

## Turkey's need for manual and general specifications for flood hazard mapping studies

smail Halta <sup>1</sup>

<sup>1</sup>Department of Civil Engineering, Zirve University, Turkey

### Abstract

Flooding is a serious natural disaster in Turkey similar to rest of the world causing significant economical damage and loss of lives every year. Statistical analyses show that in Turkey, after the earthquake, flooding is the second most serious natural disaster in terms of life losses and economical damage. Unlike many other natural hazards, flooding is a natural hazard that can be forecasted and modeled ahead of time. Hence flooding can be prevented or the consequences can be reduced through proper planning.

On the other hand, in Turkey detailed flood modeling and mapping is not common, and a manual and general specifications document for flood studies is not available. Yet for an effective, detailed and consistent flood hazard-mapping study there is a need for such a document. Actually, literature review shows that many other developed country do not have a detailed and comprehensive manual and general specifications document for flood studies. These countries started launching programs to standardize and extend the flood hazard mapping studies in the recent decade, after experiencing increasing number of flood hazards each year.

In this study foremost from US, EU Member States, Australia, and Canada several references are reviewed. A current special specifications document for a flood hazard mapping study in Northern Turkey is considered as the reference from Turkey.

The reviewed references are compared under basic components of a detailed flood hazard mapping study. These components are:

1. Hydrologic-hydraulic modeling and engineering methods.
2. Flood hazard mapping
3. Reporting of a flood study
4. Quality control measures

Based on the evaluation of the comparison result, some recommendations are made for the issues that are considered to be included in a manual and general specifications document for flood hazard studies.

### Introduction

Flooding causes loss of lives and property every year in Turkey similar to in the rest of the world. In the report by Turkish Ministry of Public Works titled "Türkiye'de Afetlerin Mekânsal ve statistiksel Da ılımı-Afet Bilgileri Envanteri 1950-2008" flooding is named the second most significant natural hazard that endangers Turkey [1]. After earthquakes the most life and property loss is experienced during flood events and the mudflow that develop after the floods. Within the reporting period totally 4 thousand and 67 flood events were recorded and the floods affected 22 thousand and 157 residents in 80 cities. Especially misuse of land and lack of storm drainage capacity results in increased number of flash flood events in cities like stanbul,

Ankara, Izmir, Adana, Bursa, Gaziantep, Hatay, Mersin etc. that expands too fast. In another report by Turkish State Water Works (DSİ), there is 1308 flood events reported between 1955-2002 in Turkey. As a result of these flood events 1235 residents lost their lives, around 61 thousand dwellings totally destroyed or fell to disuse. The same report states that only in Izmir, Bartın, Hatay, Gaziantep and Trabzon there are more than 100 million US dollars of property damage within the reporting period due to the flood events.

Flood events can be predicted and modeled so the damage due to the flood can be prevented or minimized through a proper planning. Yet in Turkey flood modeling and mapping studies are limited and the ongoing projects are not conducted based on any comprehensive nation wide standards and specifications. For flood studies to become prevalent, flood awareness must be established in public as well as the governing authorities. Also, for effective, detailed and nation wide consistent flood mapping studies a manual and general specifications document must be prepared. For that in order to be reference for the document that is going to be prepared, several manuals, specifications and example applications are reviewed and evaluated. This review and evaluation results are documented in a report [2].

### **Reviewed manuals and specifications**

How the flood studies are conducted and administrated, and the applied standards are investigated for four developed countries (US, EU Member States, Australia, and Canada) as well as Turkey.

Based on the advise from Turkish State Water Works (DSİ) Survey, Planning and Allocation Department (email communication) there is not any general specifications document to be reference for flood studies in Turkey. The flood studies are conducted according to specifications document particular for each study. State Water Works shared an up-to-date specifications document [3] prepared for the flood study to be conducted in Samsun province as an example with the research group. This particular specifications document is taken as the reference for Turkey case during the investigation and comparison of flood study practices.

For the investigation of flood study practices conducted in US the manual and specifications document [4] by Federal Emergency Management Agency (FEMA) is taken as the reference. This document covers the technical procedures to be followed, the standards of the flood hazard maps, and documentation and administrative coordination activities during the flood studies. FEMA's related personnel, all the technical and administrative professionals involved in flood studies (municipalities, other federal agencies, engineering firms, and researchers) are indicated as being the target audience of the document. This document replaced all the previous manuals, specifications, and guides related to flood studies by revising, and merging them into a single document in year 2003, and it is updated time to time. This extensive document is composed of three main volumes and 14 appendices, and it is currently the only reference and legally binding document in use for all the flood study related technical and administrative issues.

Although not all the potential flood hazard areas are mapped in Europe yet, there are some standards in EU Member States for flood hazard mapping studies. In 2007 a group of flood study experts under EU Water Directorate formed European Exchange Circle on Flood Mapping (EXIMAP) to evaluate the flood study practices in EU. This evaluation exercise resulted in a handbook titled "Handbook on good practices for flood mapping in Europe" together with some example flood hazard maps from 19 EU States, US and Japan [5]. Parallel to the review study by EXIMAP, European Commission proposed a Flood Directive on 18 January 2006, and the proposal is accepted and effective since 23 October 2007. The aim of the directive is stated as "to help the Member States to prevent flooding and minimize the harm to human health,

environment, property and infrastructure due to the flooding”. After the flood directive is accepted, the member states started revising the existing specifications or preparing a new specifications document in alignment with the main principles and provisions. For the investigation of flood study practices in EU the Flood Directive and the handbook by EXIMAP is taken as the reference. In addition to these two main references some references from specific member states are also considered. In this context the specifications document [7] by German Working Group of the Federal States on Water Issues (LAWA) for Federal Germany is reviewed and involved in comparative evaluation.

Australia is another country that recently started updating its existing National Flood Risk Management approach; therefore they started revising their flood study specifications document. Australian government started the National Flood Risk Information Project together with Geoscience Australia in 2011 [8]. The aim of the project is to improve the extent and quality of the information about flooding nationwide. Within the project they plan to develop a Portal to publish the flood risk maps and the other data and information about flood risk. Also, Geoscience Australia is planning to prepare a directive to guide how the data and information about the flood risk in a specific format and standards. This directive is not published yet, therefore for the investigation of flood study practices in Australia the report [9] by the Australian Standing Committee on Agricultural and Resource Management (SCARM) is taken as the reference.

In Canada there is not any flood study specifications or directive that is used nationwide. Instead of a common and legally binding document, each state uses its own manual and specifications. Between these manual and specifications the document [10] for British Columbia is standing out with its content. Although this document is prepared for flood studies in Fraser Basin, Basin council plans to extrapolate this document to the whole British Columbia.

### **Flood hazard modeling**

The time and resources to spend for flood modeling and mapping studies and the level of details in the output of the study depends on the needs of the community. The social-economic level of the study area, the level of flood risk, available hydrologic, hydraulic, and geographic data are some of the main factors that set the extent of the study to be conducted. In a flood study simple regression curves may be enough, while in another study running a rainfall-runoff model may be inevitable. Also in some flood basins it may be necessary to develop flood extent, depth and velocity maps for several return periods, while in another flood basin flood extent just for 100-year return period may be enough. Therefore it is impossible to set single specifications or methodology for such a wide spectrum of flood studies. River flood modeling requires some hydrologic analyses/modeling and hydraulic modeling. The purpose of the hydrological analyses is to determine the peak discharge-frequency values. The hydraulic models identifies the flood extent, depth and velocities for each peak discharge. The methodology and models depend on the aim and scale of the study.

#### *Return periods for peak discharges*

One of the important decisions for the flood studies is the return periods that are going to be modeled as well as the selection of base flood return period. In practice the peak discharges with return periods ranging from 2-year to 500-year are modeled. DS [3] require to model peak discharges with 2, 5, 10, 25, 50, 100, and 500-year return periods. FEMA [4] sets the flood with 100-year return period as the base flood. For some study areas flood maps also show flood extent with 500-year return period. SCARM [9] requires to model 2, 5, 10, 20, 50, 100, 500 year return periods as well as the Probable Maximum Flood. Australia also takes 100-year return

period as the base flood. On the other hand, in British Columbia 200-year return period is accepted as the base flood [10]. For some large and social-economically important basins with long hydro-measurement records they apply the PMF as the base flood elevation. LAWA [7] propose to use varying return periods for each individual basin depending on the particular needs and requirements of the basin as well as the local hydro-information. As seen from the examined examples from different authorities there are several different approaches to return periods to be modeled and the return period for the base flood. The manual and specifications document to be prepared should provide some guidance on the selection of the return periods to be modeled and the return period for the base flood.

### *Hydrologic analyses*

The peak discharges are calculated using different hydrological methods. The most commonly used methods are listed as;

- a) Flood frequency analysis,
- b) Rational Method with the intensity duration frequency curves,
- c) Hydrological rainfall-runoff models.

Each method needs several hydrological data, as an example; FEMA [4] requires at least 10 years of discharge measurement data for flood frequency analysis. An unsteady hydraulic model needs the peak flood hydrograph; therefore, such studies need hydrological rainfall-runoff models. The mistake in the selection of the hydrological method or ignoring the limitations of the applied method may result in significant errors in the calculated peak discharges that have the crucial importance in the flood study. Therefore the manual and specifications document should have detailed and specific guidance in the selection and application of the hydrological methods.

### **Hydraulic analyses**

The purpose of hydraulic models is to calculate the maximum flood extend, depth and velocity for each peak discharge. It is important to conduct the hydraulic modeling study in basin scale for consistency and continuity purposes. Hydraulic models can be at various dimensions and states. It is important to select the correct type of hydraulic model for meaningful and accurate results. The manual and specifications document should have some detailed and particular guidance on the selection and the application of the correct type of the hydraulic model.

### **Hydraulic model elements and parameters**

In hydraulic models there are several elements and parameters such as cross-sections, hydraulic structures, roughness coefficients, etc. In order for the hydraulic model to output meaningful results with minimum error, the model elements have to be set up and the values of the parameters to be entered into the model precisely and consistently. For example, the energy loss due to the contractions and expansions at the cross-sections along a channel is modeled with the expansion/contraction coefficients. FEMA [4] requires to use 0.1 and 0.3 for gradual contraction and expansions and 0.3 and 0.5 for sudden contraction and expansions respectively. Similarly how the downstream condition is defined in a one-dimensional steady hydraulic model is important to compute the for the correct water profiles. For consistent and correct hydraulic models there should be detailed and specific guidance and standards in the manual and specifications document about the set up of the hydraulic model elements and assigning and calibrating the values of the model parameters.

## **Floodway analyses**

FEMA [4] divides the expansion area of 100-year flood as floodway and flood fringe. In floodway is the corridor where the main flood discharge is conveyed to downstream; therefore any development that has the potential to increase the water level in floodway is not allowed. Some iterative methods are used to identify the hydraulic floodway. The current specifications in Turkey [3] do not provision any guidance or specification on delineation of floodway. It is important that there is detailed and specific guidance and standards in the manual and specifications document about the delineation of floodway and the regulations related to floodway and flood fringe.

## **Flood hazard mapping**

A Flood hazard map shows the calculated flood extent and depths overlapped with the background images and other spatial information. The flood hazard maps can be analyzed together with some other spatial data layers to produce flood risk maps. For example; analyzing flood hazard maps together with the property economic value map layer may result in flood economic risk maps. Similarly, analyzing flood hazard maps together with the environmental pollutant source map layer may result in flood environmental risk maps.

In several developed countries flood hazard maps are the main reference for evaluation of flood insurance rates. In US as part of the National Flood Insurance Program, flood insurance rate maps (FIRM) are developed. Although the main purpose of FIRM maps is evaluation of flood insurance rates, they are also actively used in urban planning and flood hazard emergency management. The FIRMs are available for all the flood prone areas in the US, and they have very basic and standard content and layout. That makes FIRMs very useful tool and reference for various different planning and management authorities. In the FIRMs the potential flood extent areas are divided into zones depending on the source of the flooding, level of detail in the modeling, and return period of the flood. The zones make easy to understand the level of risk and compare to previous maps or maps of other flood prone areas even by non-technical professionals and the public. The content and layout format and standards for FIRMs are covered in FEMA [4] Appendix K: Format and Standards for Flood Insurance Rate Maps in details.

Although DS [3] requires the submittal of the digital flood model results, it does not ask for the flood hazard maps in specific content and format. Therefore, in Turkey there are no standards established for the flood hazard maps yet. The manual and specifications document should involve some guidance and standards for the flood hazard maps.

## **Reporting and submittals**

The main outputs of a flood study are; flood hazard maps, flood study technical report, the hydrologic and hydraulic models, and the digital basemap. Storing all the study outputs together is important for future updates in the same study area and/or flood studies in the adjacent areas as a reference and input data. Therefore it is considered that storing all the study outputs of flood studies in Turkey in a specified format in a database will help to increase the effect of the studies. FEMA [4] specified the study report content and format as well as the format of the other study outputs. As part of the NISP all the study outputs are collected in a Technical Support Data Notebook (TSDN) and the TSDN of each flood study is stored in the flood study database of FEMA.

There is no such database in Turkey where the flood study outputs are stored and shared with the interested parties. There is a need of comprehensive study on developing a Flood Study database and standards of the inputs for the database. The manual and specifications document should cover these standards and formats.

### **Quality control/assurance**

Flood hazard maps have very important role in urban planning, flood control, flood hazard emergency management, and flood insurance; therefore, following the highest quality measures is necessary in conducting flood studies and developing flood hazard maps. A flood study is a comprehensive process that involves data collection and processing, engineering analyses and modeling, and mapping. The precision and accuracy of flood hazard maps depend on conducting each step of the flood study process with caution and accuracy. Therefore at each critical point of the processes there should be quality checks.

FEMA [4] propose quality assurance / quality control (QA/QC) measures at several levels. That measures include both internal and independent (external) review process for the hydrologic and hydraulic analysis and models. The quality QA/QC measures and the review processes are covered in the manual and specifications document [4] in details. FEMA also suggest the flood hazard maps to be reviewed as a draft for as much as 90 days by the public before it becomes final and effective. In the manual and specifications document to be prepared for Turkey the QA/QC measures have to be included in details.

### **Conclusion and discussions**

This review study shows that there is no any manual or specifications that is used nation wide in flood studies in most of the developed countries. Also in Turkey there is a need for a comprehensive and detailed manual and specifications for flood modeling and mapping studies. Several developed countries started programs on modernization and standardization of flood studies due to ever increasing number of events that harm human health, social life and economy. One of such programs was launched by FEMA, US in 1968 as National Flood Insurance Program –NISP. This program only recently in 2002 resulted in a comprehensive and detailed manual and specifications for flood modeling and mapping studies. It is observed that the manual and specifications documented by FEMA is far more comprehensive and detailed compared to the other reviewed documents. It is considered that the FEMA's Flood Modeling and Mapping Manual and Specifications document which is updated frequently parallel to the advances in the recent technologies and engineering methods can be a good reference and starting point for a manual and general specifications document that is going to be prepared for use in Turkey.

The particular flood study specification documents that are currently used in Turkey are observed to be in competence with the international standards in general especially in hydrologic and hydraulic modeling sections. On the other hand, in issues like reporting, flood map content and layout standards and formats, the standards and formats of the other study outputs, and the quality control there is some room for more comprehensive and detailed guidance. As such it is concluded that there is a need for a comprehensive and detailed manual and general specifications that is to be taken as the reference for flood studies in Turkey.

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