Current Status of Flood Hazard Analysis in Turkey

Istanbul Technical University
Department of Civil Engineering
Division of Hydraulics (ITU)

In collaboration with
Bogazici University
Kandilli Observatory and Earthquake Research Institute (KOERI)
<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>What is lacking</th>
<th>Reasons/Drawbacks</th>
<th>SciNetNatHaz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods</td>
<td>Systematic <strong>Flash Flood Hazard</strong> assessment on a local scale in order to design preventive measures.</td>
<td>Multitude of methodologies, lack of reliable, accurate and harmonized data.</td>
<td>Harmonization of Methodologies, freely accessible GIS platform with PRODUCED by the Project Data &amp; Results, Metadata according to INSPIRE provisions.</td>
</tr>
<tr>
<td>Cross Border cooperation.</td>
<td>Lack of Political will, lack of public awareness.</td>
<td>Raising public awareness, provide assistance to Decision Makers</td>
<td></td>
</tr>
</tbody>
</table>
**Activity 8:**

Evaluation of existing flood hazard assessment models in terms of scientific soundness, data demands and result credibility.

Flood hazard assessment models used in different partners countries, will be tested / confronted to flood events recorded. Their effectiveness will be evaluated according to successful assessment of floods in close relation with the nature of data needed to be used as input, or with the difficulty/cost to obtain them.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LP will be responsible for synthesis of all partners deliverables and evaluation of the most successful and efficient models</td>
<td></td>
</tr>
<tr>
<td>IPA: evaluation of models used in Turkey, with local data</td>
<td></td>
</tr>
<tr>
<td>P3: evaluation of models used in Bulgaria, with local data</td>
<td></td>
</tr>
<tr>
<td>P4: evaluation of models used in Romania, with local data</td>
<td></td>
</tr>
<tr>
<td>P5: evaluation of models used in Moldova, with local data</td>
<td></td>
</tr>
<tr>
<td>P6: evaluation of models used in Ukraine, with local data</td>
<td></td>
</tr>
</tbody>
</table>

**Activity 12:**

Development/modification/adaptation of existing flood models that will be used to assess flood hazard, based on local conditions and needs of the proposal. Flood hazard will be examined at a regional scale on the areas proposed for implementation.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LP will be responsible for the assessment of flood hazard models to be used in a regional scale. Partners IPA beneficiary, P3, P4, P5 and P6 will work in parallel with the LP, in order to define models’ sensitivity regarding input data, and they will provide relevant data, if needed.</td>
<td></td>
</tr>
</tbody>
</table>
FLOOD HAZARD ASSESSMENT METHODS

Statistical/Conceptual Tools
- Flood frequency analyses
- Historical flood maps

Basin Based Models (SWAT, WEAP, ...)
- Hydrologic Models (HEC-HMS, ...)
- Basin Management Models (MIKE-BASIN, ...)

River Flow Network Based Models (MIKE11, HEC-RAS, ...)
- 1D Models
- Quasi 2D Models (1D + inundation)

Spatial Flow Models (TUFLOW, RMA-4, SMS, MIKE21, POM, Aquadyn, ...)
- 2D Models

Other Models (3D models such as Telemac, Delft 3, MIKE 3D, ...)

Regional Scale Model (preliminary screening)

- Must be morphology based
- Must be generic
- Must demand affordable data
- Must be easy to implement
- Must be GIS based (e.g. Stream Power, TWI,...)
Meteorological Data Input

Hydrologic (Basin) Model:
- Infiltration
- Evaporation
- Surface storage
- Runoff

Hydraulic (Flow) Model:
- 1D-2D Flow
- Flow velocities
- Water levels

Topographical Data Input

Inundation Output
- Flooded area
- Urbanization/settlement
- Transportation facilities
- Industrial facilities
- Agricultural facilities
FLOOD HAZARD ASSESSMENT PRACTICES IN TURKEY
250 of 1478 river flow measurement stations are able to make real time data connection (using modem)

GIS based inventory of flood events is available (for floods since 1955)
FLOOD STRATEGY ACTION PLAN OF STATE HYDRAULIC WORKS
PREPARING FLOOD HAZARD MAPS

1. Hydrological Modelling
2. Obtaining maps
3. Hydraulic Modelling
The revised ‘hazard rating’ expression based, primarily, on consideration to the direct risks of people exposed to floodwaters is:

\[
\text{HR} = d \times V + DF \quad \text{(for } Q_{2.5} \text{ and } Q_{10})
\]

\[
\text{HR} = d \times (V + 0.5) + DF \quad \text{(for } Q_{25}, Q_{50}, Q_{100}, Q_{500})
\]

where,

- \( HR \) = (flood) hazard rating;
- \( d \) = depth of flooding (m);
- \( v \) = velocity of floodwaters (m/sec); and
- \( DF \) = debris factor (= 0, 0.5, 1 depending on probability that debris will lead to a significantly greater hazard)

<table>
<thead>
<tr>
<th>( d \times (v + 0.5) )</th>
<th>Degree of Flood Hazard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.75</td>
<td>Low</td>
<td>Caution “Flood zone with shallow flowing water or deep standing water”</td>
</tr>
<tr>
<td>0.75 - 1.25</td>
<td>Moderate</td>
<td>Dangerous for some (i.e. children) “Danger: Flood zone with deep or fast flowing water”</td>
</tr>
<tr>
<td>1.25 - 2.5</td>
<td>Significant</td>
<td>Dangerous for most people “Danger: flood zone with deep fast flowing water”</td>
</tr>
<tr>
<td>&gt;2.5</td>
<td>Extreme</td>
<td>Dangerous for all “Extreme danger: flood zone with deep fast flowing water”</td>
</tr>
</tbody>
</table>
1. HYDROLOGIC MODELLING
2. MAPS

Harita Alımı (1/5000, 1/1000 Ölçekli)
3. HYDRAULIC MODELLING (1D)

HEC-RAS & HEC-GEORAS

MIKE 11
A Microcomputer Based Modelling System for Rivers and Channels
HYDRAULIC MODELLING (2D)

HYDRAULIC MODELLING (1D + 2D COMBINED)
WATER DEPTH AND FLOOD HAZARD MAPS FOR TERME RIVER (Q100)
FLOOD HAZARD MAPS

are base for FLOOD RISK MAPS to be used/prepared by AFAD (Disaster and Emergency Management Presidency of Turkey)

will be taken into consideration for construction (by municipalities and provinces)

are necessary for insurance companies on determining possible flood areas

are base for flood early warning systems.
Black sea – Middle East Flash Flood Early Warning System
In 2007, the 15th World Meteorological Congress requested preparation of early warning systems for floods.

In 29-31 March 2010, the first meeting of Black Sea – Middle East Flash Flood Early Warning System was held.

Using meteorological observations, SNOW-17 (snow model), SAC-SMA (Sacramento soil moisture accounting model), runoff threshold model and flash flood warning model (FFG) the Project aims to make early warnings of flash floods.
INPUT: Snow Depths
OUTPUT: Sow Water Equivalent

SAC - SMA

OUTPUT: Areal Soil Moisture
FFG (FLASH FLOOD GUIDANCE)
6 Saatlik Taşın Tehlike Haritası
(FFFT 24.01.2013 18:00 UTC +6 Saat)

EGE DENİZİ

1- Hafif
2- Orta
3- Yüksek

Bodrum

Karpuzlu

Çine

Didim

Milas

Yatagan

MUĞLA

Ula

Köyceğiz

Dalaman

Marmaris

Arastirma Daire Baskanligi Hidrometeoroloji Sube Mudurlugu
Flood Assessment Guidelines of DSI (State Hydraulic Works)

This is a group of work packages to be followed for extreme flood assessment, rather than a single method. (Especially for design discharge of structures).

- Meteorological and hydrological data are obtained from MGM (State Meteorological Service) and DSI (State Hydraulic Works).
- More suitable for riverine floods.
- Not GIS based.
Get a representative storm’s D-A-D curve

Obtain maximum probable precipitation

Calculate $P_{max}$ with $t=24$ hours $A$ basin area

Calculate $P_{max}$ from physical method

Calculate $P_{max}$ from statistical method

Get $P_{max}$ as the maximum of these

Get $U_{24hrs}$ using Snyder’s method

Superpose all three with peaks intersecting.

Hydrograph of snowmelt (obtained from daily melting & hypsometric curves)

Obtain baseflow from average flow

Flood Assessment Guidelines of DSI (State Hydraulic Works)
APPLICATION OF STATE HYDRAULIC WORKS GUIDELINE IN MURAT RIVER BASIN

ANALYSIS OF PAST STORM EVENTS / DEPTH-AREA-DURATION CURVES
PROBABLE MAXIMUM PRECIPITATION ESTIMATION USING PHYSICAL METHOD

By using the formula

\[ P_{\text{max}} = P_{\text{ac}} \times W_{\text{max}} / W_{\text{ac}} \]

\( P_{\text{max}} \): Probable maximum precipitation

\( P_{\text{ac}} \): Observed average precipitation

\( W_{\text{max}} \): Precipitable water

\( W_{\text{ac}} \): Maximum precipitable water

<table>
<thead>
<tr>
<th>Fırtına Tahmini</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y. Kaleki Baraj (A = 21.837 km²)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>50.7</td>
</tr>
<tr>
<td>50.7</td>
</tr>
<tr>
<td>45.8</td>
</tr>
<tr>
<td>45.8</td>
</tr>
<tr>
<td>42.7</td>
</tr>
<tr>
<td>42.1</td>
</tr>
<tr>
<td>31.0</td>
</tr>
<tr>
<td>54.6</td>
</tr>
</tbody>
</table>
PROBABLE MAXIMUM PRECIPITATION ESTIMATION USING HERSHFIELD’S (STATISTICAL) METHOD

By using the formula $P_{\text{max}} = P + KS$

$P_{\text{max}}$: Probable maximum precipitation

$P$: average of yearly maximum precipitation series

$K$: frequency factor

$S$: standard deviation of yearly maximum precipitation series

<table>
<thead>
<tr>
<th>Fırtına Tarihi</th>
<th>Ortalama Yağış(mm)</th>
<th>A. Kalezio Başak (A = 21,037 km²)</th>
<th>Brykhan II - I Saray (A = 25,427 km²)</th>
<th>Fırtına Başak (km²)</th>
<th>İstatistik Sayısı</th>
<th>Wiloc. / Wloc.</th>
<th>Olası En Büyük Yağış(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 - 30 Nisan 1972</td>
<td>35,6</td>
<td>35,6</td>
<td>35,3</td>
<td>24</td>
<td>7</td>
<td>32,5 / 15,5 = 2,10</td>
<td>64,4 / 64,5 = 71,6</td>
</tr>
<tr>
<td>11 - 12 Nisan 1973</td>
<td>37,8</td>
<td>37,8</td>
<td>37,5</td>
<td>24</td>
<td>8</td>
<td>35,2 / 13,9 = 2,54</td>
<td>63,8 / 62,5 = 71,4</td>
</tr>
<tr>
<td>7 - 9 Mayıs 1974</td>
<td>35,6</td>
<td>35,6</td>
<td>35,5</td>
<td>24</td>
<td>8</td>
<td>25,2 / 13,9 = 2,62</td>
<td>66,2 / 65,9 = 71,4</td>
</tr>
<tr>
<td>1 - 2 Mayıs 1975</td>
<td>37,8</td>
<td>37,8</td>
<td>37,5</td>
<td>24</td>
<td>8</td>
<td>33,7 / 13,9 = 2,44</td>
<td>104,7 / 101,3 = 101,7</td>
</tr>
<tr>
<td>2 - 3 Mayıs 1976</td>
<td>37,8</td>
<td>37,8</td>
<td>37,5</td>
<td>24</td>
<td>8</td>
<td>33,7 / 13,9 = 2,44</td>
<td>104,7 / 101,3 = 101,7</td>
</tr>
<tr>
<td>26 - 30 Mayıs 1977</td>
<td>35,6</td>
<td>35,6</td>
<td>35,5</td>
<td>24</td>
<td>11</td>
<td>21,5 / 10,8 = 2,01</td>
<td>65,6 / 67,3 = 68,4</td>
</tr>
<tr>
<td>17 - 18 Nisan 1980</td>
<td>37,8</td>
<td>37,8</td>
<td>37,5</td>
<td>24</td>
<td>11</td>
<td>27,5 / 16,5 = 1,74</td>
<td>60,6 / 60,5 = 60,5</td>
</tr>
</tbody>
</table>
HYDROGRAPH OF PROBABLE MAXIMUM PRECIPITATION

\[ Q_0 = 70 \text{ m}^2/\text{s/cm} \]

\[ \text{Zaman, Saat} \]

\[ \text{Düz, m}^2/\text{s/cm} \]

Şekil: 1.11 Yukarı Kaleköy Baraj Yeri Yağış Alanı 24 Saat - 1 cm'lik Birim Hidrografı (Snyder Yöntem)
Şekil 1.14 Yukarı Kaleköy Baraj Yeri Olası En Büyük Yağışın Akış Hidrografı
SNOWMELT FLOW AND HYDROGRAPH

Snowmelt flow is calculated by degree-day approach. Daily temperature, snow depth, snow water equivalent data is obtained from meteorological stations. Then snowmelt is calculated for every day.

Probable maximum snowmelt hydrographs are obtained from these calculations.
Hydrograph for probable maximum precipitation + maximum snowmelt + baseflow are superposed (and peak flows of these hydrographs are overlapped)
An Investigation on the Evaluation of Flood Potential In Northwest Black Sea Region

- Flood potential in Northwest Black Sea region with the aid of Geographical Information System (GIS).
- **Input Parameters**: Precipitation climatology, Digital Elevation Model (DEM), land-use and drainage network characteristics are considered.
- Potential flood areas are determined for a period of 50 years.
- Flow measurements between 1969-2002 are used.
- Peak flows are calculated and corresponding water depths are determined using the rating curve.
- Using GIS, DEM and water depths are buffered.
Figure 3. Digital drainage map of the studied area.

Figure 4. Shaded relief map of the study area produced from digital elevation model.
Figure 6. Flood areas calculated for (a) Hisiroğlu-Devrek (b) Navsaklar-Karabük settlement regions
EU FLOODS DIRECTIVE

Preliminary Flood Risk Assessment

Flood Hazard and Flood Risk Mapping

Flood Risk Management Plans
EU - Turkey Twinning Project: Methodologies

1. EXZECO Method (France)
   Based on elevation of water level using Aster GDEM

2. Water Level Rise Method (Romania)
   Based on elevation of water level using SRTMDEM

3. Aluvion Method (France)
   Determining the places alluvials deposited to find out possible flood area

**Chosen method: Alluvial deposition**
- Covers both past events and other two methods’ considerations.
- Less computational time
ALÜVYON ALANLARI YÖNTEMİNE GÖRE TAŞKIN ALANLARI
FLOOD AREAS ACCORDING TO ALUVION METHOD
* Turkey – Bulgaria Cross Border Cooperation for Meriç/Maritza Flood Forecast and Early Warning

EU Funded Project
Between 2008 – 2010

Transfer of past event and real time data between two countries
Preparation of DEM for Maritza river
Hydrologic model for basin + hydraulic model for river bed
MIKE11 and Mike FloodWatch are used for modelling

Real time data on dynamic web portal : www.dsiedirnenehir.com
50 – 100 – 500 year floodplain maps
First early flood warning project in Turkey
Results
### GÜNCEL NEHİR DEBİLERİ

<table>
<thead>
<tr>
<th>NEHİR ADI</th>
<th>İSTASYON ADI</th>
<th>DEBİ (m³/sn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARDA</td>
<td>Ivoylovgrad</td>
<td>303</td>
</tr>
<tr>
<td></td>
<td>Elhma</td>
<td>40</td>
</tr>
<tr>
<td>TUNCA</td>
<td>Suakacaği</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Parvomay</td>
<td>62</td>
</tr>
<tr>
<td>MERİÇ</td>
<td>Svilengrad</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>Kirışhane</td>
<td>234</td>
</tr>
<tr>
<td></td>
<td>İpsala</td>
<td>362</td>
</tr>
<tr>
<td>ERGENE</td>
<td>İnanık</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Lüleburgaz</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Yeniceörece</td>
<td>32</td>
</tr>
</tbody>
</table>

Copyright © 2008 ver 2.0 DSI 11. Bolge Müdürlüğü - EDiRNE Nehir Debileri m³/sn
What’s Next?

• Evaluation of existing flood hazard assessment models.
  - Already underway

• Choose a model for development/ modification/ adaptation to the needs of the proposal  
  - Regional Scale
  - Local Scale

  - First step is this workshop
# A proposal for model rating

<table>
<thead>
<tr>
<th>MODEL NAME</th>
<th>X Model</th>
<th>Y Model</th>
<th>Z Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Type</td>
<td>Conceptual Model</td>
<td>Basin Based Model</td>
<td>Hydraulic Model</td>
</tr>
<tr>
<td>Equations</td>
<td>Rational formula, TWI, SPI</td>
<td>SCA precipitation-to-runoff model, water budget, conceptual flood routing,…</td>
<td>Empirical concentration times, Continuity, Conservation of Momentum</td>
</tr>
<tr>
<td>Temporal Domain &amp; Resolution</td>
<td>Steady, Return period basis (10~100 years)</td>
<td>Steady, 1 day-1 month</td>
<td>Unsteady, 1 min-10 hrs</td>
</tr>
<tr>
<td>Spatial Domain &amp; Resolution</td>
<td>Raster Image, 1~10 km</td>
<td>GIS based, 250 m~2 km</td>
<td>GIS+Local Coordinates, 5 m~100 m</td>
</tr>
<tr>
<td>Input Parameters</td>
<td>Extreme pdf of precipitation, catchment area, slope, bed character,…</td>
<td>Mean monthly precipitation data, DEM with 1/25000, land use data,…</td>
<td>Daily precipitation data, DEM with 1/5000, flow crosssections, land use,…</td>
</tr>
<tr>
<td>Output Parameters</td>
<td>&quot;Flood Hazard Risk&quot; index</td>
<td>Max. flow rate, estimate of water level variation, estimate of inundation area</td>
<td>Flow rate timeseries (hydrograph), flow depth, flow velocity, inundation areas, urban flooding, estimate of flood damage,…</td>
</tr>
</tbody>
</table>

## RATING OF THE MODEL

<table>
<thead>
<tr>
<th>Rating Criteria</th>
<th>GIS based? (0 to 2)</th>
<th>Generic? (0 to 2)</th>
<th>Data Demand (0 to 2)</th>
<th>Resolution (0 to 2)</th>
<th>Result Accuracy (0 to 2)</th>
<th>Ease of Implementation (0 to 2)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
<td>2</td>
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<td>0</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Y Model</td>
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<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Z Model</td>
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<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
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<td>7</td>
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</table>