0.005	1.92	37.90
Evacuation buildings knowledge: yes	**2.13**	0.66	2.45	0.014	1.16	3.90
Evacuation routes knowledge: No knowledge	**0.22**	0.08	-4.02	0.000	0.10	0.46
High income	**1.89**	0.67	1.80	0.072	0.94	3.78

To provide guidance for interpreting the *Odds ratio* for each of the significant variables (**P>|z|**), here the results for Cilacap are taken as an example. They are discussed according to the categories associated with the variables (Table 15, first column):

*Hazard knowledge: E.g. r*espondents possessing the correct knowledge of the Estimated Time of Tsunami Arrival (ETA <= 30 min) rather tend to respond quickly to a given warning.

Vulnerability perception: Those respondents, who generally fear a tsunami impact and those who even consider and perceive a tsunami as a major threat unlike other threats such as car accidents or the struggle for daily livelihoods, rather tend to quickly respond to tsunami warnings.

Perception on the implications for action of tsunami warnings: Respondents, who rather expect guidance for action and not just a tsunami warning alert, tend to hesitate before they start evacuation. Vice versa, those who understand tsunami warning alerts as an indirect call for evacuation, also tend to quickly respond to warnings and evacuate immediately.

Evacuation perception: The knowledge of evacuation routes and safe areas (higher ground or vertical shelters) are of utmost importance for quick reactions to tsunami warning alerts. Especially those who are familiar with the shelters accessible to them (relatives living at higher ground) tend to quickly respond to warnings.

Socio-economic features of the respondents: In general, the analysis does not provide information of a specific social group that tends to respond slowly or quickly to tsunami warnings. In this model, income plays the sole role. It assumes that the higher the income-class the higher the probability of quick response. Also a qualitative assessment of the triggers for warning response revealed that low income groups rather fear not being able to maintain their livelihoods if they evacuate as a consequence of its time consuming nature.

3.4.2 Evacuation Readiness Products

What is the most useful tool for decision makers to get informed about the level of evacuation preparedness in their region? One solution is to develop an Index and respective sub-indexes of the indicator values. A second solution is to display the index in a map and to produce readiness mean values at the village level.

3.4.2.1 Evacuation Readiness Index and Sub-Indexes

After knowing that the logistic regression model has the capacity to predict the hypothetical reactions of the respondents to tsunami warnings, and after having identified the most significant variables in the model influencing these reactions, an equally weighted Evacuation Readiness Index and respective sub-indexes for each surveyed village in all three pilot areas has been constructed.

(1) Index architecture

Although in the three pilot areas for each of the evacuation readiness categories (hazard knowledge, vulnerability perception etc.) different variables were significant (compare Table 6), the construction of the respective sub-indexes and aggregated index included all significant variables from all three pilot areas, except variables that lack clarity in terms of the interpretation of the model fit measures. The major advantage of using the same variables for calculating the indexes for all pilot areas is that the results are then comparable. Moreover, by looking at the end-users needs, it does not make sense to stick only to a model's statistical values as the bases for the judgement which variables to include in the (sub-) index. In this sense, variables that were significant in Padang were also included in the (sub-) index construction for Bali or Cilacap. Although in the statistical model the variables household size and income as well as the degree of exposure were also influencing individuals' evacuation readiness, they were not included in the index. This decision was taken based on the fact that household size and income are not as variable and dynamic as those related to the cognitive and emotional dimension of evacuation readiness. Since the assessment results are the base for developing an evacuation readiness monitoring system, only these dynamic features require regular update for effective socialization campaigns. But still the results show that emphasising the need to specifically target large households and different income groups during socialization campaigns is highly important.

To derive aggregated information about the degree of evacuation readiness of the population that can be used by decision makers, the factors identified in the regression analysis were grouped into sub-indexes and labelled according to their logic association.

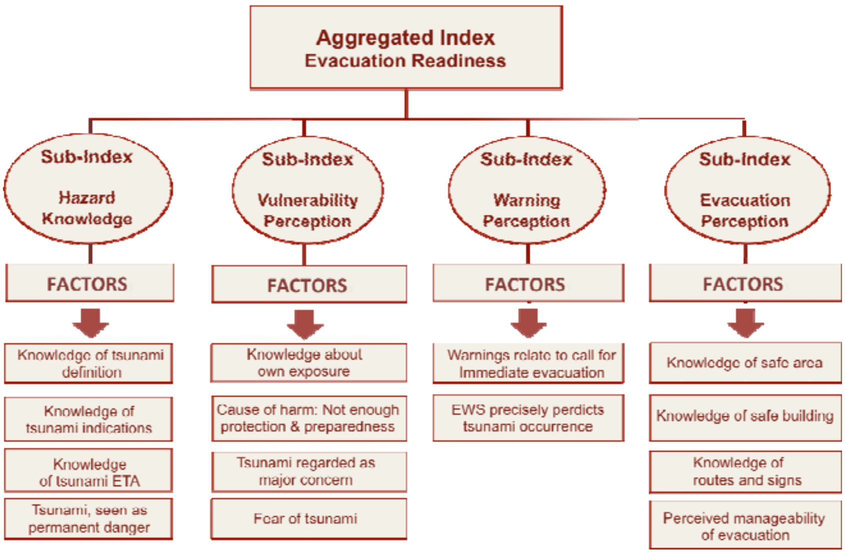


Figure 15: Components and parameters of the Evacuation Readiness Index

(2) Index calculation

The (sub-) index was calculated by first assigning points to each variable value based on the influence of the value's impact on the evacuation readiness of a case (survey respondent). Summed up, the (sub-) index values cases (whether households or villages) with the highest amount points are likely to have e.g. the highest hazard knowledge or vulnerability perception thus also being more or less ready to evacuate compared to others. To measure the degree of evacuation readiness and its sub-indexes at the village level the following steps were conducted (compare Figure 11).

1. Scoring system development: Recoding the case values of each variable into 0, 0.5; and 1. The higher the value the more likely the specific factor contributes to overall evacuation readiness.
    a. Yes/No variables: yes = 1 point; no = 0 points
    b. Likert scale variables: very much no = 0 point, little no = 0 point, little yes 0,5 point; very much yes = 1 point
2. Aggregation: All case values for each variable belonging to the same village were aggregated by calculating mean values.
3. Sub-(index) calculation: To derive sub-index values, village level mean values of the variables belonging to a sub-index were calculated. The same procedure was applied to derive evacuation readiness index values.
4. Grouping of the index values: The index values were grouped into four levels of evacuation readiness using the equal interval method: very low, low, high, very high.

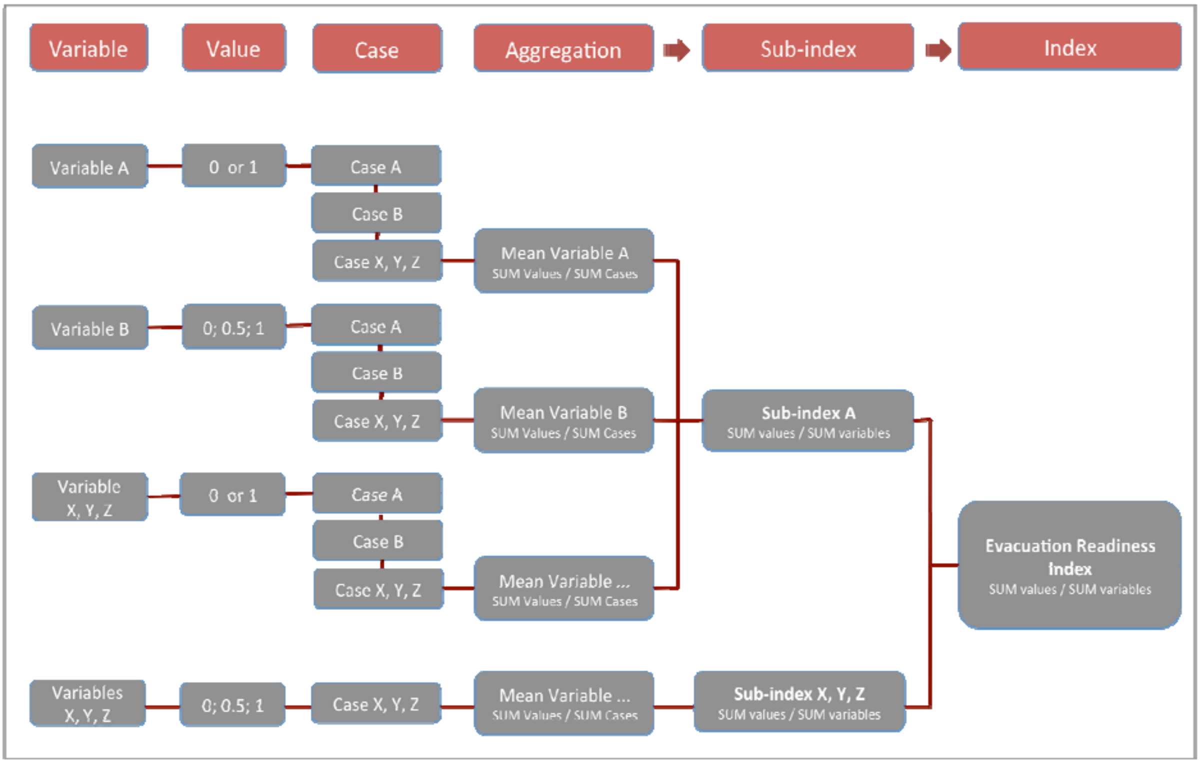


Figure 16: Evacuation readiness Index construction

3.4.2.2 Evacuation Readiness Map

Finally, the index and sub-index results were mapped for each pilot area by applying an equal intervals classification scheme (0 – 0.25; 0.26 – 0.5; 0.51 – 0.75; 0.76 – 1) in order to be able to distinguish between very low, low, high and very high levels of hazard knowledge, vulnerability perception, warning perception, evacuation perception and finally overall evacuation readiness.

As shown in the map the Evacuation Readiness Index is composed of the following sub-indexes representing the contributing factors to overall evacuation readiness: Hazard knowledge, vulnerability perception, warning perception, and evacuation perception. The map indicates the degree of evacuation readiness of households living in the surveyed village in Cilacap (Central Java) expressed by the categories very low, low, high and very high.

3.5 Evacuation Time

The ability to respond properly to a tsunami warning message, i.e. the ability to evacuate in time, depends on several factors:

- Extent of the (modeled) hazard impact
- Properties of temporary shelter areas / evacuation buildings
- Land use (using streets or grassland is better than forest)
- Slope (you are faster when terrain is flat and not steep)
- Population density (moving in a crowd is slower than moving alone)
- Age and gender distribution / human response capabilities
- Density of critical facilities (primary schools, hospitals)

Basic principle in the assessment is to define the best evacuation route from a given point to a temporary shelter area or an evacuation building. Here the fastest path from that point to the shelter location has to be found.

The fastest path is not always the shortest path (which is the direct line between point and the assembly point). In this concept the accessibility is calculated on a *cost surface* which consists of a regular two- dimensional grid where each cell represents either passable routes such us roads, vegetation and beach or relatively inaccessible land and water bodies. Different types of evacuation routes have different characteristics. A flat road, for example, allows faster travel speed than dense vegetation. Therefore it is not enough to measure the *distance* between two points. Instead, a measure of travel *cost* is preferable, which can be considered as *travel time.*

Instead of defining the cost surface as the distance between starting point and each cell in the domain, it is possible to define it as the distance between each cell and the “evacuation shelter points” (which are more than one). The value of each cell is the *cost weighted distance* (CWD) between cell and the closest evacuation shelter point.

In principle, the steps which have to be performed are the same for both national and local level analysis. But for the local level the input data is more comprehensive and of course more detailed, and the output has a better spatial resolution (sub-national 30 m, local level 1 m).

The analysis is conducted using ESRI's ArcGIS software. Figure 17 shows an overview of the workflow to perform the evacuation time modelling.

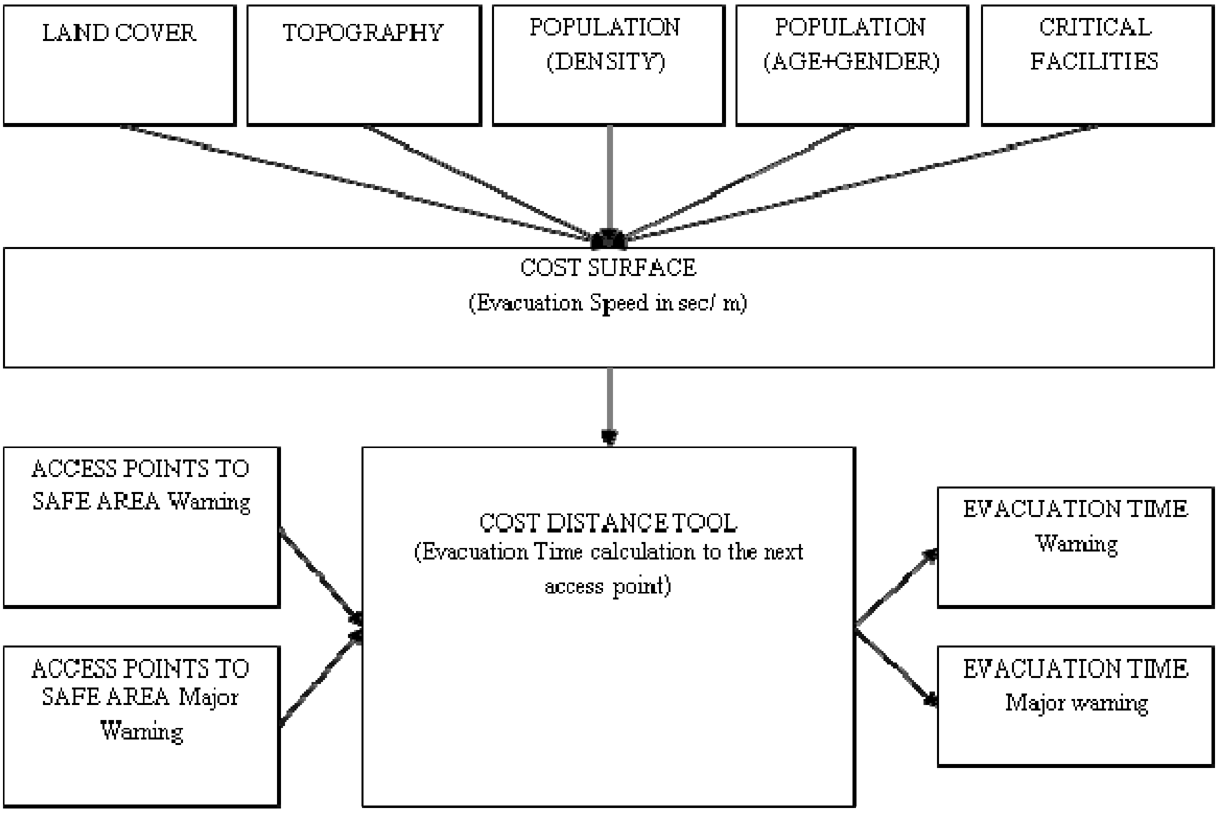


Figure 17: Workflow evacuation time modelling (DLR 2009)

3.5.1 Evacuation time modeling

In principle, all areas which are not flooded or otherwise impacted by a tsunami can be considered as safe areas. Still, not every safe area is suitable as assembly area for a larger amount of evacuees (like for example dense forests or swamp areas). Thus, areas which suit as assembly areas – so-called temporary shelter areas – have to meet certain criteria: they feature a suitable land use (see

Table 20), a minimum size of 10.000 m², a slope below 20° and a good accessibility (i.e. connection to the road network).

An evacuation target point (or access point) refers to a target point that the evacuees from the hazard zone (i.e. the evacuation area) should reach to avoid any hazards arising from a tsunami. The evacuation can take place either vertically (the target point then is an evacuation building) or horizontally Ideally, a horizontal evacuation target point leads to a temporary shelter area and consequently lies on an intersection of the road network and the maximum inundation line (which is the boundary of the hazard zone).

3.5.1.1 Temporary shelter areas

Selecting temporary shelter areas requires the following steps:

- Input: 1) land use shapefile
  2) slope raster
  3) inundation zone (= hazard zone) shapefile
- Make sure that all input files have a projected coordinate system assigned
- *Reclassify* slope raster (2 classes: < 20°, > 20°)
- *Convert* reclassified raster to polygon
- *Erase* hazard zone shapefile from land use shapefile
- *Select* polygons of class > 20° from reclassified slope shapefile and *export* to new shapefile
- *Erase* new slope shapefile from land use shapefile
- *Select* from modified land use shapefile all polygons attributed with unsuitable land use classes and *delete* them
- *Dissolve* remaining land use classes (<u>no</u> multipart features!)
- *Calculate area*, *select* polygons < 10.000 m² and *delete* them
- **Output**: shapefile with temporary shelter areas

3.5.1.2 Evacuation target points

At sub-national level, only horizontal evacuation target points are considered. These points can be extracted from available vector and / or raster data (e.g. roads, land use). Nevertheless, as e.g. road network data is usually more or less generalized depending on the scale the authors make no claim that the extracted access points are complete.

The identification of buildings suitable for vertical evacuation is complex and requires on-site confirmation. Therefore, evacuation buildings as vertical evacuation target points are only considered at local level for the analyses in the three GITEWS pilot areas. The description how to identify evacuation buildings can be found in chapter 4.

<u>**Coarse scale**</u>

For horizontal evacuation target points, the points were placed along the border of the hazard zone (maximum inundation line) accessible through e.g. street network. As input data for selection of access points a land use data set, a road data set, the hazard zone and the coastline are necessary.

Especially the hazard zone at warning but also at major warning does not cover the coastline entirely on the whole length. There are small patches of hazard zones which are not connected. As each part of the hazard zone has to be adjacent to an access point to not falling out of calculation of the evacuation time modeling, and as it would imply a lot of work to set the access points manually to assure the connection to an access points of each zone part, a small buffer along the coast is set. This small buffer (30 m inland) assures that also small hazard zone patches have connection to an access point, even if they don't have an 'own' access point (see Figure 18 for illustration).

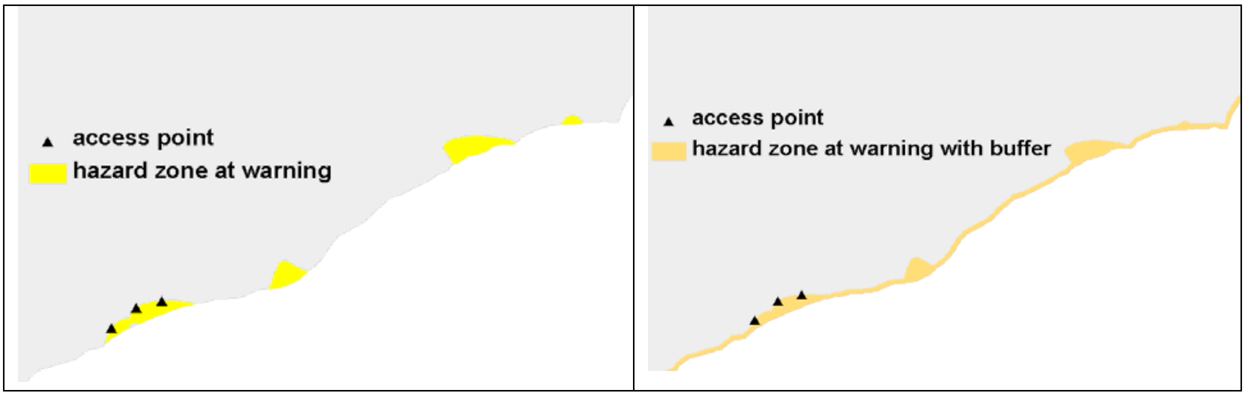


Figure 18: Illustration of necessity of a coastline buffer

If there are large coastal segments or islands where no access point is installed by following all conditions it is necessary to set additional access points manually. To take into consideration the lack of detailed road network data (applies mainly on Sumatra and offshore islands), it is advisable to check the automatically set access points and set additional points if applicable. At last, the access point shapefile has to be completed by four corner points which describe the bounding box and by adding an ID field populated with consecutive numbers starting with 1.

Setting evacuation target points requires the following steps:

- **Input**: 1) road network shapefile
  2) hazard zone shapefile
  3) coastline shapefile
  4) land mask shapefile
- Make sure that all input files have a projected coordinate system assigned
- *Buffer* coastline 30m
- *Union* buffered coastline shapefile and hazard zone shapefile and *dissolve*
- *Erase* new hazard zone shapefile from land mask shapefile and *convert* polygon to line (= maximum inundation line)
- *Intersect* maximum inundation line shapefile and road network shapefile (output type: point)
- Use *multipart to singlepart* to explode generated multipoints to separate singlepart points
- Review generated access points and if applicable, remove or add manually points where necessary, e.g. on islands with no road and/or land use information available

- *Start editing* the access point shapefile, CREATEfour new points describing a bounding box around the whole area the evacuation modeling shall include, *save edits* and *stop editing*
- Open attribute table of access point shapefile, *add field* (named e.g. ‘ID’, type: integer), use *field calculator* to populate the new field with consecutive numbers starting with 1 (e.g. by typing *[FID]+1* in the box)
- **Output**: complemented hazard zone shapefile, access point shapefile

Pilot areas

The derivation of horizontal evacuation target points is for pilot areas the same as described for sub-national above.

The identification of buildings which are suitable for vertical evacuation is described in chapter 3.1. Each vertical evacuation target point should be placed at the location of the building’s known or presumed entrance and close to the nearest road. For the local level analysis, both the horizontal and vertical evacuation target point shapefiles have to be merged to one single shapefile, again including four points describing a bounding box and a field (‘ID’) populated with consecutive numbers starting with 1.

3.5.1.3 Inverse speed

The inverse speed raster is needed as input for the cost allocation tool which finally calculates the evacuation time. The inverse speed is the result of the combination of an average evacuation speed per raster cell and a cost value per cell. The cost value describes the speed conservation, i.e. the percentage the average evacuation speed is reduced due to outside influences like slope or condition of the surface. The preparation of the inverse speed raster is similar for both sub-national and local level.

The authors made the experience that administrative boundaries as well as the coastline can vary quite a lot depending from which organisation or institution they are released. To avoid that the evacuation modeling results only fit to one coastline file, all raster data used are artificially expanded seawards by 300 m. This assures that the modeling results are without gaps whatever coastline is chosen for visualization.

(1) Evacuation speed

Evacuation speed is calculated as a function of population density and spatial age and gender distribution.

a) Population dependent evacuation speeds

In this research, it was assumed that the population density influences the evacuation speed significantly as moving alone will be much faster than moving in a crowd. Studies about average evacuation walking speed show values in the range of 0.7 to 1.5 m/s (Klüpfel 2003, Teknomo 2002, Kawamura 1991, Pan 2006, Toyosawa 2002). The used speed values are listed in Table 16.

Table 16: Used average evacuation speed values according to population density

population density [per ha]	speed [m/s]
0 – 10	2.0
10 – 50	1.2
> 50	0.7

b) Demography dependent evacuation speeds

Additionally, a second speed parameter was used based on social and demographic factors like age and gender. According to Thompson et al. (2003) average walking speeds are different according to age and gender in the productive age, whereby gender does not make a difference for children and elderly. The data source for the calculation is the Indonesian BPS-Census 2000.

Definition of age groups

As a basis for estimating evacuation speeds for different age and gender groups it is necessary to define the age cut-off values for each age group, defined along drastic changes in walking speed capability.

- The cut-off value to differentiate between “adults” and “elderly” has been set at an age of 62 years following the findings of research conducted on age related speeds of walking: “The eldest group (63 yr and older) had a significantly slower speed of walking and smaller step length than the younger groups (19 to 39 and 40 to 62 yr) for all paces” (J. E. HIMANN, D. A. CUNNINGHAM, P. A. RECHNITZER, and DONALD H. PATERSON. Age-related changes in speed of walking. Med. Sci. Sports Exerc., Vol. 20, No. 2, pp. 161-166, 1988.)
- The cut-off value to differentiate between “children” and “adults” has been set at an age of 14 years following the dependency ratio classification. Empirical evidence was not found to determine age values at which speeds are changing drastically.

Table 4: Age group definition according to changes in running speed values

	Age group
Adult male	15 – 62 years
Adult female	15 – 62 years
Child	<= 14
Elderly	> =63 years

Calculating evacuation speed values according to gender and age

“Average running” is a speed value calculated and used for the assessment. It is the mean of “maximum running” and “average walking speed” for gender-differentiated age groups (Table 17).

Table 17: Age and gender differentiated running and walking speeds Thompson et al. (2003)

Population type	Average Walking	Maximum running	Average running
Adult male (15 – 62 years)	1,35 m / s	4,27 m / s	2,81 m / s
Adult female (15 – 62 years)	1,15 m / s	4,27 m / s	2,71 m / s
Child (<= 14 years)	0,90 m / s	3,40 m / s	2,15 m / s
Elderly (> =63 years)	0,80 m / s	2,74 m / s	1,77 m / s

The literature studied does not provide a further differentiation between „average walking“ and „maximum running“. Variance and std. deviation are highest for the “maximum running” variable, although there is no gender differentiation for the values. Thus, using this variable does not make much sense, if a gender differentiation is desirable.

Using „average running“ fits more the purpose of the assessment, due to the fact that people hurry during evacuation procedures. Therefore, the “average running” speed variable is the best fitting variable for calculating evacuation speeds: The different villages show sufficient variance and the speed estimations are more realistic for an outdoor evacuation case. The only downer of the medium running speed values is the fact that the gender speed differences are smaller than in the respective average walking speed values.

Calculating the demography dependent average evacuation speeds at the village level

1. Calculation of 4 gender differentiated age groups

a. <= 14 years (total)
b. 15 – 62 years (female)
c. 15 – 62 years (male)
d. > =63 years (total)

2. Assigning different speeds (walking speed, medium running speed, max running speed) to the different groups. Then calculate the medium running speed, which is the mean of walking and maximum running speed.

3. Calculation of the average speed per desa according to the following formula:
Average speed per desa =
SUM of
Number of children (female and male) per desa x speed (cm/ s) **+**
Number of adult males per desa x speed (cm/s) **+**
Number of adult females per desa x speed (cm / s) **+**
Number of elderly (female and male) **+**
DIVIDED BY
Number of total population per desa

SPSS-Syntax for calculating the speeds for different age groups:

```
AGGREGATE
/OUTFILE=*
MODE=ADDVARIABLES
/BREAK=kddes2
/p05b_flt = FLT(p05b '15').
AGGREGATE
/OUTFILE=*
MODE=ADDVARIABLES
/BREAK=kddes2
/p05b_fgt = FGT(p05b '62').
AGGREGATE
/OUTFILE=* MODE=ADDVARIABLES
/BREAK=kddes2
/p05b_fin = FIN(p05b '14,999' '62').
USE ALL.
COMPUTE filter_$=(p03 = "1").
VARIABLE LABEL filter_$ 'p03 = "1" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
AGGREGATE
/OUTFILE=* MODE=ADDVARIABLES
/BREAK=kddes2
/p05b_fin_gender_1=FIN(p05b '14,999' '62').
USE ALL.
COMPUTE filter_$=(p03 = "2").
VARIABLE LABEL filter_$ 'p03 = "2" (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMAT filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
AGGREGATE
/OUTFILE=* MODE=ADDVARIABLES
/BREAK=kddes2
/p05b_fin_gender_2=FIN(p05b '14,999' '62').
FILTER OFF.
USE ALL.
EXECUTE.
AGGREGATE
/OUTFILE='/Users/niklasgebert/Desktop/census 2000/sp51_output.sav'
/BREAK=kddes2
/p05b_flt_sum=SUM(p05b_flt)
/p05b_fgt_sum=SUM(p05b_fgt)
/p05b_fin_sum=SUM(p05b_fin)
/p05b_fin_gender_1_sum=SUM(p05b_fin_gender_1)
/p05b_fin_gender_2_sum=SUM(p05b_fin_gender_2)
/N_BREAK=N.
mergen der spxx_output.sav
COMPUTE running_speed=(p05b_flt_sum * 3.4 + p05b_fgt_sum * 2.74 +
p05b_fin_gender_1_sum *
4.27 +
```

```
p05b_fin_gender_2_sum * 4.27) / (p05b_flt_sum + p05b_fgt_sum + p05b_fin_gender_1_sum
+
p05b_fin_gender_2_sum).
EXECUTE.
COMPUTE walking_speed=(p05b_flt_sum * 0.9 + p05b_fgt_sum * 0.8 +
p05b_fin_gender_1_sum *
1.35 +
p05b_fin_gender_2_sum * 1.15) / (p05b_flt_sum + p05b_fgt_sum + p05b_fin_gender_1_sum
+
p05b_fin_gender_2_sum).
EXECUTE.
COMPUTE medium_running_speed=(p05b_flt_sum * 2.15 + p05b_fgt_sum * 1.77 +
p05b_fin_gender_1_sum * 2.81 +
p05b_fin_gender_2_sum * 2.71) / (p05b_flt_sum + p05b_fgt_sum + p05b_fin_gender_1_sum
+
p05b_fin_gender_2_sum).
EXECUTE.
```

Both speed values are combined for each cell; the respective processing steps are as follows:

- **Input**: 1) population density shapefile
  2) socio-demographic speed shapefile
- Make sure that all input files have a projected coordinate system assigned
- Open attribute table of population density shapefile and *add fields* 'speed' (type: float) and 'rc_speed' (type: long integer)
- Use *field calculator* on the newly created field 'speed', *load* the calculation file *reclass_popdens.cal*, check field names and values in the expression and click ok
- Use *field calculator* on the newly created field 'rc_speed', type *[speed]*100* in the expression box and click ok
- *Convert* population density shapefile to raster (value field: rc_speed; cell size: 30 m for sub-national or 1 m for local level)
- *Expand* raster (number of cells: 10 for sub-national or 300 for pilot areas; zone values: all unique values present in the field 'rc_speed')
- Open attribute table of socio-demographic speed shapefile and *add field* 'rc_speed' (type: long integer)
- Use *field calculator* on the newly created field 'rc_speed', type *[walking_sp]*100* (check field name!) in the expression box and click ok
- *Convert* socio-demographic speed shapefile to raster (value field: rc_speed; cell size: 30 m for sub-national or 1 m for local level)
- *Expand* raster (number of cells: 10 for sub-national or 300 for local level; zone values: all unique values present in the field 'rc_speed')

- **Output**: population density speed raster and socio-demographic speed raster (both: integer; cell size 30 m for sub-national or 1 m for local level) with speed values in m/s multiplied by 100

Costs

Each grid cell has now assigned a certain evacuation speed based on population density, age and gender distribution. This speed might be reduced due to physical settings of each cell like the kind of land use, slope and the presence of critical facilities.

Reclassification of land use, slope and critical facility density is a basic step of the analyses. Each class of each dataset got a new value, describing the capability to conserve the speed of a walking person. The new values represent then how much the average evacuation speed will be reduced on different land use types, at different slopes or at the presence of critical facilities. Based on a value of 100 (100% speed conservation), for example, a value of 80 means that the speed will be reduced by 20%.

There are land uses or slopes which are totally or almost impassable (e.g. water bodies, mangroves or very steep slopes). Nevertheless, for further analyses all classes have to be retained, therefore relatively inaccessible classes are reclassified to very small values like 1 or 5, good evacuation routes like roads receive the value 100.

Slope

The processing steps to prepare the slope costs raster are as follows:

- **Input**: digital elevation model
- Make sure that all input files have a projected coordinate system assigned
- *Filter* DEM (filter type: low) or use *focal statistics* (statistics type: mean, neighborhood settings depend on pixel size and mapping scale). May not be necessary in case of DTM
- CREATE*slope* (output measurement: equally usable)
- *Reclassify* slope raster according to classes in Table 18
- *Expand* reclassified raster (number of cells: 10 for sub-national or 60 for local level; zone values: all unique cost values)
- **Output**: expanded slope cost raster (integer; cell size 30 m for sub-national or 1 m for local level)

Table 18: Cost values for slope classes

Slope [degree]	Slope [%]	costs
0	0	100
0 - 5	0 – 8.75	94
5 - 15	8.75 – 26.8	88
15 - 30	26.8 – 57.75	73
30 - 45	57.75 – 100	46
> 45	>100	20

Critical facilities

The presence of facilities like hospitals or primary schools may also influence the evacuation speed insofar as around such facilities there is a large amount of people present who potentially need more assistance for evacuation as the average population (sick persons, children) and thus slow down the evacuation process in general. There are studies which examine the evacuation speed of elderly people, children or hospital staff pushing wheelchairs (Johnson 2006, Sugimoto 2003, Pan 2006, Klüpfel 2003) with the result that those people in general move slower than 'normal' people. But there is also a study (Klüpfel 2003) which finds out that pupils evacuate faster (in average 3.2 m/s) than the average population (in average 1.2 m/s). Referring to those studies, only hospitals were taken into account by using a buffer of 100 m around each hospital with a cost value of 50 and only for the local level as information about the location of hospitals is not available for the whole coast of Sumatra, Java and Bali; thus, for sub-national level critical facilities are not considered.

The following steps are needed to prepare the respective raster:

- **Input**: 1) hospital point shapefile
  2) bounding box polygon shapefile
- Make sure that all input files have a projected coordinate system assigned
- *Buffer* hospital point shapefile 100 m
- Open attribute table of the buffered hospital shapefile, *add field* 'costs' (type: long integer), use *field calculator* and type *50* in the expression box and click ok
- Open attribute table of the bounding box shapefile, *add field* 'costs' (type: long integer), use *field calculator*, type *100* in the expression box and click ok
- *Update* bounding box shapefile (input feature) with buffered hospital shapefile (update feature) (Borders: checked)
- *Convert* to raster (value field: costs; cell size: 30 m for sub-national or 1 m for local level)
- **Output**: hospital costs raster (integer; cell size 30 m for sub-national or 1 m for local level)

Remark: If the bounding box shapefile is large enough it is usually not necessary to expand the cost raster as the critical areas near the coastline will then be included anyway.

Land use

Due to the fact that not every class of land use is a passable one, like water bodies or mangroves, a suitable filter had to be set. For further analyses all classes had to be retained, therefore relatively inaccessible classes got the value 1 or 5, good evacuation routes like roads receive the value 100 (see

Table 20).

The following steps are needed to prepare the land use cost raster:

- **Input**: 1) road network shapefile
- 2) land use shapefile
- 3) bounding box polygon shapefile
- Make sure that all input files have a projected coordinate system assigned
- Open attribute table of road network shapefile and add field 'buffer' (type. float)
- Use *field calculator* on the newly created field according to one of the following conditions:
  - If the road network shapefile contains information about road types and widths, the field 'buffer' should be populated according to Table 19 :
    - → If the road type is defined by 'KODE_UNSUR' *load* the calculation file *streets_bufferwidth.cal*, check field names and values in the expression and click ok
    - → If the road type is defined otherwise CREATEan expression similar to the one in the calculation file *streets_bufferwidth.cal* and according to the values listed in Table 19 and click ok
  - If there is no information about road types and widths available use an assumed average road width, type 3 in the expression box and click ok
- *Buffer* road network shapefile (distance: field 'buffer'; side type: full; dissolve type: list; dissolve field: kode_unsur or other field differentiating road types)
- Open attribute table of buffered road shapefile and *add field* 'costs' (type: long integer)
- Use *field calculator* on 'costs' according to one of the following conditions:
  - If the road type is defined by 'KODE_UNSUR' *load* the calculation file *reclass_streets.cal*, check field names and values in the expression and click ok

- If the road type is defined otherwise CREATEan expression similar to the one in the calculation file *reclass_streets.cal* and according to the values listed in
-
- Table 20 and click ok
- If there is no information about the road type, type *90* in the expression box and click ok

- Open attribute table of the bounding box shapefile, *add field* ‘costs’ (type: long integer), use *field calculator* on ‘costs’, type *0* in the expression box and click ok
- *Update* bounding box shapefile (input feature) with buffered road shapefile (update feature) (Borders: checked)
- *Convert* updated road shapefile to raster (value field: costs; cell assignment type: maximum area; priority field: costs; cell size: 30 m for sub-national or 1 m for local level)
- *Reclassify* road cost raster (NoData to 0; all other values remain)

Remark: The steps including the bounding box shapefile are then necessary if the otherwise generated road raster had a smaller extent than the below described land use raster

- Open attribute table of the land use shapefile, *add field* ‘costs’ (type: long integer), use *field calculator* and *load* the calculation file *reclass_landuse.cal*, check field names and values (according to
-
- Table 20) in the expression and click ok
- *Convert* land use shapefile to raster (value field: costs; cell assignment type: maximum area; priority field: costs; cell size: 30 m for sub-national or 1 m for local level)
- Use spatial analyst tool *Con* (input conditional raster: road cost raster; input true raster: road cost raster; input false raster: land use cost raster; expression: *"Value" <> 0*)
- Expand raster (number of cells: 10 for sub-national or 300 for local level; zone values: all unique cost values)
- **Output**: road cost raster, land use cost raster, combined land use / road cost raster

Table 19: Road types and buffer width

Road type	**KODE_UNSUR**	**Buffer width [m] (each side of line)**
Double path highway	20102, 20104	7.5
Major road	20110, 20112	4.5
Minor road	20114	3
Other road	20116	2.25

Unknown road	0	2.25
Foot path	20120	1.5

Table 20: Cost values for different land use classes

Costs	**Landuse class**	**Landuse_class (indo)**	**Suitable as temporary shelter alrea?**
1	Pond	Tambak	No
1	Canal	Kanal	No
1	Swamp	Rawa	No
1	Lake	Danau	No
1	Mangroves	Mangrove	No
1	River	Sungai	No
1	Water/Sea	Laut	No
5	Settlement from detailed scale landuse data (house-/blockwise)	Bank, Building, Gedung Pertemuan, Hotel, Kampus/Sekolah, Masjid, Masjid/Pura, Pasar, Rumah Sakit, Sekolah,Perkantoran, Pertokoan	No
5	Industry Building	Industri	No
5	Sport Field (Tennis field)	Lapangan Olah Raga (tutup)	Yes
5	Airport	Bandara	No
5	Market building	Pasar	No
40	Dense Vegetation		No
40	Forest	Hutan	No
50	Rice Field	Sawah	No
50	Settlement from sub-national landuse data	Permukiman, Perumahan	No
50	Harbor	Pelabuhan	No
50	Garden	Perkebunan	Yes
50	Shrubs	Shrubs	No
50	Other Vegetation	Vegetasi lain	Yes
50	Bus Terminal	Terminal, Stasiun	No
50	Other	Lain	Yes
60	Agricultural Field		Yes
60	Crops		Yes
60	Plantation	Tegalan	Yes
80	Graveyard, Park5	Makam Pahlawan, Taman	Yes
80	Open Vegetation (medium dense)		Yes

80	Pathway/Footstep Way	Pathway/Footstep Way	No
80	Bridge Pathway/Footstep Way	Bridge Pathway/Footstep Way	No
90	Sand	Pasir	No
90	Beach	Pasir Pantai	No
90	Local Road	Local Road	No
90	Inner-district-road	Inner-district-road	No
90	Other Road	Other Road	No
90	Bridge Local/Other	Bridge Local/Other	No
95	Railways	Kereta Api	No
95	Open Field	Lahan Kosong	Yes
95	Grass	Lapangan Olah Raga (Gras)	Yes
100	Bridge (unknown)	Jembatan	No
100	Bridge Arterial/Collector/Double path highway	Bridge Arterial/Collector/Double path highway	No
100	Arterial Road	Arterial Road	No
100	Collector Road	Collector Road	No
100	Double path highway	Double path highway	No
100	Street node	Perempatan	No
100	Inner-urban-connection	Inner-urban-connection	No

Inverse speed raster

The inverse speed raster is a combination of all the raster data prepared as described above.

The inverse speed raster has to be calculated using the following formula:

$$\frac{1}{\frac{costs\_landuseroads}{100.0} * \frac{costs\_slope}{100.0} * \frac{costs\_hospitals}{100.0} * \left(\frac{\left(\frac{speed_{populationdensity}}{100.0}\right) + \left(\frac{speed_{socio-demographic}}{100.0}\right)}{2} \right)}$$

- Input: 1) complemented hazard zone shapefile
  2) land use / road cost raster
  3) slope cost raster
  4) hospital cost raster
  5) population density speed raster
  6) socio-demographic speed raster
- *Load* land use / road cost raster, slope cost raster, hospital cost raster, population density speed raster and socio-demographic speed raster into ArcMap
- Use *raster calculator*, type the formula in the expression box and click *evaluate*

- *Make* the so generated temporary data set then *permanent* (use *.img as data type)
- *Buffer* complemented hazard zone shapefile 30 m (for sub-national level) or 5 m (for local level)
- Use *Extract by Mask* to clip the inverse speed raster to the hazard zone extent (feature mask data: buffered complemented hazard zone shapefile)
- **Output:** inverse speed raster, clipped inverse speed raster (unit: s/m)

3.5.1.4 Cost allocation tool

The evacuation time map is calculated using the *Cost allocation* tool in ArcGIS on the basis of the inverse speed map and starting from each of the placed shelter points.

- **Input**: 1) clipped inverse speed raster
  2) access point shapefile
- Use *Cost Allocation* (input raster or feature source data: access point shapefile; source field: field with consecutive ID from access point shapefile starting with 1; input cost raster: clipped inverse speed raster; define an output allocation raster and an output distance raster)
- **Output**: cost allocation raster, cost distance raster

The output is first a cost allocation raster which divides the whole area into catchment areas. This means that this raster identifies which cells will be allocated to which access point. Second output is a cost distance raster (evacuation time) which contains the time needed (in seconds) from a cell in the raster to reach the most beneficial access point (which is determined by the catchment areas).

3.5.2 Response time

The human response capability depends on the estimated time of arrival (ETA) of a tsunami at the coast, the time at which technical or natural warning signs (ToNW, determined by Institutional Decision Time IDT and Notification Time INT, see Figure 19) can be received by the population, the reaction time (RT) of the population and the evacuation time (ET). The actual available response time (RsT) is then obtained by:

$RsT = ETA - ToNW - RT$ (1)

with

$ToNW = IDT + INT$ (2)

Human response capability can then be estimated on the basis of the relationship between ET and RsT. For RsT>ET people in the respective areas are able to rescue themselves by reaching a safe area. Critical areas possess RsT<=ET values because people within these areas will be directly impacted by a tsunami.

As previously mentioned the human response capability is determined by social vulnerability factors which play a role in constituting the reaction time (RT, see Figure 19). Human reaction time to a tsunami warning depends mainly on warning dissemination (can the warning be received and is it understood?) and on the response (do people respond by evacuating?). Quantification of these factors needs to consider complex social and psychological settings and processes which consider the sequential process of hearing, understanding, believing, personalizing, confirming and responding to a warning (Sorensen, 2000). Additional challenges lie in describing these processes by relying only on available nationwide statistical data. Birkmann et al. (2009) describe which social parameters represent these process factors and the statistical proxies derived to describe social vulnerability in the warning context. Human response capability depends largely on the extent of the potential tsunami impact on land. This is required to describe the evacuation area or the credible emergency planning zone (EPZ, Cova and Church, 1997). The credible EPZ determines the questions of ‘who needs to evacuate and needs special attention’, and “where people need to be routed to reach safety”. Distribution of warning dissemination devices (e.g. sirens) within the EPZ and institutional settings in disaster management (e.g. availability of standard operational procedures related to warning response/evacuation behaviour) drive the determination of the “Institutional Notification Time (INT)”. Finally the response time (RT, see Figure 19) has to be quantified and accordingly the response capability.

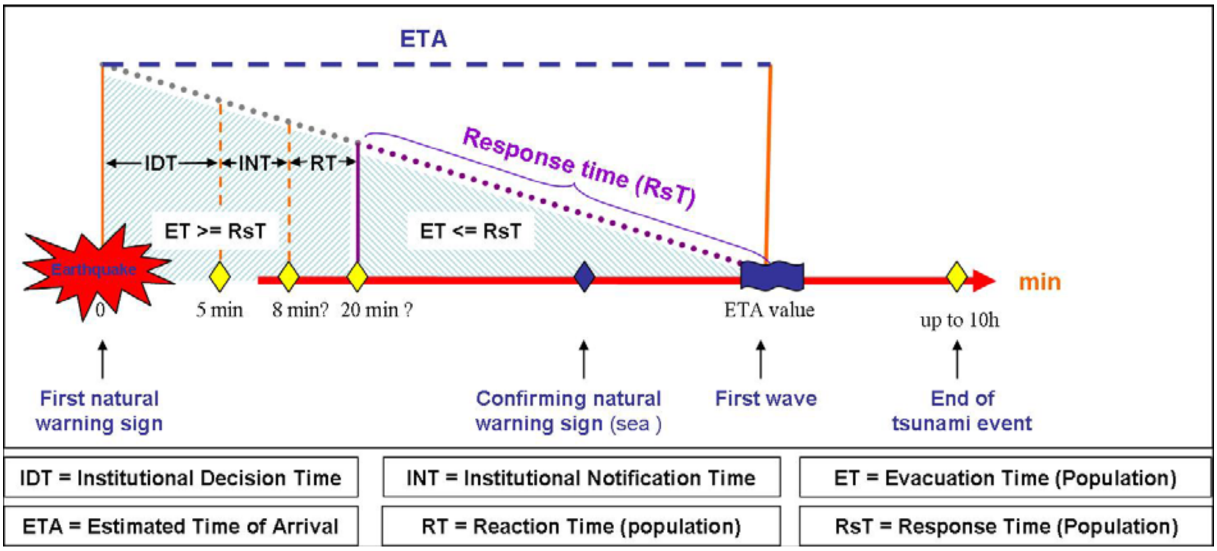


Figure 19: Different times between a tsunamigenic earthquake and the arrival of the tsunami wave on land

IDT is assumed to meet the presidential decree of 5 minutes. INT is not taken into account as it is very difficult to quantify and may also change from case to case. Regarding RT, UNU-EHS has performed a set of analyses based on demographic, social and economic data and surveys. This component is very complex and timely varying and was therefore not taken into account for the work at hand. For results please refer to chapter 3.4. ET is the output from the cost allocation tool (see chapter 3.4.1.4).

The determination of ETA is slightly different for sub-national and local level as follows:

From the tsunami propagation modeling, the estimated time of arrival can be derived for any point at coast. To integrate the arrival times of the various single scenarios, the 1st percentile is taken as threshold for the minimum ETA. For the sub-national analysis, the minimum ETA is aggregated per warning segment (see chapter 2.2), each warning segment is hence related to one ETA. For the local level, the ETA turned out to not change within those small areas. Only for Kuta, the ETA varied between the west and the east coast; here, the minimum value was taken. Table 21 gives an overview of the used ETA values for the local level and the minimum and maximum ETA value occurring among the 112 warning segments.

Table 21: Minimum ETA values for local level and the two warning segments with the highest and lowest minimum value

Location	Minimum ETA [minutes]
Kuta, Bali (east coast)	20
Cilacap, Java	50
Padang, Sumatra	30
Lampung, Sumatra	21
Sumut (Nias)	142

3.5.3 Evacuable areas

To identify areas in the hazard zone which can be evacuated within a certain time frame (evacuable areas) it is necessary to consider two possible constraints:

The first constraint is of course the time which is available to reach a shelter area (response time). Only when the time needed to reach a shelter place (evacuation time) is shorter than or equal to the response time, the evacuation is successful. The response time is calculated as described in chapter 3.4.2.

The second constraint may be the capacity of a shelter area. This especially applies to evacuation buildings as buildings can only hold a certain amount of evacuees. Thus, it is possible that evacuees would be able to reach an evacuation building in time but that this building is already crowded. For evacuation planning, it is of great importance to know about each evacuation building's capacity and to identify the evacuable area covered by each building. To be able to evacuate successfully it is hence necessary to meet both constraints.

In the frame of GITEWS, it was assumed that horizontal shelter areas have unlimited capacity and only evacuation buildings have capacity constraints. As the sub-national analysis only considers horizontal evacuation possibilities this constraint is only relevant in local level.

The size of the evacuable areas, especially of those connected to horizontal evacuation target points, is naturally highly dependent on the response time.

The calculation of evacuable areas was conducted for the local level (raster cell size: 1 m) on the whole while for sub-national level the processing steps for evacuation buildings are omitted.

- **Input**: 1) access point shapefile
  2) cost allocation raster
  3) cost distance raster
  4) population density raster (population per m²)
- *Convert* cost allocation raster to polygon (field: value; simplify polygons: unchecked)
- Open attribute table of cost allocation shapefile, *add field* 'ID' (type: long integer), use *field calculator* on 'ID', insert the field defining the access point ID (probably GRIDCODE) in the expression box and click ok
- *Reclassify* cost distance raster with classes of a designated interval (e.g. 60 seconds) to consecutive values starting with 1 (e.g. seconds 1-60 = 1, 61-120 = 2, 121-180 = 3, etc.)
- *Convert* reclassified cost distance raster to polygon (field: reclass value; simplify polygons: unchecked)
- Open attribute table of cost distance shapefile, *add field* 'time_step' (type: long integer), use *field calculator* on 'time_step', insert the field defining the reclass value (probably GRIDCODE) in the expression box and click ok
- Use *Identity* (input feature: cost distance shapefile; identity feature: cost allocation shapefile)
- *Dissolve* this identity shapefile (dissolve fields: 'ID' and 'time_step'; CREATEmultipart features: checked)
- Open attribute table of dissolved shapefile, *add field* 'ID_new' (type: text), use *field calculator* on 'ID_new', type *[ID]&"_"&[time_step]* in the expression box and click ok
- Use *Zonal Statistics as Table* (feature zone data: dissolved shapefile; zone field: ID_new; input value raster: population density raster)

Remark: This step provides the information about how many people are within each polygon defined by shelter ID and time step (attribute field 'SUM'), and hence the information for checking the capacity constraint

- *Join* zonal statistics output table to dissolved shapefile (join fields: ID_new)
- *Export data* to new shapefile to make join permanent
- To identify areas evacuable by vertical evacuation, *select* for each vertical shelter individually those time step polygons whose sum of the attribute field 'SUM' is less than or maximal equal to the building's capacity. To calculate the sum of the selected polygons right-click the field name 'SUM' and choose *Statistics*). If the sum exceeds the capacity, revise the selection of polygons.
- *Export* selected features to new shapefile
- Repeat the previous two steps for all vertical evacuation shelters

- Optional: Generalize all exported shapefiles by removing 'donut holes' and by generalizing the out shape of the polygon. This might be necessary for evacuation planning purposes where the determination of a building's catchment area is usually geared to e.g. street courses or blocks of houses. Attention: A generalization process may lead to an "overcrowding" of the building! Therefor, it is recommended to first select less time step polygons, generalize them, recalculate zonal statistics with the generalized shapefile as feature zone data, check the sum and add more time step polygons if there is still capacity available.
- If there is one or more buildings which, after this procedure, still have capacity left but covered already their whole catchment area ("no people left"), then the following steps have to be performed (otherwise go on with horizontal evacuation points):

  - Make a copy of the access point shapefile and delete all vertical evacuation building points except from those buildings which had capacity left after the first pass

  - Use *Cost Allocation* with this reduced access point shapefile (input raster or feature source field: field with ID from reduced access point shapefile; input cost raster: clipped inverse speed raster; define an output allocation raster and an output distance raster)

  - Redo the steps described above with one additional step to do after dissolving the to avoid double counting of people in overlapping areas of the catchment areas calculated in the second pass with the evacuable areas of adjacent evacuation buildings identified in the first pass, those already defined evacuable areas have to be cut out of the identity shapefile before doing the zonal statistics. *Erase* therefor all evacuable areas from the identity shapefile (input feature: identity shapefile; erase feature: evacuable area shapefiles) before proceeding with the steps described above
- To identify areas evacuable by horizontal evacuation, make a copy of the access point shapefile and delete all vertical target points (only keep horizontal evacuation target points), use *Cost Allocation* with this horizontal access point shapefile (input raster or feature source data: horizontal access point shapefile; source field: field with ID from horizontal access point shapefile; input cost raster: clipped inverse speed raster; define an output allocation raster and an output distance raster), *reclassify* the cost distance raster as described above, *convert* it to polygon as described above, use *select by attribute* on this polygon shapefile and CREATEan expression to select those polygons which belong to a time step smaller than or equal to the response time (e.g. *"time_step" <= 25*)
- *Export* selected features to new shapefile
- *Merge* the created evacuable area shapefiles (including those of both horizontal and vertical shelters)
- **Output**: cost allocation shapefile, reclassified cost distance shapefile, merged evacuable area shapefile

3.5.4 Estimation of potential casualties

The estimation of casualties is done for the local level on desa level and for sub-national level on warning segment level. But despite the reference level, the applied method is the same as follows:

- **Input**: 1) population density raster (population per m²)

  2) reference level shapefile (desa, warning segment, etc.)

  3) hazard zone shapefile

  4) merged evacuable area shapefile
- *Clip* reference level shapefile (input features: reference level shapefile; clip features: hazard zone shapefile)
- Use *Zonal Statistics as Table* (feature zone data: clipped reference level shapefile; zone field: e.g. Desa ID; input value raster: population density raster)
- *Join* zonal statistics output table to clipped reference level shapefile (join fields: e.g. Desa ID)
- *Export data* to new shapefile to make join permanent

  → Overall amount of people per reference level inside the hazard zone (exposed people)
- Recommended: Round the exposed people value by using the following procedure:

  - Open attribute table.

  - *Add field* „rd_exposed“

  - Right-click field heading rd_exposed and select Calculate Values.

  - Place a check in the Advanced checkbox on the field calculator.

  - Paste the following code into the Pre-Logic VBA Script Code box.

  ```
  Dim dblRnd as Double
  dblRnd = math.round([Field]/N)*N
  ```

  - Replace [field] with field to be rounded and N with value to round the values to.

  Nearest Ten N = 10

  Nearest Fifty N = 50

  Nearest Hundred N = 100

  - In the final dialog box type "dblRnd" without the quotes.
- *Erase* clipped reference level shapefile and merged evacuable area shapefile (input features: clipped reference level shapefile and merged evacuable area shapefile; output type: input)
- *Dissolve* erased shapefile (input features: erased shapefile; dissolve field: e.g. Desa ID; CREATEmultipart features: checked)
- Use *Zonal Statistics as Table* (feature zone data: dissolved erased shapefile; zone field: same as dissolve field, e.g. Desa ID; input value raster: population density raster)

- *Join* zonal statistics output table to clipped reference level shapefile (join fields: e.g. Desa ID)
- *Export data* to new shapefile to make join permanent

  → Amount of exposed people per reference level who are not able to evacuate within the defined response time (affected people, potential casualties)
- <u>Recommended</u>: Round the affected people value by using the following procedure:

  - Open attribute table.

  - *Add field* „rd_affect“

  - Right-click field heading rd_affect and select Calculate Values.

  - Place a check in the Advanced checkbox on the field calculator.

  - Paste the following code into the Pre-Logic VBA Script Code box.

  ```
  Dim dblRnd as Double
  dblRnd = math.round([Field]/N)*N
  ```

  - Replace [field] with field to be rounded and N with value to round the values to.

  Nearest Ten   N = 10

  Nearest Fifty   N = 50

  Nearest Hundred   N = 100

  - In the final dialog box type "dblRnd" without the quotes.
- <u>Optional:</u>

  - *Intersect* clipped reference level shapefile and merged evacuable area shapefile (input features: clipped reference level shapefile and merged evacuable area shapefile; output type: input)

  - *Dissolve* intersected shapefile (input features: intersected shapefile; dissolve field: e.g. Desa ID; CREATEmultipart features: checked)

  - Use *Zonal Statistics as Table* (feature zone data: dissolved intersected shapefile; zone field: same as dissolve field, e.g. Desa ID; input value raster: population density raster)

  - *Join* zonal statistics output table to clipped reference level shapefile (join fields: e.g. Desa ID)

  - *Export data* to new shapefile to make join permanent

  → Amount of exposed people per reference level who are able to evacuate within the defined response time (evacuable people)
- <u>Recommended</u>: Round the evacuable people value by using the following procedure:

  - Open attribute table.

  - *Add field* „rd_evac“

  - Right-click field heading rd_evac and select Calculate Values.

  - Place a check in the Advanced checkbox on the field calculator.

  - Paste the following code into the Pre-Logic VBA Script Code box.

```
Dim dblRnd as Double
dblRnd = math.round([Field]/N)*N
```

- Replace [field] with field to be rounded and N with value to round the values to.

  Nearest Ten   N = 10

  Nearest Fifty   N = 50

  Nearest Hundred   N = 100

- In the final dialog box type "dblRnd" without the quotes.

- **Output**: two (optional: three) shapefiles with attributes for sum and rounded sum of exposed and affected (optional: evacuable) people, reclassified cost distance shapefile, merged evacuable area shapefile

Remark: Possible inconsistencies or differences in sum of exposed / affected / evacuable people may originate from the rounding. Nevertheless it is highly recommended to round the numbers to at least the nearest Fifty to avoid that a not given accuracy of numbers is pretended.

3.5.5 Evacuation time map products

Evacuation Time Maps are available at two scales: 1:100.000 for the southern and western coasts of Sumatra, Java and Bali (in total 138 map sheets) and 1:25.000 and 1:30.000 respectively for three pilot areas (Padang, Cilacap and Kuta/Bali).

The 100k map series contains the evacuation times classified into 5 classes of 15 minutes time steps (0-15 min evacuation time, 15-30 min, 30-45 min, 45-60 min, > 60 min), temporary shelter areas and ETA values.

The maps for the pilot areas contain basically the same, with slightly different classes of evacuation times in order to best-fit each region. The potential casualties are displayed per desa, and if available, a table listing the evacuation buildings, their names and capacities is included. Evacuation time is classified for Bali in 30 minutes time steps, for Cilacap in 45 minutes steps, and for Padang in 20 minutes steps.

The rgb values of the five classes in the maps are (in ascending order): 250-215-246; 227-161-190; 199-111-138; 173-66-95; 143-17-57.

3.6 Evacuation Capability Index

The evacuation capability index was calculated only for the sub-national scale. The cost distance raster contains the time needed to evacuate from a certain pixel to the nearest access point to a safe area (evacuation time, see chapter 3.5). This evacuation time raster is normalized to the ETA of the tsunami wave aggregated to warning segments (time raster divided by ETA). This classifies the areas into three classes:

areas with values < 1: reaching the shelter locations within the available evacuation time

areas with values = 1: threshold; needed time = available time

areas with values > 1: not reaching the safe spot in time

Normalized values greater than 1 were reclassified to 1.

All areas with a normalized value greater or equal to 0.99 are than classified as “weak evacuation capability”, values between 0.5 and 0.99 as “moderate evacuation capability” and values below 0.5 as “good evacuation capability”.

Areas where none of the available tsunami scenarios affects the coast are classified as “area not affected” and where no scenarios are available or other data are missing are classified as “no data”.

3.6.1 Evacuation capability index map products

The evacuation capability index is included in the evacuation time maps as small complementary map. The index is classified and displayed in three classes (good – moderate – weak evacuation capability with the rgb values 0-168-132, 255-255-115, 255-0-0) as mentioned above.

3.6.2 Evacuation capability index products for early warning

In the Decision Support System in the Tsunami Early Warning Center in Jakarta, evacuation capability information is implemented as maps and as tabular data.

To be displayed as maps, the evacuation capability information has to be prepared in three different scales (as shapefiles) and for both warning and major warning case: detailed scale (1:100k), aggregation to desa level (1:1M) and aggregation to warning segment level (1:3M).

The map visible in the DSS contains five classes: weak – moderate – good evacuation capability – area not affected – no data.

For the aggregation to warning segments and desas the following steps have to be performed:

- multiply the evacuation capability raster with 10000, convert to integer and in case of using an ESRI grid build value attribute table (e.g. in raster calculater type: *buildvat [rastername]*)
- **Remark:** This step should be done in order to reduce the file size and shorten computing times.

  - calculate zonal statistics as table with warning segment (desa) shapefile as zones

  - join to warning segment (desa) shapefile

  - add field ‘median_res’

- copy median values of joined table to the field ‘median_res’

- remove join

- classify into five classes (weak – moderate – good evacuation capability – area not affected – no data) as described above

- re-project result to geographic coordinate system WGS84

- For the detailed level it is just necessary to perform the following three steps:

  - convert raster to polygon

  - classify into five classes (weak – moderate – good evacuation capability – area not affected – no data) as described above

  - dissolve

  - re-project result to geographic coordinate system WGS84

The tabular data of evacuation capability contains the total number of exposed people in a warning segment depending on the currently announced warning level for each segment. As the level of evacuation capability was calculated during the preparation of the map layer aggregated to warning segments (see above) it is only necessary to perform three steps:

- join the result file from warning segment aggregation to the key number shapefile (joining field is warning segment ID)
- copy the value of the field containing the classes to the corresponding field (RI_WL2 for warning and RI_WL3 for major warning)
- remove join

4 Risk Assessment

The risk assessment is the final step in order to accomplish hazard and vulnerability assessments.

4.1 Risk assessment on local level

The risk analysis to is based on a GIS approach. To deal with the continuous hazard probabilities, the flux velocity and the population density, each of these data was classified as shown in Table 22 and Table 23.

Table 22: Flux classes and stability of persons and buildings

Flux (m²/s)	Effect on persons	Effect on buildings
< 1	stable	stable
1-7	unstable	possibly partial damage
> 7	unstable	destruction

Sources: Jonkman and Vrijling 2008, RESCDAM 2000, CDIT 2009)

Table 23: Classification of risk assessment input data

Parameter	Value range	Class
Hazard probability	0 – 1% of probability range	Low probability
	1 – 10% of probability range	Medium probability
	10 – 100% of probability range	High probability
Hazard intensity	< 1 m²/s	Low intensity
	1 – 7 m²/s	Medium intensity
	> 7 m²/s	High intensity
Population density	< 100 persons/km²	Low density
	100 – 2500 persons/km²	Medium density
	> 2500 persons/km²	High density
Evacuation capability	ET[1] > AT[2]	Weak evacuation capability
	ET[1] ≤ AT[2]	Good evacuation capability

[1] Evacuation time

[2] Time available for evacuation

The procedure to calculate the risk is as follows:

- **Input**: 1) merged evacuable areas shapefile
  2) hazard probability raster
  3) flux velocity shapefile or raster
  4) population density shapefile
- *Reclassify* the hazard probability raster according to the classes indicated in **Fehler! Verweisquelle konnte nicht gefunden werden.** (low haz prob = 1; moderate = 2; high = 3). Make sure that the raster output cell size is 1 m.
- In case of a flux velocity shapefile: *add field* 'fluxclass', use *field calculator* and populate field with values 1, 2 or 3 according to Table 23 (< 1 m²/s = 1; 1-7 m²/s = 2; > 7 m²/s = 3). Convert *feature to raster* (field: fluxclass; output cell size: 1)
- In case of a flux velocity raster: *reclassify* raster according to Table 23 (< 1 m²/s = 1; 1-7 m²/s = 2; > 7 m²/s = 3)
- *Add field* 'popclass' to population density shapefile, use *field calculator* and populate field with values 1, 2 or 3 according to Table 23 (low density = 1; medium density = 2; high density = 3), convert *feature to raster* (field: popclass; output cell size: 1)
- *Add field* 'response' to evacuable areas shapefile, use *field calculator* and populate field with values 1 (good = evacuable) or 2 (weak = not evacuable), convert *feature to raster* (field: response; output cell size: 1)
- *Combine* reclassified rasters (input rasters: reclassified hazard probability raster, reclassified flux velocity raster, reclassified population density raster, reclassified response raster)

Remark: The output raster contains then three fields (named like the input rasters) with the respective input values and a field 'value' with consecutive numbers, one for each combination of values of the input rasters.

- *Add field* 'risk' to the combined raster's attribute table and populate the field according to Table 24 (using *field calculator*).
- **Output:** risk raster

For the three study areas Padang (Sumatra), Cilacap (Java) and Kuta (Bali), detailed tsunami modeling results were provided by GKSS / DHI-WASY with a spatial resolution of 25 m. Table 25 gives an overview of the detailed tsunami scenarios. In total, for Padang 90 scenarios, for Kuta 137 scenarios and for Cilacap 300 scenarios with moment magnitudes of 8.0, 8.5 and 9.0 were available.

While for all pilot areas, hazard probabilities could be calculated on basis of the provided scenarios, the flux velocity values were only used for Kuta and Padang. This is caused by the fact that the detailed modeling for Cilacap does not cover the whole examined study area but only about a quarter of it. For the remaining area, the sub-national tsunami modeling provided by AWI with a spatial resolution between 100 and 500 m was used. For this coarse modeling, flux velocity is not available; thus, the flux velocity was also not considered for the small area where it is available by the detailed modeling. In consequence, the risk analysis for Cilacap was performed slightly different than for Kuta and Padang by omitting the flux raster.

Table 24: Classification of the risk layer (local level)

hazprob	flux	popdens	response	Degree of risk	Generalized for map
1 / 2 / 3	1 / 2 / 3	1 / 2 / 3	1	1	very low
1 / 2 / 3	1	1 / 2 / 3	1 / 2	2	very low
1 / 2 / 3	1 / 2 / 3	1	2	3	very low
1	2	2	2	4	low
1	2	3	2	5	low
1	3	2	2	6	low
1	3	3	2	7	low
2	2	2	2	8	moderate
2	2	3	2	9	moderate
3	2	2	2	10	moderate - high
3	2	3	2	11	moderate - high
2	3	2	2	12	high
2	3	3	2	13	high
3	3	2	2	14	very high
3	3	3	2	15	very high

Table 25: Overview tsunami modeling for local level

Pilot area	Number of scenarios	Probability range	Spatial resolution	Flux velocity available?
Cilacap	300	0.03‰ – 7%	25 m	no
Kuta	137	0.01‰ – 7‰	25 m	yes
Padang	90	0.5‰ – 13%	25 m	yes

4.2 Risk assessment on sub-national level

Three raster layers (hazard probability, evacuation capability index and population exposure) serve as input data for the calculation of the overall risk. All raster layers have a pixel size of 50 m and a value range from 1 to 3.

Currently, all layers are treated equally, i.e. no weighting factors are applied.

The procedure to calculate the risk is as follows:

- **Input**: 1) evacuation capability index raster
  2) hazard probability raster
  3) population exposure shapefile
- *Reclassify* the hazard probability raster:low haz prob (< 0.25‰) = 1; moderate (0.25‰ - 2‰) = 2; high (> 2‰) = 3). Make sure that the raster output cell size is 50 m.
- *Add field* 'popclass' to population exposure shapefile, use *field calculator* and populate field with values 1, 2 or 3 according to chapter 3.2.1.3 (low density = 1; medium density = 2; high density = 3), convert *feature to raster* (field: popclass; output cell size: 50)
- *Classify* evacuation capability index raster (1 = good evacuation capability; 2 = moderate evacuation capability; 3 = weak evacuation capability)
- *Combine* reclassified rasters (input rasters: reclassified hazard probability raster, reclassified evacuation capability index raster, reclassified population density raster)

Remark: The output raster contains then three fields (named like the input rasters) with the respective input values and a field 'value' with consecutive numbers, one for each combination of values of the input rasters.

- *Add field* 'risk' to the combined raster's attribute table and populate the field according to Table 26 (using *field calculator*).
- **Output:** risk raster

Table 26: Classification of the risk layer (sub-national level)

response	hazprob	popdens	Degree of risk	Generalized for map
1	1 / 2 / 3	1 / 2 / 3	1	low
2 / 3	1	1 / 2 / 3	2	low
2	2	1	3	low
2	3	1	4	low
2	2	2	5	low
2	3	2	6	low
2	2	3	7	moderate
2	3	3	8	moderate
3	2	1	9	moderate
3	3	1	10	moderate
3	2	2	11	moderate
3	2	3	13	moderate
3	3	2	12	high
3	3	3	14	high

4.3 Risk map products

For the 100k map series, the risk layer was classified into three classes: low risk, moderate risk and high risk (see Table 26; rgb values: 0-168-132, 255-255-115, 255-0-0). For the detailed maps in the pilot areas, the risk is displayed in six classes, ranging from very low to very high risk (see Table 24, rgb values: 56-140-0, 180-220-0, 255-255-0, 255-170-0, 255-80-0, 240-0-0).

4.4 Risk products for early warning

In the Decision Support System in the Tsunami Early Warning Center in Jakarta risk information is implemented as maps and as tabular data.

To be displayed as maps, the risk information has to be prepared in three different scales (as shapefiles) and for both warning and major warning case: detailed scale (1:100k), aggregation to desa level (1:1M) and aggregation to warning segment level (1:3M).

For the detailed level it is just necessary to perform the following three steps:

- convert risk raster (output from chapter 4.2) to polygon
- classify into three classes (low – moderate – high risk) according to Table 26
- dissolve if applicable
- re-project result to geographic coordinate system WGS84

For the aggregation to warning segments and desas the following steps have to be performed:

- calculate zonal statistics as table of risk raster with warning segment (desa) shapefile as zones
- join to warning segment (desa) shapefile
- add field ‘medianrisk’ (integer) and copy median values of joined table to this field
- remove join
- add field ‘risk’ (string) and classify field ‘medianrisk’ into four classes (low – moderate – high – no risk – not data) as described above

The tabular data of risk contains the degree of risk in a warning segment depending on the currently announced warning level for each segment. As the degree of risk was calculated during the preparation of the map layer aggregated to warning segments (see above) it is only necessary to perform three steps:

- join the aggregated risk layer to the key number shapefile (joining field is warning segment ID)
- copy the value of the field ‘risk’ to the corresponding field (risk_WL2 for warning and risk_WL3 for major warning)
- remove join