

FLOOD MANAGEMENT AND CONTROL

by

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ABSTRACT

FLOOD MANAGEMENT AND CONTROL

The severity and frequency of flood events are expected to grow at global scale while flood events continue to lead losses and damages all around the world. Floods need a special focus to describe the risks and minimize losses or damages. In this study, main reasons of flood losses or damages researched. Solutions produced dependent on the reasons or insufficiencies determined. Also flood events that caused great damages or losses in history became a guide for preventive solutions. River basins, low lying settlements, agricultural, industrial and rural areas, cities, hillsides, high population and high precipitation areas, settlements that close to water resources are the great risk regions for flood events, and they need observations, measures, preventive approaches, flood plans, strong infrastructures, early warning systems, predictions, flood parameters, green solutions, struggle and advices as components to minimize the risks. The research aims to explain those components to prevent flood events. The flood risks of some countries and the flood risky regions or cities in the Turkey explained and predicted. Conventional flood parameters and management concepts questioned while new ones were produced. Formulation and determination of limit value of those parameters became a goal too, and also a new flood parameter structure emerged. Briefly, the contributions to the early warning system and to the elimination of complexity of flood predictions are expected as results at the end of the study.

ÖZET

TAŞKIN YÖNETİMİ VE KONTROLÜ

Taşkın olayları dünyanın her yerinde kayıp ve zararlara yol açmaya devam ederken taşkın olaylarının şiddet ve frekansında global ölçekte artış beklenmektedir. Taşkınlar, riskleri tanımlamak ve kayıp yada zararları azaltmak için özel bir odaklanmaya ihtiyaç duymaktadır. Bu çalışmada taşkın kayıp ve zararlarının ana sebepleri araştırıldı. Saptanan sebepler ya da yetersizliklere bağlı olarak çözümler üretildi. Aynı zamanda tarihte büyük kayıp ve zararlara neden olan taşkın olayları bu çalışmada önleyici çözümler için bir rehber oldu. Nehir havzaları, alçak yerleşim alanları, tarımsal, endüstriyel ve kırsal alanlar, şehirler, yamaçlar, yüksek nüfus ve yüksek yağış alanları, su kaynaklarına yakın yerleşim yerleri taşkın olayları için büyük risk bölgeleridir ve riskleri azaltmak için bileşenler olarak önlemlere, koruyucu yaklaşımlara, taşkın planlarına, güçlü altyapıya, erken uyarı sistemlerine, tahminlere, taşkın parametrelerine, yeşil çözümlerle, mücadele ve önerilere ihtiyaç duymaktadırlar. Araştırma taşkın olaylarını önlemek için bu bileşenleri açıklamayı amaçlamaktadır. Bazı ülkelerin taşkın riskleri ve Türkiye'deki bölgelerin yada şehirlerin taşkın riskleri açıklandı ve tahmin edildi. Geleneksel taşkın parameterleri ve yönetim anlayışları sorgulandı ve yenileri üretildi. Bu parametrelerin limit değerlerinin saptanması ve formülasyonu bir amaç oldu ve aynı zamanda yeni taşkın parametre yapısı oluşturuldu. Kısaca çalışmanın sonunda erken uyarı sistemlerine katkılar ve taşkın tahminlerinin güçlüğüne giderme bir sonuç olarak beklenmektedir.

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LIST OF SYMBOLS/ABBREVIATIONS

Symbol	Explanation	Unit
AFRF	Anil Flood Risk Factor	mm
BDT	Bangladesh Taka	
EFR	Eken Flood Ratio	Unitless
FEP	Flood Effect Percent	%
FRERR	Flood Rainy Effect Risk Ratio	Person
RFEP	Relative Flood Effect Person	%
Rs	Indian Rupee (INR)	

Abbreviation	Explanation
EIS	Environmental Information System
GIS	Geographical Information System
IUCN	International Union for Conservation of Nature
LEDMC	Local Environment and Disaster Management Council
MIS	Meteorological Information System
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NDEAP	Natural Disaster Emergency Action Plan
NDRIS	Natural Disaster Risk Reduction System
NEMA	National Emergency Management Agency
NOAA	The U.S. National and Atmospheric Administration
NRLF	National Flood Relief Commission
OCHA	UN Office for the Coordination of Humanitarian Affairs
ONDRRP	Official Natural Disaster Risk Reduction Plan
PPPs	Prediction Prevention Protection studies
TRMM	Tropical Rainfall Measuring Mission
UNDRO	United Nations Disaster Relief Organization
UNEP	United Nations Environment Program
WMO	World Meteorological Organization

1. INTRODUCTION

Flood events are expected to be common in the future. This expectation means more damages and losses. Measures and management related with flood events seem inadequate as well. Those actualities are a significant risk for the life; therefore, flood events need special focus for the determination of flood reasons or deficiencies, the creation of solutions upon flood problems and improvement in the flood management to minimize risk, damages and losses. Past flood events will be used as an experience and a guide in this work.

The aim of study is to prevent the damages of flood events against life. Any kind of approach, idea, observation, solutions, plans, parameters, data, experiences and advices that will probably prevent or minimize the damages of floods are the issue of this study basically. River basins, settlement places that are close to water sources, cities (especially low-lying areas) that high population lived, settlements in hillside, shores or coastal areas, and the areas that the rainfall average is high are main flood prone areas. It is no doubt that such as areas need special precautions, good plans and solutions against flood events to minimize the losses. The main goal of this study is to offer this precautions and solutions.

Designing flood parameters and using their data, prediction of flood events, forming early warning systems, green-blue planning cities or settlement places, the management of river basins and water resources, the protection and design of agricultural, rural, industrial areas against flood events, implementing the precautions and principles taken before against the flood events are the synopsis of this study. It is inevitable that all kind of these precautions, solutions, approaches, and idea offered in this study against possible flood events will be useful in the management of flood, they will minimize the risks, damages and losses, and they will contribute flood knowledge in that research discipline.

2. FLOOD MANAGEMENT CONCEPT

In this chapter, Flood Management Concept will be introduced, which is required to cope with major flood problems.

2.1. Flood Definition, Flood Management Concept and Types of Floods

Flood definition, Flood management concept and flood types are significant to understand the flood problems and bring logical solutions to the available ones. For this reason, it is useful to explain the headings.

2.1.1. Flood Definition

Floods are a phenomenon that commonly observed on earth. Floods can be defined as a disaster when they are not controlled and managed. In other words, they can be described as natural hazards that come from water resources against humans or human activities, especially when those human activities are not compatible with water resource or nature. Any type of human activities must be compatible with water resources, environment, nature or nature's balance, and those activities must be sustainable always; otherwise, flood disasters and losses become inevitable results.

If water resources or rains are available in a place, flood events might occur in there as a result. Precious efforts in the flood management are to predict the risks and the changes in the environmental conditions, determine the patterns, the abnormalities and the hazards in the region, and prevent the damages, losses and negative effects of flood disasters with precautions, knowledge and techniques.

2.1.2. Flood Management Concept

Regions or settlements need predictions, preventions and protections against natural disasters, and they need efforts upon these issues continuously, which can be defined as three PPP studies (PPPs). Highly valuable concepts are to implement three PPPs continuously before the flood events or damages, however; during and after the flood event, implementing the concept is so precious too. To implement this PPPs concept, settlement councils for each settlement, regional councils for each regions and coastal council for each coastal cities must be created by authorities. In the flood management concept, the settlement, regional and coastal councils that will implement continuous

three PPPs must be independent and composed of engineers or experts, mainly from Environmental and Earth Sciences.

Each section of three PPPs is composed of four significant elements. These are; 1-Determinations of problems such as the hazards or risks, the needs and requirements related with the flood disasters, 2-Creating plans and programs to meet those needs or requirements to reach the aims, 3-Designing systems and implementations of those systems for solutions, and 4-Continuous inspections and revisions of all those elements and their compounds. Not only flood hazards but also all kind of disasters must be under the debate related with those PPPs concepts and its elements to bring logical and quality solutions and to minimize the damages, losses and risks. Satellite data or images and earth observation outputs from space may be a part of those efforts. Integrated flood management, structural, non-structural measures against flood events in literature are a part of this PPPs concept too. All scenarios related with flood events must be investigated and evaluated in the boundary of the three categories such as pre-flood, during-flood and post-flood.

Flood risk management cycle include four phases: 1-risk assessments, 2-mitigation, 3-preparedness, 4-response and recovery to cope with flood problems. All of these phases in the cycle must be reviewed and monitored continuously. Consultation and communication are part of all these phases. Three PPPs and their elements together with the flood risk management cycle and its phases are a flood management concept of this study. The aim of the concept is to minimize the losses or damages and maximize benefits from flood events.

2.1.3. Flood Types

Determinations of flood types are significant in the flood management and control because floods events require a standard classification concept. After a flood event, a flood result report must be written by public or other flood authorities, and the type of the flood event must be specified on this report as shortly or compulsorily. This report concept will enlighten the future flood studies and the flood management experts. This study divided the flood events into seven types mainly to remove uncertainty related with flood event types in the flood management field. The study will evaluate all kind of flood events dependent on this classification. Sometime it is not easy to classify the flood events within those types because of becoming together as multi flood types. Such as kind of floods events must be evaluated dependent on the location or geography they occurred, accepted as synergistic floods and placed on the report as one of the seven flood types with emphasis of synergistic flood name. Such as kinds of floods can be described as synergistic flood type and the

effects of those floods are defined as synergic flood effects. Flood types may be a component of synergic flood except for its own type. Flood types can be classified like that; 1-Flash Floods, 2-Riverine Floods, 3-Inland Floods, 4-Urban Floods, 5- Coastal Floods, 6-Snowmelt Floods, 7-Debris Floods.

2.1.3.1. Flash floods. Flood event is defined as flash flood when it occurs suddenly or in a short period of time. Flash floods are result of heavy rains in a short period of time from few minutes to six hours. The flash flood type is most deadly flood type because time for warning the humans and the systems is so short, and people do not know what will do under the unexpected sudden developing conditions because of the panic. It is not easy to predict the flash floods because they might be any time of the year independent on season.

Furthermore, water level rises so quickly and water flows so fast in the flash flood events. They might drag humans, automobile, trees, rocks, bridges, buildings and other things dependent on the slow-moving thunderstorm, the intensity or the duration of heavy rain, the steep slopes, and the rise or speed of the water. The topography of the location is significant except for the rainfalls' amount or water speed under flash flood condition. Soil conditions and ground cover can cause more damages if they are not suitable to absorb water or rains sufficiently on the ground. Mud slide can occur due to flash floods. Dam or levee failures must be evaluated as flash floods types in the flood management as well.

Every settlement place from village to city need own meteorological (MIS)-environmental (EIS) and geographical information system (GIS) data, and those places must have their own independent Local Environment and Disaster Management Councils (LEDMC). In other words; the settlement places must have a Natural Disaster Emergency Action Plan (NDEAP) and its operations against disasters prepared by their own councils. Those plans must be checked and revised by disaster management experts and announced for each year. Those plans must show i-) the duties of people, organization and authorities together with the coordination ways among them, ii-) infrastructure needs or requirements, iii-) the place and the using procedure of any kind of tools, equipment, technology and systems, iv-) maps related with risky places, v-) the lists of risks and hazards determined, vi-) the limit values of the parameters followed in the region, vii-) the early warning values or levels of those parameters, viii-) regulations and standardizations of actions, and ix-) the measures or implementations before the disaster events, during the events and after the events. Employee settlers, civil defense forces, logistic managers, disaster managers and organizations must do practice to test and develop the quality of the plans periodically. Expert authorities for the

settlements must prepare an audit report monthly to check the implementation and quality of emergency action plans and the other available risks against possible floods or natural disasters. They must inform local, metropolitan municipalities and other organizations with insufficiencies they observed via this report. It is inevitable that this approach or concept will create great change toward sustainable cities, prevent flash floods and minimize the disaster risks.

This study accepts the possible flash flood events as an alert risk for unplanned or highly populated cities, unplanned rural settlements, metropolitan municipality managers, environmental-meteorology or climate experts, early warning system practitioners or managers, district and city planners, and for civil engineers due to being sudden deadly and destructive floods. They must take the flash flood and natural disasters as priority in their management work to minimize the damages and losses.

2.1.3.2. Riverine floods. Creeks, lakes or rivers burst their banks in this type of floods. If natural fresh waters in a location rises above the banks and floods the surrounding areas due to rain or other factors, this event is accepted as a riverine flood. Decisive term is the natural fresh water for riverine flood type.

Dam or levee failure on natural waters is not assumed as a riverine flood when it becomes suddenly without prediction or forecasting. Flash floods on fresh waters together with riverine floods need extra consideration in the river basin plans. A flood prediction or a forecasting data and its warning must be available minimum six hours in advance to describe the flood as a riverine flood upon fresh water. If flash floods occur in fresh water so much than the riverine floods, it means that the data collection plans or measurements from river are poor quality or so slow, and they must be checked and renewed to get early warning data.

Riverine flood management is a part of river basin plans and water resources management by regional administrations or state organizations. If river basins are managed well by regional administrations with coordination of local governments or municipalities and state organizations, river pollutions and riverine floods do not become threat to environment, humans, agricultural and industrial activities. Structural measures and investments might be required for river basins to control the riverine flood damages but structural measures might change the natural environment of water resource, leading to losses of habitats together with the losses of productivity of natural systems as well. Balance must be among the structural measure choices. Best choice is that settlements, industrial areas must be far away from fresh water resources. The distance concept to water resources will

protect water pollution together with flood damages. Local and regional administrators should not give permission to new settlements and new industrial areas that are close to water resources because it is a great pollution and flood risk, and it is a great public health or environmental problems. Available ones, especially industrial processes must be rehabilitated, transformed or moved to suitable places to reduce their risks against nature or water resources.

Agricultural and industrial areas which are close to fresh waters must have an emergency flood management plans against possible flood disaster events. Those plans must be revised yearly. The areas must be checked in place against natural disasters and an audit report must be prepared by authorities to regulate the areas against floods and possible crop or agricultural damages. The discharge of the waters of industry, agriculture and settlements to the fresh waters must be stopped immediately because it increases flow rates in fresh waters, which is flood and pollution risks. Structural measures must be implemented against industrial, agricultural waters and the waters that come from settlements to prevent the discharge of those waters to the fresh waters. Advanced collection and treatment systems must be built for industrial waters, domestic waters, agricultural waters and rain-flood waters severally in the river basin areas, and those waters must be treated and reused separately. Treated industrial waters must be reused in the industry or in energy production. Those treated waters should not be discharge into fresh waters because more discharge from industry to the fresh waters means more water-environmental pollution and flood risks for that fresh water even if those discharges are under the limit value of regulations. Any kind of discharge of industrial, agricultural and domestic waters into fresh waters must be stopped to increase the quality of the fresh waters. Advanced water collection, storage and treatment system must be developed and be utilized for the reuse of waters instead of discharge into fresh waters basically.

River basins together with all kind of fresh waters need protection planning and the measurements about parameters to control floods and pollution. Parameters on those plans must have a limit and specific values for the risks or early warnings. They must include water quality parameters, flood parameters, meteorological parameters, environmental parameters (water-air-soil-ecosystem-physical-chemical-biological parameters), topographic and geological parameters. Such as measures on river basin plans together with the threshold or limit values on parameters will help to the prediction of disasters, the early warning systems or designs, the observation of the quality of fresh waters, the prevention of the riverine flood damages or losses substantially, and the creation of representative Meteorological Information System (MIS), Environmental Information system (EIS) and Geographical Information System (GIS) eventually. It can be stated that the quality of river basin plan, fresh water measurement parameter plans together with their appropriate management and

implementations determine the level of pollution and riverine flood risks. Every kind of fresh water resources must be controlled, protected and monitored continuously through those parameters.

River Basin Planners should not forget that riverine floods might support ecosystems, floodplain and wetlands as well. Sometime floods might include benefits to some species, plants, birds, fishes, other ecosystems and some agricultural products related with reproduction. They can support or be useful for agricultural lands, especially when those lands are prolonged to the drought for a long time. Floods might help to the movement of species. Some fishes might move to up or down via floods. River Basin Planners must evaluate and consider that flood events might include positive effects on ecosystems and environment.

2.1.3.3. Inland floods. Inland floods are the floods that occur away from coastal regions. In general, they are due to storms or hurricanes. They come from coastal regions towards inland. A dangerous hurricane or any kind of strong storms include some threats such as strong-damaging winds, heavy rain fall and strong storm surge. After a storm made landfall, the threat finishes at coastal region but the risk of flood remains for the inland, and the threat continues as a great flood potential for up to several days later. This type of floods gives huge damages to the inland areas. Strong wind speeds, heavy rainfall and storms are distinctive features to determine this type of flood. It is an expected flooding rain in inland within up to several days after dangerous strong wind, storm surge, hurricane and its landfall. It does not occur suddenly like flash floods because there is an expectation on inland after hurricane, strong winds and its landfalls.

The areal floods that are far from fresh water resources can be evaluated in this inland flood category. Flooding in rural areas can be accepted as inland floods as well if those areas are far from coastal region or rivers or fresh waters. Meteorological, hydrological, topographic, geographical, geological, ecosystem, economic, industrial, and infrastructure characteristics of the area are significant in flood disaster management. The characteristics of the area forge great MIS, EIS and GIS (Geographical information System) for flood management. It is inevitable that green city or rural area planning in the light of MIS, EIS and GIS characteristics will minimize the inland flood and other disaster risks substantially. Quality observation and early warning in the coastal cities help to protect inland areas or cities against inland floods as well.

2.1.3.4. Urban floods. Highly densely populated urban areas are under the highly risk category of this flood type. When rain overwhelms drainage capacity, urban floods occur in there. Risk reduction measures must be implemented on urban areas continuously and periodically to be successful against

urban flood damages. Flood risks on urban areas are very diverse. In urban areas, major risks related with urban floods are due to drainage and sewerage conditions together with its age in general. They are old and neglected in most urban areas. They need renovation and maintenance periodically.

Water holding capacity, field capacity, hydraulic conductivity together with permeability of roads or grounds are crucial factors in urban flood damages. When the water capacity reaches the saturation on ground, the amount of rainwaters starts to runoff on surface. More building causes more water runoff into drains and into sewers dramatically; therefore, managing the run off on surface are crucial in urban flood management. Runoff from roads, roofs, paves must be controlled very well to minimize the urban flood risks.

Underground drainage system, water soaking by ground, water collection for watering gardens, planning the low lying urban areas against flood events, blockages of water ways, green spaces, transport system (roads, railways, subways), bridges, water supply and usage, energy production and supply systems, and rain water collection and its channel system are determining points against urban flood events. If such as determining points are planned and managed well against possible flood events, it is inevitable result that urban flood risks will be minimized or removed. Green-blue infrastructures or cities in urban areas will contribute positively against this risk reduction. Major losses and damages occur in urban areas. Urban areas must be planned and designed very well in the light of meteorological, environmental, hydrological, topographical, geographical parameters and socio-economical characteristics of the region. True and secure materials must be selected and used in the urban areas. In every step, this disasters must be considered as focal point from infrastructure to the building designs; otherwise, it is inevitable that urban area's itself will be chaos against humans.

2.1.3.5. Coastal floods. Coastal floods are the floods that occur in the coastal region. Coastal flood might be due to storm surges. Storm surges might be described as sudden rises in sea level by strong wind. For example, hurricanes or cyclone can cause floods in coastal areas. Strong winds push the water on ocean or sea's surface, lead to sea level rising and floods on coastline. Low pressure causes strong winds, strong winds create strong powerful waves, and sea level rises, which might lead to floods at the end after overtopping coastal defense so they are important parameters that must be checked continuously in coastal areas against possible flood events. After storm surge events like hurricane or cyclone, inland flood might be expected up to several days later. Climate and sea parameters might give a clue related with possible inland floods and its magnitude after possible storm surge events. Storm surges are very dangerous during high tides because of sea level elevation;

therefore, high tides must be observed especially if there is a storm surge risk, and officials must be ready under the high tide conditions.

Low lying areas that are close to coastal regions must be determined, and protective measures must be taken against those areas related with coastal floods because even weaker winds or small sea level rises can cause floods on those areas. Reclaimed lands that obtained from the sea are similar like the low-lying areas too so they need special protection against possible coastal floods.

Tsunami may damage coastal cities. Every coastal city must have tsunami emergency action plans. It occurs after earthquake in generally but major displacement of water in ocean, meteor effects or volcanic eruptions can lead to tsunami. Risks of tsunamis on coastal cities must be evaluated, determined, and precautions must be taken against the possible tsunami event. If a coastal region and its climate include storm surge events and volcanic activities while it is under the earthquake zone, the risk of tsunami is inevitably extremely high in that region. All measures and early warning systems must be ready in there against tsunami or other deadly natural disasters. Sea or ocean level, wavelength, speed and amplitude of waves are crucial parameters in coastal cities against sea floods. Those parameters need measurements continuously for that coastal city's security. Tsunami can reach several miles to the inlands. The speed of tsunami is very high, and its damages are very immense. They might inundate more areas and sweep everything; therefore, coastal cities, even inland regions need the protections well in a planned way against possible tsunami, storm surge and flood events.

2.1.3.6. Snowmelt floods. Melting snow is a source of this type of floods. Snow stores the water until it melts. The arrival of water to soil might even last for months. When arriving to the soil, it might soak into ground and run-off or flood might occur after exceeding the water capacity of the ground. Heavy snow cover, frozen grounds, rapid snow melt due to warm temperature, high humidity and rainfall, high soil moisture prior to snowmelt, and heavy rain during melting period can be reason of a snowmelt flood events so those parameters must be checked well against possible snow melt disasters. If ice jam accumulation in river or in a region do not occur suddenly, it must be evaluated as a snowmelt flood type with emphasize of ice jam snowmelt flood. Predictions minimum six hours in advance are required to describe the ice jam as ice jam snowmelt flood in a region; otherwise, ice jam must be accepted as flash flood type.

Mountain regions accumulate snow in winter time and those snows melt on spring season, leadings to water level rise or acceleration in rivers and resulting to the floods at the end. Snow level or volume on mountain regions must be followed very well on the winter time because they are an

early warning for the floods in spring or summer season. If the mountain region is close to the settlement places, it may create great risk for snowmelt flood. Other geographical characters of the region such as rivers, lakes, rocks, vegetation and so on can make the flood risks maximum in the region depending on the location of settlements. Keep in mind that snow accumulation, especially on mountain regions may be a contributor of riverine or flash flood events after snowmelt through rainfall or heavy precipitation.

2.1.3.7. Debris floods. Debris floods occur on burned hill slopes due to rainfall. Even small amount of rainfall can cause the debris flood. Those areas need rehabilitation with green plants of that region which will absorb rains on this hill slopes. The strong forceful of water, rock, and soil on hill slopes can destroy roads, railways, bridges, and structures in debris flow. The slurry of rock or mud can drag trees, houses, cars, buses and block tributaries, leading to flooding along its path. It is inevitable that as rain runs off steep valley walls, it gains velocity, carries large materials or boulders or other debris and causes damages along its path as a result in this type of flood.

Landslide is more general term than mudslide or mudflow, and flash flood may cause debris flood due to landslide. According to the definition of U.S.A National Academy of Science, mud-flow refers to a flood that carried heavy loads of sediment as much as 50 % by volume including coarse debris. If mud flows occur due to a flash flood and outweigh the flash flood, the event must be evaluated as debris flood type. Landslide assessment is required on hill slope regions to prevent possible hazards. Burned hill slopes must be determined in the regions, plans are required for rehabilitation, and precautions must be taken against it to prevent this type of floods. Suitable vegetation choices especially that will absorb more water or rain on those hill slopes must be preferred to prevent mud flows or landslide together with other precautions. Erosion rate, type of plants or vegetation, permeability of soil or region, drought, heatwaves and forest fire situation of the region are important factors to struggle with this type of floods.

3. FLOOD HISTORY

Flood History will be discussed in this section, which helps to discover flood risky area, major flood problems, flood risks or hazards and effects of flood disasters. Past flood disasters are experiences that must be learned to prevent future flood damages or losses as well. It is useful chapter because past floods events will be used as experiences to create solutions against flood disasters dependent on the determinations in this chapter.

3.1. Flood History and Significant Flood Events

Flood history is a past knowledge and a part of PPPs to point out available problems as a pre-flood activity. All locations, regions or settlements must have a flood history data for the determinations of problems and the evaluations of management and implementations in the region; therefore, recording, reporting and archiving the flood events objectively are very significant in flood management and control.

3.1.1. Flood History

Flood events have occurred since the formation of the earth or universe. In history, religions or holy books talked about flood events in their texts so much. Noah's ark can be a simple example to the well-known flood events in the texts. The floods in belief system were usually described as disastrous in the end time or doomsday. Flood events in the holy books frequently have occurred on the Middle East's rivers such as Nile. After Abrahamic religions, flood legends on the texts started to be common in America or in North West Europe so much. Most probably in ancient world's texts and in the cave drawings, the floods were described in Mesopotamia, Asia Minor or Anatolia, Thrace, Eastern Europe and Western Balkans as flood legends. In fact, where level of science, drawing, writing, recording, archiving, expressions and legends during those periods are high, flood events occurred and became visible in there, transferred to the today as valuable knowledge. This does not come to meaning that the flood events during those periods were not occurring in other part of the world severely. Maybe it was occurring more severe than those regions but there were no developed writing skills, video cameras, reporting and recording concepts; the flood events were not becoming visible on other part of the world.

Scientists do not know when first flood records of human being start and will never know the flood record origin in the future too. Even today's some states are not successful to record flood events and their damages properly. Some scientists might claim a discovery related with the flood record origin but there is a before than a time or a discovery claims always; therefore, the claim will be just an assumption, not more than it. Most probably, new generations or future scientists will not know the past flood events in the future because of not being reported and no being recorded properly. History and future are unknown and undescribed if there is no proper reporting or recording, especially without proofs or evidences. Historical knowledge is an experience and a tool to cope with the future's flood problems; therefore, past information related with flood events are very significant to shape the future against flood disasters. In this part, the study will focus on past flood events as experiences to benefit from them for the elimination of the present and the future's flood risks or events. Table 3.1 shows some significant historical deadliest flood events between 11 and 18 centuries. Those historical flood events might be speculative, unrealistic, undiscovered and unknown events but they are available in the western flood literature. The table might little bit keep light to this period bad or good, maybe for the future flood studies. Flood events in the table show the North-West Europe as region in general, and named as saints' name.

Table 3.1. Some Deadliest Flood Events between 11 and 18 centuries.

Name	Year	Cause	Region	Death Number	Other Effects
Great Sea Flood	28 Sept 1014	Asteroid strike/	West & South Coast of Britain/ Netherland/ Scotland/	80,000	1-Earthquake/ 2-Tsunami/ 3-Storm Surge/ 4-Mountain Slides/ 5-Flash Flood/
St. Juliana Flood	17 Feb 1164	Storm surge/	Rhine & Elbe estuaries/	20,000	1-Formation of Jade Bight Bay/
North Sea Flood	June-Nov 1212	Misty rain& Cyclone/	English & Netherland Coast/	60,000	1-Buildings collapsed/ 2-Road uprooted/
St. Marcellus Flood	16 Jan 1219	Storm Tide	West Friesland & Groningen	36,000	It had enormous consequences on the development of the two larger inner seas/

St. Lucas's Flood	14 Dec 1287	Heavy Storm	Amsterdam/	50,000	Direct sea access for the villages of Amsterdam/
St. Clements Flood	23 Nov 1334	1-Severe Storm 2-Dike breaks	Dutch & Flemish Coasts /	Several thousand	All frontal dunes were washed away, towns were abandoned to waves/
St. Mary Magdalena Flood	22 July 1342	Hurricane	Germany/ Austria/ Italy/	6,000	Destroying house, mills, bridges/ Great Erosion/ Famine/
St. Marcellus' Flood	15 Jan 1362	European Windstorm/ Storm tide/ Storm surge/	British Isles/ Netherland/ Northern Germany/ Denmark/ Ireland/	25,000	1-Drowning/ 2-Home, buildings, churches, and towers were destroyed/ 3-Thousands of trees were blown/ 4-Changing the shape of coastal lines/ 5-Helping to form Zuiderzee (inland body of water) /
St. Elizabeth Flood	18 Nov 1421	Heavy storm/ Levee breach/	Netherland/	10,000	1-Dike breaks/ 2-Villages swallowed by floods/ 3-Dordrecht became island, and it separated with Geertruidenberg

St. Felix	5 Nov 1530	Storm / High winds/ Extremely high tides/	Netherland/	100,000	1-Reimerswaal city together with eighteen villages were destroyed/ 2-Zeeland was hit by storm and flood, it was left isolated as a small island/
All Saints' Flood	1 Nov 1570	Windstorm/ Levee breach	Netherland & neighboring countries	20,000	1-More thousands homeless/ 2-Unprecedented heights of water/ 3-Broken innumerable dikes on Dutch Coasts/ 4-Livestocks, fodder and food lost/ 5-Small islands were permanently lost/
Bristol Channel Flood	30 Jan 1607	Storm surge/ High Tide/ Tsunami/	England/ Cardiff/ Devon/ Somerset/ South Wales/	2,000	1-Drowining/ 2-Houses and villages were swept away/ 3-51.800 ha of farmland inundated and livestock destroyed/ 5-High water level rises/

Burchardi Flood	11 Jan 1634	Storm Tide/	North Frisia/ Dithmarschen/ Germany	1, 000	Much of the island of Strand was washed away, forming the islands Nordstran, Pellworm, and several Halligen/
St. Martin's Flood	12 Nov 1686	Levee breach/	Large part of Groningen	1,558	1-1,387 horses and 7861 cows died/ 2-631 houses were swept away and 616 houses damaged/
Great Storm	7 Dec 1703	Extratropical cyclones/ High winds/	London/ South of Great Britain/	8,000	1-2,000 chimney stacks collapsed in London/ 2-4,000 oaks damaged in New Forest/ 3-Ships were blown hundreds of miles, and over 1,000 seamen died on the Goodwin Sands alone/ 4- Up to 130 km/h wind speed destroyed more than 400 windmills/
Christmas Flood	24 Dec 1717	Northwest Storm/ Dyke breach/	Scandinavia Germany/ Netherland/	14,000	1-Drowning/ 2-The damage to dyke and sluices were immense/ 3-Missing people/ 4-Large number of cattle were lost/

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

It can be understood from the table that storms, volcanic eruptions, earthquakes, asteroid strikes, heavy precipitations, strong winds, snow accumulations, ice occurrences and water resources may

lead to flood events together with its damages, especially when the places or cities or regions are not ready against such as natural phenomena. Preparation of those places against natural disasters will eliminate the damages or losses; therefore, any kind of city or settlement places must be designed against natural disasters primarily, and those places need Official Natural Disaster Risk Reduction Plans (ONDRRP) to eliminate the losses or risks. To create proper plans, experts need to have geographical, topographical, hydrological, climatological, astronomical information and its parameters to design and prepare those places against natural disasters. This information can be described as Natural Disasters Risk Information System (NDRIS). Cities, regions, basins, settlement places or other disaster management plans must primarily be created with this stable, accurate and revised information obtained or produced. Those data or information obtained must be accessible to everyone through official webpages. When a change occurs in the values of parameters with new broken records or any kind of changes, available plans or records for the region must be revised, updated and modernized immediately.

Natural events might offer benefits to a region or a city when they are controlled or managed properly in a suitable and sustainable ways or plans. They might be transformed into benefits as well so experts must focus on how to get benefits from extreme events. If a natural event does not provide benefit to a region or a city or a settlement places, expert must consider that there is a lack in the management, which means the management needs new concepts to get benefits from this extreme event. For example, flood events are related with heavy precipitation and uncontrollable water resources. When heavy precipitation and water resource can be collected and controlled well, those risks can be transformed into benefits or abundance instead of losses or damages.

Flood management activities consist of three stages basically. These are pre-flood activities, during flood activities and post-flood activities. Three PPPs must be considered and implemented dependent on all those three stages separately. All flood plans must be created in this concept, and benefits must be considered in every stage and in the implementations of those activities. ONDRRP and NDRIS are a part of pre-flood activities. When the flood events continue to destroy a place more than two times with deaths, loses or damages, it means that flood management, precautions and state decisions or managements are not successful in there; therefore, new precautions, deeply changes on the plans and the management concepts, and reforms in the flood management activities are required to eliminate the possible future risks until finding the ideal, the true and the stable solutions with minimum or zero damages or losses.

Flood management was not successful in northern-west Europe during the period of the table at above. Repetitive deaths are proof for this reality. Many flood management sources praise the flood management of today's Netherland. If Netherland is successful in this flood management today, the main reason is the repetitive deadliest flood experiences that have occurred since centuries. But even today floods may still continue to damage the Netherland. For example, a flood event on 23 June, 2016 due to heavy storm hit the Netherland again (DutchNews.nl, 2016). The main reason of this high frequency flood event occurrences in Netherland is that this country is a low-lying area; in other word, its elevation is so close to water level and to the North Sea. With the combination of extreme weather events, this low-lying country has experienced many deadliest flood disasters since centuries.

Those flood events in the table give a clue related with flood management in fact. It can be stated that; i-) if a place or city or region are close to water resources and they are in the intersection zone of water resources such as river, sea or ocean, ii-) if places or region have low elevation compared to surrounding areas, iii-) if they include high population, iv-) if the character of the seasonal distribution of rainfall or precipitation are high with extreme weather condition in there, and especially; v-) if infrastructure or plans in this region do not meet the capacity of precipitation or extreme weather conditions and the needs of population, it can be expressed that those places are extremely high flood risk areas, and flood losses or damages are inevitable results in there.

Keep in mind that the infrastructure of a settlement places or a city or a region must be designed and revised depending on climate parameters or the characteristics to eliminate flood risks, and other disasters primarily. Topographic, geologic, geographic and hydrologic characteristics are very significant characteristics too, and no doubt that all the properties and limit values of those characteristics might change with time; therefore, revision and updates are required when changes occur in the regime.

The saint names of flood events started to change in the world after 18th century. Most deadly flood events until now occurred between 19 and 20 centuries according to literature. Main reason of this interval is that such as floods were occurring always in other parts of world before but there were no proper records or awareness to the events. After the 18th century, awareness started to develop toward flood issues. Records, press media and science began to develop so much. Many revolutions occurred, new national states and international organizations started to be born during this period, and they began to work together in the light of science against natural disasters. Records or data started to be collected all over the world against flood events. Therefore, the disaster events or its damage became more visible than before. Technology developed so much to eliminate the any kind

of natural disasters but sometime technology's itself or mismanagement of the technologies damaged so much than flood disaster's itself. All of these developments in the world were an experience learned for the flood management and possible future flood events. It can be stated even today this experience and technological struggle for better flood management against possible flood events continue without stop.

3.1.2. Significant Flood Events on Earth

Most deadly flood events on earth occurred between 19 and 20 centuries. In this part, the floods that caused to more than 1,000 deaths will be discussed. For example, 10,000 people lost their lives in 1824 St. Petersburg flood in Russia. It is just an example in the 19th century for a deadliest flood. Deadliest floods in human history generally became in China. No doubt that the main reason of the deadliest effect of floods in this country is due to high population of China, which is number one in world population but other factors were reasons too. Major badly affected countries from such as deadliest floods in world are generally in the Asia, South Asia and East Asia countries such as China, Bangladesh, India, Pakistan and Philippines. Some other countries affected by great flood disasters were in the South America such as Peru and Venezuela and in Central America such as Guatemala. All these regions are either under the effects of monsoon systems or the rain forests; therefore, it can be expressed that the regions under the effect of monsoon systems and rain forests are highly risky regions for possible deadliest flood events. Also, when those places include high precipitation together with high population and that infrastructure is weak to meet the precipitations, the severity and the risk of deadly flood events occurrences become so extremely high. Great or deadliest flood damages generally occur in such as specific places repetitively.

3.1.2.1. China floods. There are six flood events in China's history that affects the flood history of the world deeply after 19th century. Two of those flood events has million deaths, and they are most deadly flood events in the known world flood history. These flood events are 1887 Yellow River Flood and 1931 China Floods. These tragic flood events still continue to show the importance of quality flood management to human beings or governments as most deadly flood events in human history. The four other deadly flood events in China were 1911 Yangtze River Flood, 1935 Yangtze River Flood, 1938 Yellow River Flood and 1975 Banqiao Dam Failure. In the future, there is no guarantee such as flood events that will not occur in any part of the world, especially in this changing climate and growing population regime. Those deadliest flood events are so important and great experience today for the world to shape the future of flood management and control against such as possible deadly floods events on earth, especially under the risk of climate change. Climate and

hydrological regime of regions need to be determined accurately. Population, infrastructure planning must be designed very well dependent on this determined climate and hydrological regime. Systems, infrastructures and plans in regions must always be ready to the update when a change occurs in the limits of determined regime as well.

Yellow river floods. Yellow River is the 2nd longest in Asia and the 6th longest river in the world. It provides a domestic water supply for more than 100 million people. Yellow River originates from the Qinhai-Tibet Plateau in the Kunlun Mountains, and it passes through nine provinces in China. These provinces are Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan and Shandong provinces. There are many tributaries of the yellow river and famous ones are the White, Black, Huang Shui, Tao river, Qingshui river, Zuli, Daxia river, Kuye river, Dahei river, Wuding river, Fen river, Wei river (largest one), Qin river, Luo river and Dawen river. After passed through the nine provinces in China, Yellow river flows into Bohai Gulf. Yellow River changes course in the flow so it causes extremely damages in the region. After flows out across North China Plains especially; it creates new routes to reach to the sea, and destroys everything on its way. It is not easy to know which way or route it will flow as well; therefore, extreme damages become inevitable in the yellow river. The water in the river is yellow color so it takes this name as yellow. The reason of this yellow color in the river is the silt nutrient rich sediments that mix to the river from Loess Plateau, which makes it perhaps the muddiest river in the world. Yellow River carries 1.6 billion tons of silt every year, and approximately 1.4 billion tons of silt reaches to Yellow sea. One estimate expresses river transports 34 kg/m^3 of silt (Baidya, 2017).

There are three stages of river: upper, middle and lower reach in the yellow river. The upper reach is particularly water scarce all year while low reach, which takes approximately 70 percent of precipitations, is prone to flooding. The majority of the sediment resources are in the upper and middle reach. In the upper reach, the average sediment concentration is around 6 kg/m^3 and the average sediment transport is around 142 million tons. In the middle reach, soil erosion due to the fine grain sizes and restricted vegetation from Loess Plateau causes a huge sediment load, especially during storms. The sediment concentration in the river can reach to the concentration of 500 kg/m^3 during storms (Li, 2001).



Figure 3.1. China's Geography: its Mountains, Basins, Rivers and Plains

(Source: <http://www.chinasage.info/geography.htm>).

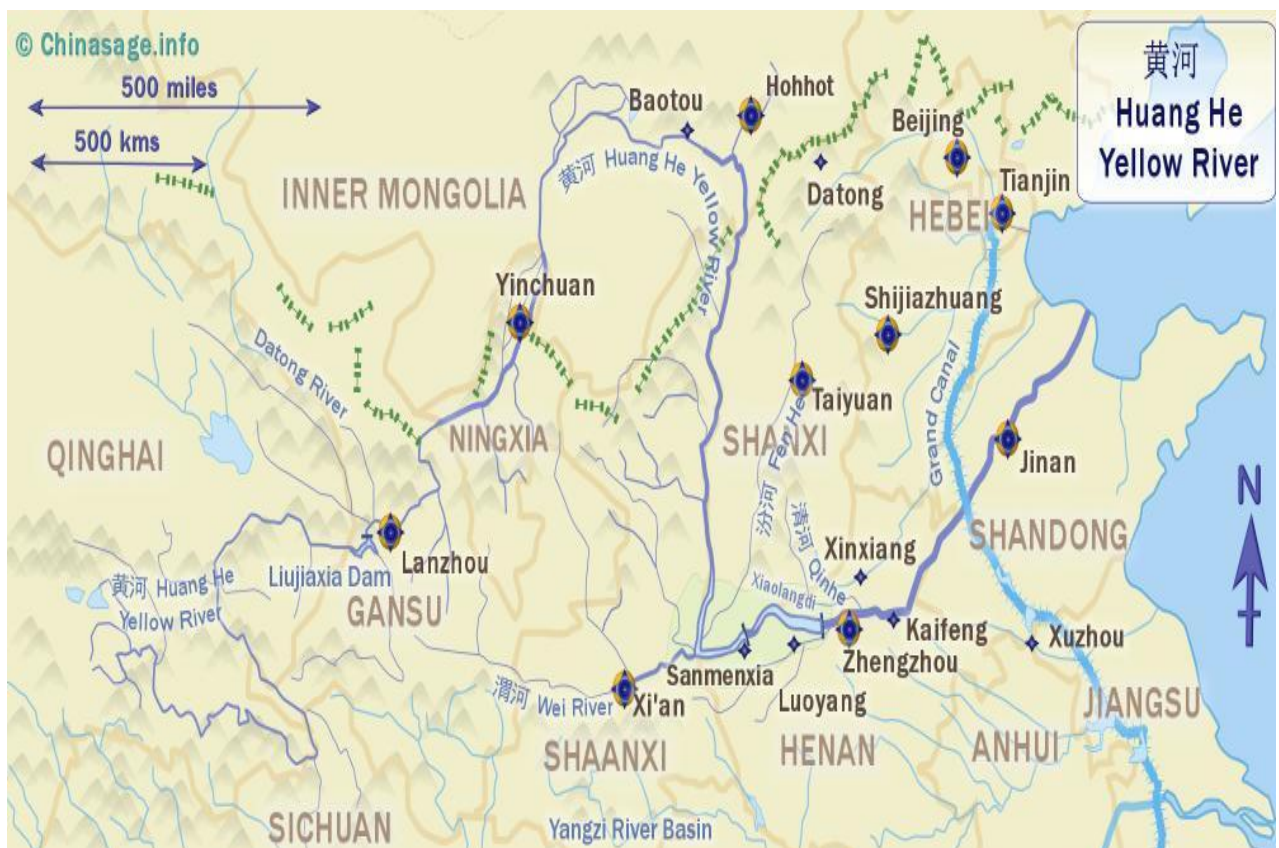


Figure 3.2. Yellow River-Huang He (Source: <http://www.chinasage.info/yellowriver.htm>).

Table 3.2. Characteristics of Yellow River basin.

Length	5,464 km
River Basin Area	752,546 km ²
Discharge Volume	Min.: 1,030 m ³ /s Av.: 2,571 m ³ / s Max.: 49,000 m ³ / s
Annual Average Runoff / Average Rain fall	58 billion m ³ / Approx. 500 to 650 mm / year
Years and death numbers of great deadly flood events in the river	1332-1333 (7 million deaths), 1642 (300,000 deaths), 1887 (2 million deaths), 1938 (800,000 deaths);
Stages of rivers	Upper Reaches: Length: 3,472 km Basin Area: 386,000 km ² Characteristic: Clean water by crystal clear lakes Elevation drop: 3,496 m Middle Reaches: Length: 1,206 km Basin Area: 344,000 km ² Characteristic: Yellow color due to getting muddy and slit-laden Elevation drop :890 m Lower Reaches: Length: 786 Basin Area: 23,000 km ² Characteristic: Yellow due to silt. Silt deposits cause the rise of river bed above ground. Elevation drop: 93.6 m

There are some discourses that yellow river flood caused to death of 7 million people in the year 1332-1333. It does not seem possible to prove this discourse but If this expression is true, there is no guarantee that such as great or deadliest flood events will not occur in the future on earth. There is a

great proverb in Turkish literature; “History repeats itself.” Therefore, recording and reporting the historical events objectively, properly and correctly are very important work to learn from past events to have experience and are a kind of investment for future to prevent or minimize new possible flood disasters.

Man-made floods in the yellow river during the war time occurred in China according to some sources. State managers ordered to broke the dikes of the river to damage the rebels, and troops broke the dike but destroyed public and themselves instead of rebels in 1642. Drowning, famine and plaque due to this man-made or state-made flood by troops lead to the death of 300,000 people in the country (Lorge, 2005).

Heavy rainfall caused to 1887 yellow river flood in China on September. Yellow river overtopped its banks in Henan province, which is in the lower reaches of the river. Dykes collapsed unexpectedly, and water started to spill over the land in the basin. In the region, 8,050 km² areas were inundated, and 900,000 people lost their lives in the event. This number reached to 2 million with flood effects such as famine, cold and plaque, and 2 million people became homeless after the tragedy. Drowning and sweeping caused to deaths majorly. Temperature was very low, and there was strong wind on the day of tragedy, which made people feel colder than it was. Many people escaped to high places such as hill, mountains, terraces, trees and so on to protect themselves from the deadly river flood but people lost their lives from cold and hunger in those places except for drowning or sweeping. Organizations, rescue operations, their resources and their capacity were very little and inadequate for such as deadly flood disaster so this death numbers were inevitable result. Yellow river is named as river of sorrow due to highly death numbers and great damages. Henan region is close to the mouth of river and to the sea level, and the average elevation of this province is less than 183 m. It can be stated that plain or low elevation regions played key role in this flood event together with heavy rainfalls. This event shows the risk of low elevation regions again and again. In the flood management, low elevation regions and plains must be determined, and protected very well against flood risks.

If China learned lesson from history, next deadliest man-made flood would not repeat itself in there. The other great man-made flood in China occurred in 1938 during war against japan invasion. Chinese troops broke the levees of rivers again to prevent the Japanese troops from invasions or advancing. Many Japanese and Chinese troops lost their lives together in the man-made flood event. Approximately 800,000 people lost their lives because of broken levee of yellow river by Chinese troops (Taylor, 2009).

After 1945, Chinese authorities started to control normal floods in the yellow river very well but water diversion activities to control flood events and to benefit from waters lead to the drying events in the river. In the year 1972, Yellow river dried first time in history. Many dams have been built to control flood events after historical deadliest flood events. The Dams have diverted water resource of yellow rivers to other places or regions to use those waters in the activities such as irrigation, industrial use, energy use, drinking and so on. No doubt that such as water diversion activities affected this first dry event in the yellow river's history.

After 1972, many drying events started to be common in yellow river and especially in 90s. For example, in 1992, the river dried for 122 days, in 1996 for 136 days, in 1997 for 227 days. Global warming is other reason in this drastically water level drop or drought in the region. After 1990s, the zero flow in the lower reach started to be more frequent than before as well; for instance; in the 1995, the length of zero flow in the lower reach was 683 km in the river (Kemink, 2002).

Total population of yellow river basin is 98 million, and total arable land of the basin are 11.93 million hectares, which is 12.5 percent of the total of nation's arable lands. Yellow river grows more than 50 percent of China's wheat, tobacco and cotton today. Flood control and management must be a continuous effort in the river because great damages can occur anytime against humans, properties, agriculture and industry due to floods. Major Risk for flood in yellow river today is the extreme erosion in Loess Plateau due to human activities such as deforestation, extreme cropping and overgrazing etc. Proximity of those activities or settlements to the river is a great risk as well. Settlement places in the region must be planned, designed, transformed and protected very well in the river basin against flood risks, climate risks, erosion risks, pollution risks, landslide or mudflow and other geographical hazards or characteristics. If settlements are under the great risk in the basin with regards such as features, they need evacuation and movement to suitable or secure places by authorities.

Forest and grassland are mainly located in upper and middle reaches in the basin. The forest area is 10 million hectares while the grassland area is 28 million hectares. Forest area and grassland in the basin are very significant in flood management. Such as green areas must be protected very well because they absorb water and prevent the flood due to high infiltration rates. Erosion in such as areas must be prevented with forestry management methods, plans, programs or activities designed by forest engineers or Ministry of Forestry. Especially afforestation activities with suitable and adaptive plants that have high infiltration rate in the monsoon climate will contribute to the prevention of erosion and floods in the region.

In the Yellow River basin, total land of the basin is 79 million hectare and 75 % of the total land area is mountains and hill sides. This percentage makes the basin risky against snow melt flood that will come from hillside or mountains toward plains or low elevation regions and settlement places. Plain lands consist 17 % of the total land. Plains that are close to mountain and hillsides are under great risk inevitably, especially due to high precipitation of monsoon climate and snow accumulation in the mountains.

Floods in the river occur between July and October due to storm in general. The frequency of flood events in the yellow river due to storms is high in the months of July and August than September and October. Ice jam floods are common in the months of February and March in the river basin. For example, The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured two images at related with ice jam flood in Yellow river. The first image in the Figure 3.3 was captured on February 26, 2008 before the river melted. The ice is turquoise in the image, which is made with both infrared and visible lights. On March 19, yellow river burst through sections of its main embankment and flooded surrounding homes. About 13,000 people were evacuated in the flood according to the China government. The other image in the Figure 3.4 was taken on March 24, 2008, after the river melted. Figure 3.5 shows the combination of the two images. The ice is turquoise in the image of February before the ice melted. The melting ice is dark blue or black in the image of March after ice melted. Blue lines the river where water flows under and around the ice. The river in the image is swollen when compared to February image and it seems to have broken through embankments on its southern banks deliberately. The government planned to channel water away from populated areas near breached embankment into an old river bed, said the Ministry of Water Resources of China on March 24. The government also redirected water from the river into Ulansuhai Lake for first time to minimize the flooding. As a result, satellite data or images and earth observation data from space are so precious in the flood management and control, especially for early warnings to save the lives (NASA Visible Earth, 2008).

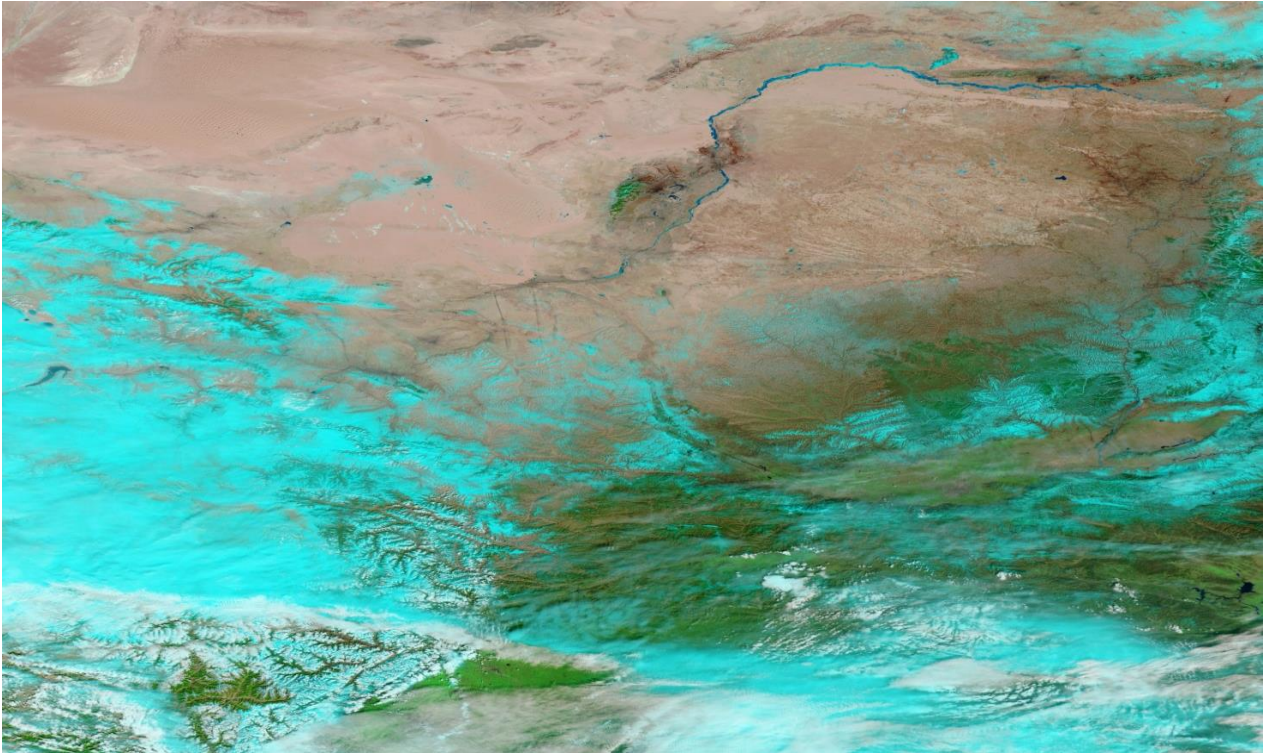


Figure 3.3. Yellow River Satellite Image on 26 Feb, 2008 before ice melted, captured by MODIS on NASA's Terra Satellite.

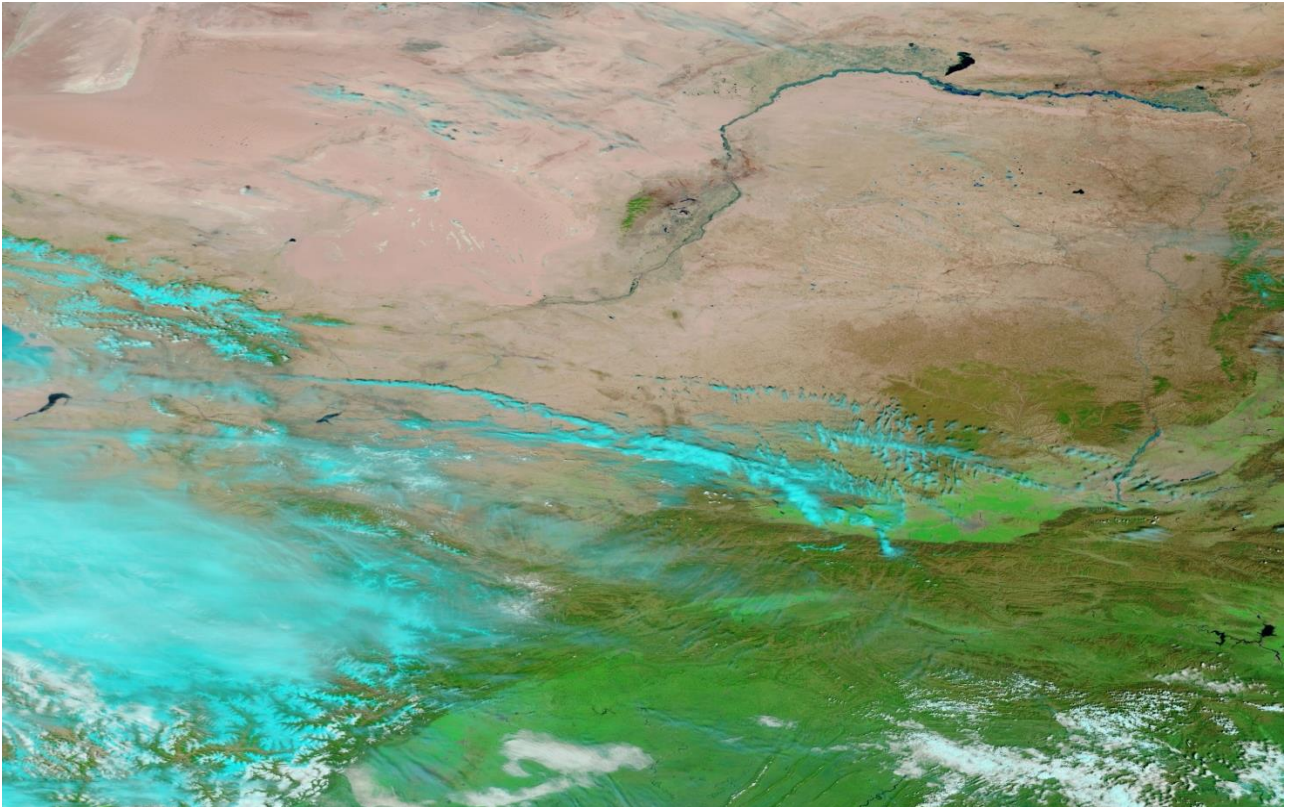


Figure 3.4. Yellow River Satellite Image on 24 March, 2008 after ice melted, captured by MODIS on NASA's Terra Satellite.

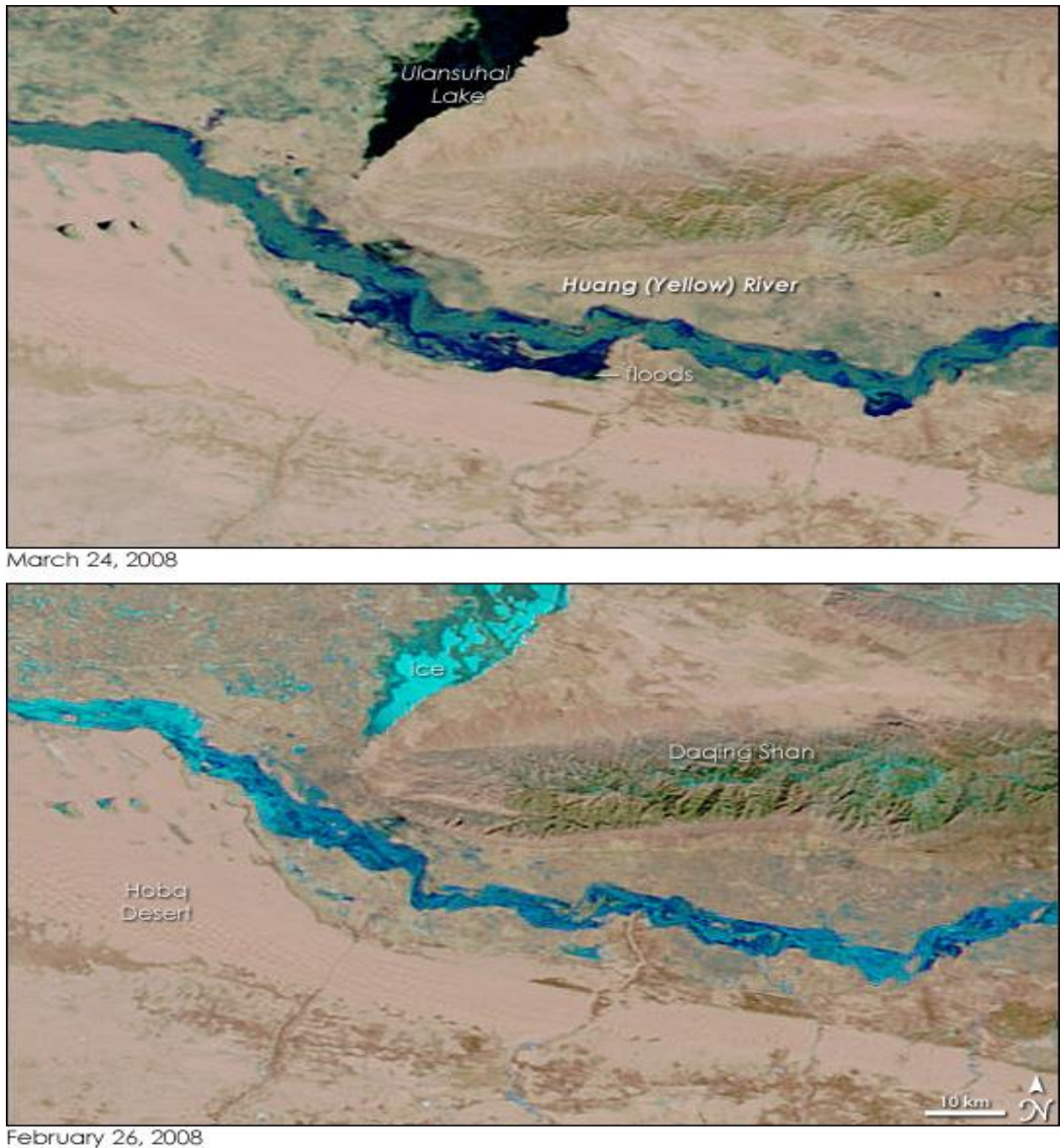


Figure 3.5. Yellow River Snow Flood Comparison Image, captured by MODIS on NASA's Terra Satellite.

Yangtze river floods. Yangtze is the longest river in China and the 3rd longest river in the world. Yangtze starts on the south west side of Mountain Geladendong, which is the highest peak in the Danggula Mountains on Qinhai-Tibetan Plateau, and it empties East Sea at Shanghai. Yangtze flows through ten provinces, and these provinces are Qinghai, Tibet, Sichuan, Yunnan, Hubei, Hunan, Jiangxi, Anhui, Jiangsu and Shanghai. Yangtze has more than 700 tributaries but includes 8 principal tributaries; Yalung, Min, Jialing, and Han are tributaries on the left banks while the Wu, Yuan, Xiang and Gan rivers are tributaries on the right banks. Han is the longest tributary of the river. Yangtze

accounts for 35 % of China's total fresh water resource and has over 20 times the flow rate of yellow river. The Three Gorges Dam in Yangtze is the largest power station in the world by the capacity 22,500 MW. It has 183 m height and 39.3 billion m³ storage capacity, and it generated 98.8 Terawatt-hours (Tw-h) power in 2014 as world record. The dam aims to increase shipping capacity in the river and reduce the potential for flood events by providing flood storage space except for electricity or power generation.

Approximately 400 million people live in Yangtze watershed. The river carries three-fourths of China's internal waterway commercial. Nearly about 210,000 ships travel on the river, discharging about 360,000 tons of oil-contaminated wastewater and sludge, in addition 75,000 tons of other waste. Pollution is very high in Yangtze because 10,000 petrochemical factories lie on its banks. 25 billion tons of wastewater generated in China, which is nearly 40 percent of all China's wastewater, flows into the river. Only 20 percent of this wastewater is treated before flowing into river. It is polluted with 40 million tons of industrial and sewage waste; therefore, it can be state that pollution is high in the river. Harvest aquatic life decreased because river is in danger of becoming dead which is unable to support marine life and provide drink water. "As the river is the only resource of drinking water in Shanghai, it had been a great challenge for Shanghai to get clean water, said Lu, also a member of the National Committee of the Chinese People's Political Consultative Conference, the country's top advisory body." (Chinadaily, 2006). Pollution prevention measures in the river basin are very significant for flood management and control. If those measures are not enough in the river to cope with pollution, both pollution and flood together will be great threat to living creatures and create synergistic harmful effects to the surrounding environment or humans with various diseases when a flood event occurs. All economic activities must be planned very well to prevent pollution in the region.



Figure 3.6. Yangtze River (Source: <http://www.chinasage.info/yangziriver.htm>).

Table 3.3. Characteristics of Yangtze Rive basin.

Length	6,397 km
River Basin Area	1,808,000 km ²
Discharge Volume	Min: 2,000 m ³ / s Av.: 30,166 m ³ /s Max: 110,000 m ³ / s
Annul Average Runoff / Average Rainfall	951.3 billion m3/approx. 1,000 to 1,150 mm
Years and death numbers of great deadly flood event in river	1911 (100,000 deaths) 1931 (4 million deaths) 1935 (145,000 deaths) 1954 (30,000 deaths)
Stages of river	Upper Reaches Length: 4,504 km Basin Area: 1,008,000 km ² Characteristic: Turbulence Elevation Drop:5,621 m (6,621 m to 1,000 m) Middle Reaches Length: 955 km Basin Area:680,000 km ² Characteristic: Silt accumulation, sediment Elevation Drop:808 m (1,000 m to 192 m) Lower Reaches Length:938 km Basin Area: 120,000 km ² Characteristic: Fluctuation in water volume Elevation Drop:152 m (192m to 40 m)

Every year minimum several hundred people lose their lives in the Yangtze River basin. This is an average yearly, and death numbers can reach to thousands or even millions with synergic effects. The flood in 1931 is an example to this synergic flood event in the Yangtze. Nearly 70 or 75 percent

of China's all floods occur in Yangtze. There are some claims that Yangtze caused to great damage with great death numbers in 1870 and in 1911. Death numbers are more than 100,000 for the 1911 flood event; however, records and sources in literature are not enough to explain the Yangtze flood events clearly for the years of 1870 and 1911.

China flood events in 1931 occurred on August. Locations or basins of the flood events include Yellow River, Yangtze River, and Huai River. It is deadliest riverine flood in human history. 180,000 km² land area were completely inundated for the report of National Flood Relief Commission (NRLF). The high-water mark recorded on 19 August at Hankou in Wuhan showed water levels 16 m above the average (Winchester, 2004). The 1931 China flood caused to million deaths due to drowning and created approximately 80 million homeless people. Death numbers reached to 4 million with diseases and famine after the event for western sources. 2,000 people drowned in their sleep in the city of Gaoyou in the resulting deluges on 25 August for the report of NRLF. Typhus, cholera, measles, malaria, dysenteries and snail fever were common observed diseases after the flood event and its destructives damages. Farmlands or crops, especially like wheat and rice are destroyed and the price of vital commodities increased sharply in the country. Famine occurred and caused to deaths of millions. Families sold their babies to survive and cannibalism events occurred to live in the region (Courtney, 2018).

Before 1931 China floods, droughts were affecting the country during two years. Drought might be clue and stimulant for future dangerous food events. It can briefly be stated that after long drought in a basin or a region, flood events can be an expectation in great possibility, and dangerous floods may occur as a result of precipitation in there. This expectation is perfect stimulant for spring or summer season floods under the possible heavy rain conditions after long period of drought.

Continuous measurements of river levels and speeds are very significant to understand the regime or characteristics of river flow. Warning levels of the height and speed in the measurement stations for each months of the year must be determined and recorded depending on available measurements in the river. If river height excesses the warning levels in the winter months or the river flows so fast or so closed to the warning values for a long time, especially under the conditions of snow accumulation in mountain or hill regions in the river basin, this situation is a great sign of a dangerous flood risk, especially for the spring or summer months. In the other words; river level, the speed of river flow and snow height in the mountains or hills in winter time are decisive flood stimulants for possible great flood events in spring or summer months, especially when the river or

water level and the speed of flow do not decrease to the average river levels at the end of the winter months under the condition of snow and ice accumulation in high elevations.

Heavy rains in the spring and summer months are so dangerous and great flood stimulants. Dangerous floods become inevitable around low elevations that are close to mountain regions in the river basin. Therefore; the frequency and the average levels of spring and summer rain precipitation in a region or a basin are very significant for flood events or warnings, especially in mountain regions that are close to river basin or water resource via the snow and ice melting. If average summer precipitation in a region is close to the average spring precipitation or the average summer precipitation is higher than average spring precipitation during minimum 30 years measurements in a region, it can be stated that this region is under great flood risk climatically, and it needs special prevention, protection and plans against flood events.

In the summer months of 1931 extreme cyclone events occurred before the 1931 China Flood. Average was two extreme cyclone events per year for summer months in the region; however, nine extreme cyclone events occurred in 1931's summer. As a result, it can be expressed that extreme cyclone events on summer months are a flood stimulant for next months, and keep in mind that autumn includes so much rain precipitation generally and this situation is very significant to understand the extent of floods in the rivers after summer events, especially in the confluence regions where more flowing bodies of water or tributaries came together. Such as regions and the areas that are close to confluence zone and the tributaries of rivers must be controlled very well because of being major flood risky regions. In 1931 China flood, such as regions or settlements or areas that remain between main streams and the tributaries of Yellow River, Yangtze River and Hui, which is a tributary of Huai River, are badly affected due to synergic flood effects. Otherwise, such as great death numbers or damages in the 1931 would not occur. For example, Qinghai, Sichuan, Shaanxi, Henan, Hubei, Anhui and Jiangsu provinces in China are under the great flood risk because of remaining among Yellow, Yangtze and Huai rivers as provinces. Other tributaries and confluences of the rivers in addition to heavy precipitation, snowmelts, high population and pollution in the region lead to extra great synergistic flood risk contributions for those provinces.

Keep in mind that pollution observation and pollution prevention plans or techniques in the river basin are extremely significant for public health and ecosystems. If pollution increases in river, the polluted waters will spread to the area under the condition of a possible flood event and lead to many types of epidemic or contagious or acute or chronic deadly diseases in the region for humans and ecosystems due to this pollution level except for deadly physical flood risks of the river. For example,

while the indirect effects of 1931 China flood was still continuing in the area, another great Yangtze floods hit the China in 1935. The flood caused to death of 145,000 people. It was another new tragedy for the region before recovering from the effects of 1931 flood event completely. The flood event was due to heavy rain on early summer one more time. Drowning and dragging were major death reasons but effects after catastrophe were other tragedy in the region. Crops, especially rice had been lost and the water was not suitable to replant. People who survived in this catastrophe died due to little food or no food, and diseases. Floods and corpses in the region gave rise to diseases such as Malaria, Dermatitis, Conjunctivitis, and Tuberculosis. The experiences learned from the China flood events appear once again that flood managers or authorities must take consideration famine and diseases in the flood management plans.

Tianjin is a city located along the Hai River, which connects to Yellow and Yangtze Rivers via the Grand Channel. In 1939, 20,000 people lost their lives in the flood. The provinces that remain between Yangtze and Hai River are highly risky against flood events as a result. Those cities include Inner Mongolia, Shanxi, Henan and Shandong. Except for those provinces, Qinghai, Sichuan, Hubei, Anhui, and Jiangsu in China are other great risky provinces because of remaining among Yellow River, Yangtze River and Huai River.

1954 flood in Yangtze occurred in Hubei province mostly. The reason of the 1954 flood is due to unusual high volume of the river together with extraordinarily long rainy season from June to September. Water level in the river started to exceed its normal values at the end of June. Although water diverted into flood gates to reduce the level, it continued to rise and reached record levels. Continuous regular water level and speed measurement are significant to understand the hydraulic regime of the river and to determine the maximum, minimum, average height, flood warning level or speed, volume of the water together with storage capacity of reservoirs. In the 1954 Yangtze flood, the maximum water level was 44.6 m in Jingzhou, Hubei and 29.73 m in Wuhan. Nearly 33,000 people lost their lives in the disaster.

China government decided to build dam in Huai River to prevent severe floods in the Henan province and to produce electrical powers. Banqiao Dam construction project completed in 1952 but cracks in dam and in sluice gate appeared because of construction and engineering errors after completion because dam's standard was very low due to absence of hydrological data, and dam was designed to tolerate 1-in-1000 years flood according to sources but it received 1-in-2000 years flood in the 1975 flood event. Typhoon Nina, which is the fourth- deadliest of tropical cyclone on record, hit the region in China and Taiwan in 1975. The highest wind speed of typhoon was 250 km/h and

lowest pressure of it was 900 mbar while record rainfall was 189.5 mm/h. Average annual precipitation was 800 mm in the region before the event but typhoon caused to 1,060 mm rainfall in a day, which is more than a year's rainfall. Banqiao dam together with 62 other dams in Huai River basin failed in the events. The Banqiao Dam failure caused to a huge wave, 10 km wide and 3-7 m high to rush downstream at 50 km/h, inundating the lower area with spreading floodwaters (Tyrell, 2016). Nearly 26,000 people lost their lives from flood directly, and 145,000 people died from famine and epidemic. Total 171,000 people lost their lives in the region. Nearly 11 million people lost their homes, and total 230,000 people lost their lives in China and Taiwan due to 1975 Typhoon Nina.

After 1954, death numbers started to decrease in Yangtze due to flood management development or activities. After highly deadliest 1975 Banqiao Dam failure, death numbers have decreased in all China since 1975. Despite death numbers in China due to flood disaster are still high, country did not live any kind of highly great flood event that death numbers are more than 7,000 after 1975 dam failure event although its population increases without stop.

Other deadliest China floods. Min River, which is important water transport channel, is a 577 kilometers long river in Fujian province. Basin size of the river is 60,922 km² and it has 1,980 m³/s average discharge rate. Fujian is a high flood risk province as well. The cloud bursts of June and July of 1948 filled the river to overflowing. The 1948 flood event became on summer month again. More than 80 percent of the province was destroyed, 1,000 drowned, and 1 million became homeless by a flood caused by the overflowing of the rain-swollen Min River on 7 August, 1948. For weeks, floating debris and bodies drifted with currents in the Min River (Davis, 2008). Total 3,500 people lost their lives in the 1948 Fujian flood. Flood managers must aware that river level and speed on spring and summer months may rise due to rainfall, snow melt and other factors. Flood expectation is high on those months; therefore; river level and speed must be checked meticulously because it will give flood warnings in great possibility to the managers. Additionally, recording of Cloudbursts' location, its rainfall and its duration in a region will be helpful always for planners or managers to understand the risks and the characteristics of regions or cities. Precautions can be created and implemented depending on characteristics of the region determined via such as data obtained or recorded.

On August 6 and 7, 1951 a flood in Manchuria caused to drowned 1,800 people (Tufty, 1969). In 1951 Manchuria flood, 48,000 people perished, and the flood was due to typhoon. Typhoon is a kind of tropical cyclone and typhoon's intensity, frequency together with its wind speed values are significant parameters in flood management and control. Typhoon may lead to strong wind, waves, foehn, salt wind, surge, heavy rain, flood, landslides and infectious diseases. Therefore, measurement

of wind speed, determination of the category of the wind, prediction of the wind direction, determination of wind regime of the region, contribution of the wind speed to water flow and early warning of possible rainfall or wind or cyclone must be taken into account in the PPPs because of being useful parameters for the plans to take precautions or measures against possible flood events and its effects.

After Banqiao dam failure flood in 1975 due to the typhoon, Sichuan, Hubei and Anhui provinces affected by flood events in 1980, approximately 6,200 people lost their lives. One year later, Sichuan and Shanxi flood occurred in China, death numbers were 2,075 in the 1981 flood. In 1989, Sichuan flood caused to deaths of 3,814 people. The repetitive flood events in 1980s, especially on the summer months such as July and August, prove that Sichuan province is a great flood risk center, and it needs continuous special protection and management plans against flood events one more time.

In 1991, continuous rainfall caused to floods in East China. From 18 May to 3 September, it affected the provinces such as Anhui, Jiangsu and Henan. Total death numbers in 1991 flood were 1,713 according to some sources. New York Times reported that death numbers were 3,000 in the 1991 flood. It can be stated that there are contradictions on reports. Flood reporting issue need consensus globally. There were some claims that China governments hide death numbers. States or organizations, scientists and press services must be objective in reporting issues because true knowledge is required to give true decisions to make true implementations in any kind of discipline. UN Department of Humanitarian Affairs' 1991 China United Nations Disaster Relief Organization (UNDRO) Situation Reports explain the China flood events very well during May-September period. Required information related with 1991 China flood can be obtained from those reports. Reliable and timely information related with any kind of global crisis and disasters can be taken from the "Reliefweb.int" as well, which is a specialized digital service of the UN Office for the Coordination of Humanitarian Affairs (OCHA).

In 1995, total 1,532 people lost their lives, 7 million people displaced and 1.9 million houses destroyed in the flood events. Major provinces in China that affected by floods in 1991 were Jiangxi, Hunan, Hubei, Anhui, Zhejiang, Fujian, Guangxi, Guangdong, Guizhou and Jiangsu. This 1995 China flood information obtained from 1995 Flood Archive Table of Dartmouth College. Other major global flood events in 1995 are available in this table too (Dartmouth Flood Archive, 1995).

In 1996, China floods caused to minimum 2,775 deaths in 21 provinces that remains Yangtze and Yellow river. Large floods occurred on the Huai River in Anhui province. A lake in the region

exceeded its shore by nearly 5 km. Typhoon and heavy rain were major reasons for the floods. The events occurred in summer months between June and August. Nearly 234,000 people were injured, 8 million people were evacuated, 4.4 million people were left homeless, and 8 million acres of cropland were damaged in 1996 floods (Davis, 2008).

1998 Yangtze floods were reported to have killed 3,656 people, destroyed 5.7 million homes and damaged 7 million more, and forced 14 million people to move to new areas. The economic losses were 31 billion USD (Kirby, 2001). Above average rainfall during several months in the regions caused to flood events. The 1998 floods events started in middle June and continued until the beginning of September. Severe floods occurred in the Yangtze, Songhua, Nen and Pearl rivers. Provincial authorities stated that 1998 flood was worse than 1954 flood event but death numbers were low in 1998 compared to 1954 flood in China. The reason was flood management development and continuous flood prevention activities little bit although not enough. According to BBC news environment correspondent Alex Kirby's report, United National Environment Program (UNEP) team identified three factors which had worsened the impact of heavy rain in 1998 Yangtze Floods. These are 1-Deforestation and Overgrazing which reduce the capacity of forests or grasslands to retain water, 2-Loss of lakes and wetlands which cut the capacity of the river's middle and lower reaches to store water, and 3-Rising erosion rate which caused rivers and wetlands to fill with silt. The study of the UNEP team shows that precaution plans to reduce deforestation, overgrazing, erosion together with protection of wetlands and lakes to storage the waters of rivers will eliminate the risks. Consequently, fighting with deforestation, overgrazing and erosion are a flood management and control method. This method will provide positive contribution to minimize the flood losses and its damages in a region.

In 2001, nearly 1,100 people were killed and 1.3 million were left homeless due to flood during the 2001 summer flood season in China. One year later, 2002 China floods occurred and lasted from June to September in central and southern provinces. Bush fires raging in Inner Mongolia for more than 20 days reported in August, which were the worst in last 53 years according to State Fire Prevention Office. Heatwaves caused to several deaths in July and August and an earthquake event in Sichuan, which is in the 5.3 Richter scale, was felt in August. At the end of the month, state of emergency was declared in Hunan province for two weeks because of water level rise in Dongting Lake, which threatened nearly 10 million people. Dongting Lake acted a giant overflow for the flood prone Yangtze River and water level in the lake was 2.15 m above dangerous level. Nearly 1,532 people lost their lives across the China. One million houses and 13.15 million hectares of crops were

damaged. Local governments temporarily evacuated more than 2.4 million people from flood prone areas. Direct economic losses were 8.2 billion USD (IFRC's Final Report-China: Floods, 2002).

In 2004, the disaster killed 1,029 people. Approximately 7.59 million hectares of farmland were affected by floods and the floods caused to a loss of 7.8 million USD (Xinhua, 2004 via Reliefweb.int). Continuous rainfall was the reason of the events. Mountain torrents, mudflows and landslide triggered by floods and caused to this damages or losses. Flood precautions must be taken in mountain region by managers because mountain regions can create mudflows or mountains torrents and landslide due to continuous heavy rain. Settlement places, especially the places that are close to mountain regions need to be protected against possible mountain torrents or mudflows and landslides as well. Such as settlement places under the effect of mountain regions geographically or climatically are highly risky regions, especially in the extreme precipitation conditions.

In 2005, flood season in China lasted from end of the May to September 20. Mountain torrents due to continuous heavy rains damaged the Hunan province on June 1. Nearly 22 people lost their lives, dozens were missing and the death toll reached to 88 in the province on July 3. Nearly 10,000 people have been evacuated in Hunan and 5 million people were affected by the seasonal rains. The country hit by mountain floods after torrential rains. Country was on high alert for future flood and landslides. June 10 flood swept through an elementary school in Shalan, Heilongjiang province, 105 students lost their lives in the event, 15 people were missing. Central government allocated 1.2 million USD to rebuilt Shalan Central Primary School. Soldiers were underway to rescue the humans and agricultural machines trapped in silt at the region. The June 24 water level of Xijiang River reached 26.70 m peak. The river was nearly 9.4 m above the dangerous level in Wuzhou city so 100,000 people evacuated from low areas against possible flood event. Railways caved due to torrential rains in Fujian province. Rescuers placed stones to consolidate the roadbeds in the railway lines, erected flood barriers and disinfected towns or villages against water borne diseases. After continuous rain, death numbers reached 750 people. Storm clouds in Shanghai caused to 60mm of rainfall downpour on June 28. Torrential rain hit the Jinan city on July 2, which caused to severely flooded areas and blocked transport. Many cars and buses were stranded on road. About 140,000 people in Henan, Anhui and Jiangsu provinces along the Huai River have been evacuated on July 12 because of expecting water level rise to 29.3 meters, which was 1.8 m higher than the warning line. Chinese firefighters were helping to evacuate residents by rafts on the flooded roads. Power cuts events occurred for media sources in the region. A bridge on the Hunhe River collapsed on August 13. A truck and two cars fell into the waters at time of collapse. The water level at Wuhan section of Hanjiang River reached 27.91 meters, which is 41 cm above the warning level because of heavy rain

and discharge of flood waters from Danjiangkou Reservoir. Typhoon Talim hit the provinces such as Zhejiang, Anhui and Jiangxi provinces on September 5. Death toll was 73 people and economical losses were nearly 960 million USD. Rainstorms hit Lianyungang on September 20. Consequently, floods and landslide killed 1,292 people and left 332 people missing. Nearly 15.43 million hectares of farmland have been destroyed and 1.22 million houses were damaged (China Daily, 2005). Flood seasons in 2005 killed total 1,624 people in China.

China had experienced its warmest year in 2006 since 1951. Natural disasters including typhoons, floods and droughts killed 3,186 people. Nearly 13.8 million people were evacuated in those disasters. Natural disasters in China damaged 41 million hectares of farmland, destroyed more than 1.9 million homes and caused 33 billion USD direct economic losses (Reuters, 2007).

Continuous torrential rain in 2007 caused to floods and landslides. Most affected provinces were Anhui province in Huai river basin, mountainous Guizhou province, Hubei province in Yangtze River basin, and Sichuan province. Total 1,348 people lost their lives and nearly 5 million people were evacuated in 2007 China floods. For the Ministry of civil affairs, 129 people were missing and nearly 7,200 people were injured in the events. Nearly 26.2 million hectares of farmlands and 1.6 million homes were damaged in 2007 China floods (IFRC report, 2007).

2010 China floods lasted from May to September, and approximately they caused more than 50 billion USD of damage in total 26 provinces of China, mainly they were central and southern areas. Nearly 230 million people were affected in the flood season. Global warming, jet stream, drought and El Nino were claimed behind the 2010 flood events. More than 3,189 people lost their lives and at least 1,056 people were missing because of flood and landslides. Over 15.2 million people were evacuated due to flood and landslide risk. Total 1.36 million houses were destroyed and millions lacked drinking water. More than 97,200 km² of crops were inundated while 2.1 million hectares of farmland were completely destroyed in China 2010 flood. A train derailment event in Jiangxi occurred because of heavy rain and 19 people lost their lives in the event. Drought in the rivers on spring months might be a sign of the flood events on summer months. Drought events occurred in some of rivers of China in 2010's spring, and rivers became flooded on summer in 2010. The Three Gorges Dam's walls had maximum 175 m and water level reached to 160 m in the 2010 flood events so the dam did a controlled release of flooding waters via its spill gates. The flow of the water was at 70,000 m³/s and 40,000 m³/s of the water were released while 30,000 m³/s hold back in reservoir. Without the Three Gorges, this kind of discharge would bring disasters to the downstream areas according to the head of China Three Gorges Corporation (BBC News, 2010).

From 2010 to 2018, china floods continued to cause the losses but death numbers did not become more than 1,000 deaths. Table 3.4 is a summary table of the floods of this section. The study in this section just discussed the years of flood events that caused more than 1,000 deaths for China. China's population is number one in the world, approximately 1,415 billion; therefore, loses of hundreds of people annually in flood events are ordinary incidents, even those losses might be perceived as low numbers in one year while such as death tolls are great losses for the other average or low population countries.

High population in a place means uncontrollable factors in general so it will lead to more chaos events as typical result. China and India are such as countries indeed. No one can cope with the chaos events without human values, intelligence, education, quality and transparent management plans on earth. Consequently; population, population density, environment quality of the region, water resources and river basin plans, meteorological and geographical features, soil and vegetation conditions, geological and topographical characteristics, the quality of transport, energy and infrastructure systems, quality of cities or settlement places and the plans, and the capacity of natural resources together with the quality of economic-agricultural or industrial activities in the region to meet the needs of the human populations are indicators in the any kind of losses and damages. All of those things must be compatible with nature or life for the health of humans and be highly quality and ready against natural disasters to minimize or eliminate the risks and losses.

Table 3.4. The Summary of Other China Floods.

Name	Death Number	Reason	Other Results
1948 Fujian Flood	3,500	Cloudbursts	1-Destroying 2-1,000 people drowned 3-1 million homeless people 4-Floating debris 5- Drifting bodies
1951 Manchuria Flood	4,800	Typhoon	1- Strong wind 2-High precipitation 3- 1,800 people drowned 4-Dragging

1975 Banqiao Dam	171,000	1-Typhoon Nina 2-Heavy precipitations 3- 1,060 mm rain/ day 4- Substandard Construction 5-Dam failure	1-Drowning 2-Dragging 3-Famine 4-Epidemic diseases 5-Nearly 11 million people lost their homes
1980 Sichuan, Hubei, Anhui Flood	6,200	1-Heavy precipitation 2-Risky provinces 3-River Confluence regions	1-Drowning 2-Dragging 3-Evacuation
1981 Sichuan, Shanxi Flood	2,075	1-Heavy Precipitation 2-More than 610 mm rain/day 3- Flood Risky Provinces 3-River Confluence regions	1-Drowning 2-230 villages were wiped out 3-5,000 people injured 4-200,000 homeless people 5-Land, Farmland or crops flooded.
1989 Sichuan Flood	3,814	1-Torrential Rain 2-Flood caused to landslide 3-More than 500 mm rain/day	1-Lanslide caused to deaths 2-Railway, Traffic and Communication cut-off 3-Bridges and motorways washed away 4-Houses collapsed, school, farmland, crop and road damages 5-People were injured, livestock perished 6-People needed food, medicine, medical equipment, construction materials, material for rehabilitation of

			irrigation system and transportation facilities, vehicles, tents, Cotton blankets, Water purifiers and water tanks, Generators,
1991 Eastern China Flood	3,000	Continuous Rainfall -17 May to 19 June: 40 mm -17 July: 1,540 mm peak, average 800 mm rain	1-Death and wounded people 2-Houses collapsed, Houses-hospitals, schools damaged 3-Agricultural lands and crops destroyed, livestock losses 4-Bridges submerged, water pipes, and drainage damaged
1995 China Flood	1,530	Heavy Rainfall River Confluence regions Flood repetitive province	1-Nearly 1,9 million houses destroyed and approximately 7 million displaced 2- Nearly 7,5 million hectares area flooded
1996 China Flood	2,775	Heavy Rainfall Typhoon River Confluence Regions	1-Lake flood occurred as well 2-Nearly 234,000 people injured 3-Nearly 8 million people evacuated. 4-Nearly 4.4 million people were left homeless 5-Approximately 8 million acres of cropland were damaged.
1998 Yangtze Flood	3,656	Heavy Rain Deforestation Overgrazing Lake and Wetland Losses	1-Nearly 5,7 million home destroyed and 7 million damaged

		Rising Erosion Rate	2- Approximately 14 million moved to new areas 3- Villages clinics and Health centers damaged 4-Water Treatment plant and irrigation systems damaged, and people boiled the waters around to drink. 5- Diarrhea, acute respiratory infections, skin infections, conjunctivitis, schistosomiasis and dehydration observed. 6-Injuries occurred from the efforts to reduce the flood effects.
2001 China Floods	1,100	Heavy Rain	1-Drowning 2- Dragging 3-Nearly 1.3 million were left homeless.
2002 China Floods	1,532	1-Continuous Heavy Rainfall 2-Bush fire 3-Heatwaves 4-Earthquake 5- High water level of lake	1-Lake flood occurred 2- Nearly one million houses damaged 3-Nearly 13.15 million hectares of crop were damaged 4-Nearly 2.4 million were evacuated 5-Approximately 8.2 million USD economic losses occurred

2004 China Floods	1,029	Continuous Rainfall Mountain torrents Mudflow Landslide	1-Mountain torrents, mudflow, landslide 2-Nearly 7.59 million hectares were affected 3- Nearly 7.8 million USD damages occurred
2005 China Floods	1,624	Mountain torrents Mountain floods Seasonal rains Torrential rains Heavy precipitation Water level of rivers reached to peak values Storm clouds Typhoon Talim	1-Approximately 15,43 million hectares of farmland have been destroyed. 2-Nearly 1.2 million houses were damaged. Water level reached peaks. Evacuation and power cuts occurred 3-Transport systems such as roads, railways and bridges damaged. Many cars and buses were stranded on flooded roads. Bridge collapsed. Cars and trucks fall into waters at time of the collapse.
2006 China Disasters	3,186	Typhoons Drought Warmest year since 1951	1-Approximately 13,8 million people were evacuated 2-Nearly 41 million hectares of farmland were damaged 3-More than 1.9 million homes were destroyed. 4- Directly economic loses were nearly 33 million USD.

2007 China Floods	1,348	Torrential Rains	1-Nearly 5 million people were evacuated 2-Nearly 128 people were missing and 7,200 people are injured. 3-Nearly 26.2 million hectares of farmlands and 1.6 million homes were damaged.
2010 China Floods	3,189	Drought Global warming Jet stream Heavy precipitation El-nino	1-Nearly 1,056 people were missing. 2-Landslide 3-Nearly 15,2 million people were evacuated 4-Nearly 1,36 million houses were destroyed 5- Nearly 2.1 million hectares of farmland were destroyed 6-More than 97,200 km ² of crops were inundated. 7- Train derailment, transport problems, drinking water lack 8- Nearly 50 billion USD of damage

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

3.1.2.2. India floods. India is one of most flood disaster prone countries of the world. India population is 1.315 billion and 2nd highest population in the world. Nearly 72 percent of total population lives in rural area. India is the world's 2nd in the farm production and approximately 60 percent of the total workforce of India are in the agriculture sector. India needs quality flood management plans in rural and agricultural areas. It is a South Asia country, which is surrounded by Arabian Sea, the Indian Ocean and the Bay of Bengal. Approximately 75 percent of total rainfall in India occurs between June and September. The reason of major floods in India is due to monsoon. In north of the country,

there are Himalayas mountain ranges. It is inevitable that snow accumulation in Himalayas region will create snowmelt floods and foster the river level or speed during spring and summer period.

Bhutan and Nepal in Himalayas are northern neighboring countries of India, the elevation levels of those countries are very high, and they take extremely high precipitation in the world. China and Pakistan are northern neighboring countries of India as well. India remains in the low elevation compared to those countries; therefore, the high precipitations of Bhutan and Nepal together with snowmelts or deposits from mountain regions direct towards India, contribute the riverine floods of Brahmaputra, Ganges, and Indus basins. This situation creates great synergistic flood risks. The risks are not only for India but also Bangladesh and Pakistan. Except for the floods, the Himalaya and sub-Himalaya regions in India are under the risk of the earthquake seismologically; hence, northern settlements of the country have to be very strong and ready against natural disasters. The general location of the Himalayas mountain range map created by Sven Manguard together with Brahmaputra, Ganges and Indus basin maps prepared by Centre for Coastal Zone Management and Coastal Shelter Belt via Ministry of Environment & Forests, Government of India might help to picture the risky regions.



Figure 3.7. General Locations of the Himalayas Mountain Range (Manguard, 2010).

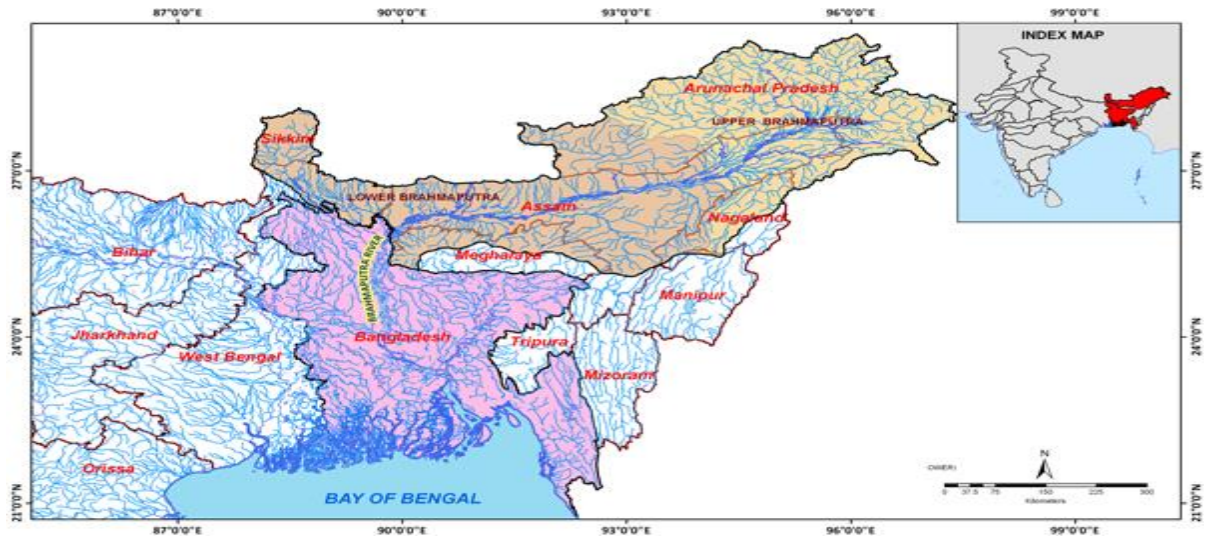


Figure 3.8. Brahmaputra River Basin Map.

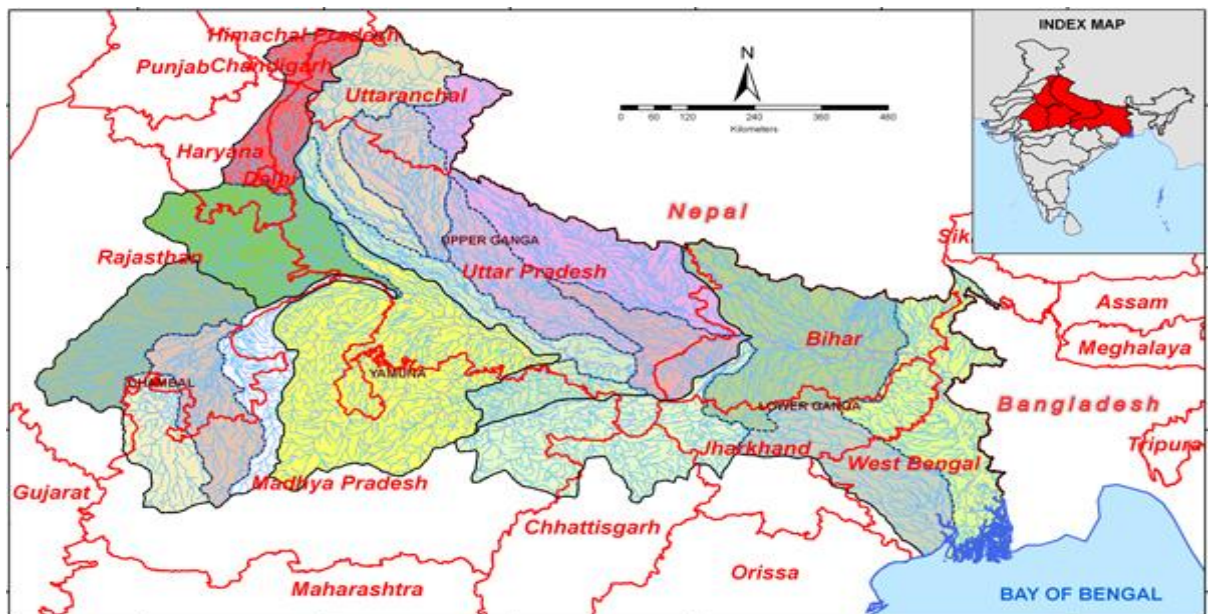


Figure 3.9. Ganges River Basin Map.

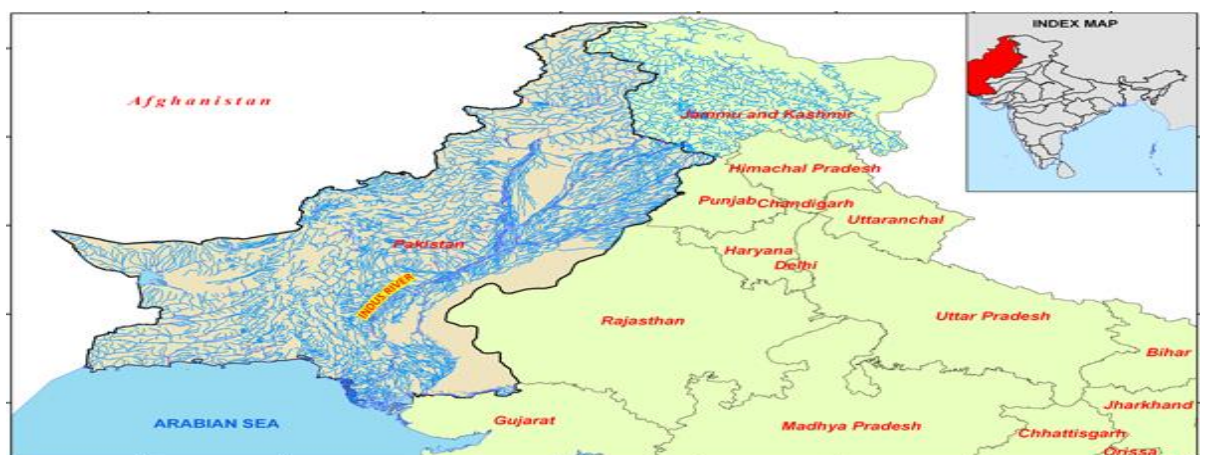


Figure 3.10. Indus River Basin Map.

Consequently, settlements or population of those basins in northern India are under the great flood risks due to remaining in low elevation compared to surrounding countries. The risk of deposits or snowmelt from Himalayas and the extremely high annual precipitations of Nepal and Bhutan create great flood risks in the country.

As for deadliest floods of India, 4 August 1943 Rajputana flood caused to deaths of 10,000 people. Khari overflowed and many villages submerged (Nash, 1976). Rajputana is border with Pakistan and it has two geographic divisions. One of the two divisions is the northwest range that includes the part of Great Indian Desert with the characteristics of being sandy and unproductive while the other is the southeast range that is higher area and fertile compared to the first, and also the region forms the hill and plateau between the north Indian plains and the main plateau of peninsular India for the Encyclopedia Britannica.

In 1955, 1,700 people lost their lives in Northern India floods. Eight rivers in the Orissa section overrun their banks, more than 300,000 people were evacuated, 10,000 villages were completely wiped out of existence by the rushing floodwaters and 28,000 villages were wiped out for International Red Cross (Nash, 1976).

In 1961, the Khadakwasla and Punshet dams, which are near Pune in Maharashtra, collapsed owing to heavy rain and caused to deaths of 1,000 people in the region (Bhattaccarya, 2012). In 1968, 4,892 people lost their lives in Rajasthan, Gujarat Monsoon Rain (Palanithurai, 2009).

In 1978, 3,800 people lost their lives in northern India floods. Monsoon floods cut off Delhi's four million populations. On 6 September, 1978, the city was in the state of emergency with telephone line down, bridges closed and army deployed to cope with the problems. Many home and governmental building submerged. In West Bengal the floods drove 2 million people from their home. People were stranded on treetops or rooftops. Lack of drinking water was serious problem and there were fears that cholera would develop. Water supplies were dropped from the air in the region (The Guardian, 1978).

In 1979, the Machchhu dam in Gujarat collapsed and led to deluge in the industrial city of Morbi located 5 km downstream. Flood in surrounding rural areas destroyed thousands of homes and lives. This dam failure was named as Morbi disaster as worst dam failure in India's history. Ten days persistent rainfall occurred and caused to the floods. The dam nearly received an inflow of 400,000 m³/s but floodgates of dam were designed for passage of 220,000 m³/s of water only. Approximately

floods of 3.6-9.2 m height inundated the low lying area of Morbi city. The dam authorities ignored the repeated warnings from the central authorities regarding the calculation of maximum flood (Wooten and Sandesera, 2011). Exact death tolls are unclear in the event. For state documents, death tolls are between 5,000-10,000 while for the book of Wooten and Sandesera, death tolls are more than 25,000 in the event.

Experience shows that the countries that have high numbers of dams in the rivers must be so careful in the management of the dams, the water level or speed and the surrounding areas which remains in the downstream especially. If there are settlements or industrial areas that are close to dams, those areas are under the great risk of dam failure. Those areas need to be away from dam regions sufficiently; therefore, distance flood parameter is required in the region to implement. Consequently, all settlements, transport systems, agricultural areas, industrial areas or facilities that are dependent on water resources or rivers must be far away from water resources sufficiently and protected well against flood or precipitation risks.

The construction of dams in a country are generally for the aims of energy production, drinking water usage, irrigation, and industrial production to benefit from water resources so much while flood damages or pollution of fresh waters are ignored in general. In downstream of dams, extra protections are required for extreme water level or precipitations for flood control; for this reason, environmental friendly diversion channels might be used to divert the extreme water level or water speed of dams to the artificial wetlands created to prevent the flood events and use flood waters efficiently. Those waters in wetlands can be used for the agricultural, industrial production or irrigation or energy production aims but settlements, agricultural, industrial production areas or transport systems must be far away to main stream or tributaries or wetlands sufficiently as priority.

After environment friendly diversion from main stream or tributaries, the water needs must be met from central water storage areas or stations like wetlands via advance treatment. Wetland implementations will be helpful for ecosystems or biodiversity as well. Directly water usage from main stream or tributaries for irrigation, industrial production and drinking water together with any kind of discharge to the main streams or tributaries or wetlands must be banned and continuous audit are required to reach for those aims by laws.

The excess amount of river water than average flow may be diverted to wetlands or some ponds. Wetlands are so much better choice than ponds, to reduce the floods. After treatment, those excessive waters must be distributed for the use; however, diversions of the natural waters should never be done

if water flow is not higher than the average flow of the month, and also continuing water diversion process under the condition of higher flow must be stopped immediately when the river flow reached to the average flow value of that month at same time.

Wetlands or water collection reservoirs from rivers must have water usage plans, especially when they become full or close to full. Sudden releases of waters from dams to the rivers and the releases via channels from rivers to the wetlands or natural collection reservoirs, especially to the loaded ones, can create great flood problems or damages. Managers must control the blockages or congestions in the stream directions or channels continuously, especially after rainfall warning. The present level, the capacity of channels, wetlands or reservoirs are significant for secure diversion during the process, and also surrounding areas of those wetlands or reservoirs must be protected very well against settlements, human activities, structures or properties continuously. If water loads or the capacity in wetlands or in reservoirs after diversions reach to 85 % of all water collection level designed, diversions to the wetlands or reservoirs must be stopped and those waters must be used immediately after treatment dependent on their consumption or usage plans for the needs of humans, industrial and agricultural production, irrigation or energy production to decrease the water levels in the reservoirs. Otherwise, high loaded water volume or level in those wetlands or reservoirs may flood easily or may not prevent the new possible floods, which will probably come from river or its tributaries via new possible precipitations, new high river water levels or speeds, and also those waters in wetlands might exposed to evaporation or water losses when they wait so much without consumption. The boundaries of wetlands or reservoirs in the area must be so obvious and clear; therefore, flood security signs should be used to specify the borders of wetlands or reservoirs. Maps are required to show the borders of wetlands, the diversion points and its routes, the places of water treatment facilities, the places of channels or other water structures, the place of dams, the places of natural lakes or mountains, nearby settlements, the places of agricultural, industrial and energy production areas, all tributaries or distributaries of the river, the convergence or divergence points or main streams and the points of measurement stations in the streams. Such as principle diversion concepts will use both the excessive waters efficiently to suppress water losses or water shortages and prevent the floods or its risks in the rivers. Evaporation and precipitation must be controlled well for the prevention of water losses to use water resources efficiently in the river streams.

As for wastewaters or industrial waters; central discharge collection units, channels, special ponds or tanks in an isolated environment are required for the collection of discharged polluted waters. After collection of those polluted waters in an isolated collection pond or a polluted water storage station, advance treatment must be implemented to those waters until becoming usable or

reusable waters, and finally, those waters must be reused or used according to their consumption plans or for the other aims such as ornamental fish breeding etc. instead of discharging those waters to fresh waters such as lake, river, wetlands or sea. Water pollution, water losses or shortages and flood damages in natural waters will be minimized or prevented and also maximum benefits be obtained from water resources through those ways while water quality of fresh waters increase.

In 1992, torrential rain triggered by cyclone in the Bay of Bengal hit southern districts of Tamil Nadu and Kerala state, caused flash floods and landslides on 16 November. Thousands of acres of standing crops were damaged, several thousand acres of land submerged, thousands of cattle washed away. 2,262 houses damaged in Kerala and 80,000 houses in Tamil Nadu. Residents of several coastal areas were evacuated to safer places. While relief and rescue operation were ongoing in those places, heavy rain battered Karnataka and Andhra Pradesh. UNDRO information reports explains the event so detailed (UNDRO information report 1-2, 1992). Floods in 1992 not only damaged the India but also hit Pakistan. Approximately, 1,834 people lost their lives in the 1992.

In 1993, turbulent rivers swollen by monsoon rains flooded more areas of India, Nepal, Bangladesh and Pakistan. 3,084 people lost their lives in the South Asia Monsoon Rain Floods of 1993. According to the news of Washington Post, 4 million people were homeless after four week of flooding. Some people lived for four days on the tree without food. After flood waters receding, slush and slime were knee-deep in some regions and putrefying flesh of dead cattle, caused to stench. Some states in northeastern India were cut-off from the rest of country as major rail and road bridges were swept away. Nearly 1.6 million people were homeless in Assam state in northeast and about 3,500 villages were flooded in there. Also 1 million people were homeless in the neighboring state of West Bengal. Military helicopters dropped packets and drinking water to marooned people. At least 316 people have died in northwestern states of Punjab and Haryana while more than 100 have died in the western state of Gujarat. Nearly half of Punjab's 1.2 million acres of crops, mostly rice, have been damaged and tens of thousands of cattle have died. In Punjab's Ajnala district, hundreds of people lived in open after their villages were washed away. The plastic tents provided by authorities were quickly ripped by howling winds and rains. According to India government figures, monsoon floods in June and July killed more than 1,500 Indians in an average year and washed away property worth 300 million USD but the rains also provided the main source of irrigation for most farmers, which make up 75 percent of India population (The Washington Post, 1993).

In 1998, eastern India floods hit northern and eastern India states and Bangladesh. Approximately 3,838 people lost their lives. On 29 August, army troops evacuated thousands of

people to higher ground in the Uttar Pradesh, where the at least 800 people died and more than a million have been marooned by high water. The army used about 6,000 boats to deliver foods to flood-stricken towns in India's most populous states. High-ways and railroads in much of eastern Uttar Pradesh have cracked under the deluge. In the Indian states of Bihar and West Bengal, at least 224 have died and nearly 12 million people have been affected (CNN, 1998). Large cholera epidemics occurred in West Bengal.

In 2004 Eastern India and Bangladesh monsoon rain, 3,076 people lost their lives due to drowning, snakebites or landslides. Total rainfall of regions between 5 and 12 July in 2004 can be seen at Figure 3.11. This information was taken by NASA's TRMM (Tropical Rainfall Measuring Mission) satellite which has been providing estimates of rainfall over the global Tropics. TRMM is able to cover vast area of tropics where rainfall is poorly measured such as over oceans and over land areas where radar coverage is lacking or poor via its active and passive sensors. Red areas in the image represent the regions that take 10 inches or more (254 mm or more) rainfall. Those regions include southern Nepal, northern and northeastern India, and northern and southeastern Bangladesh. Some of highest totals, which are close to 16 inches (406.4 mm), can be seen at dark red areas. Dark red areas include central Nepal at the base of Himalayan Mountains and over the Khasi Hills near the border between province of Sylhet in Bangladesh and the state of Assam in India.

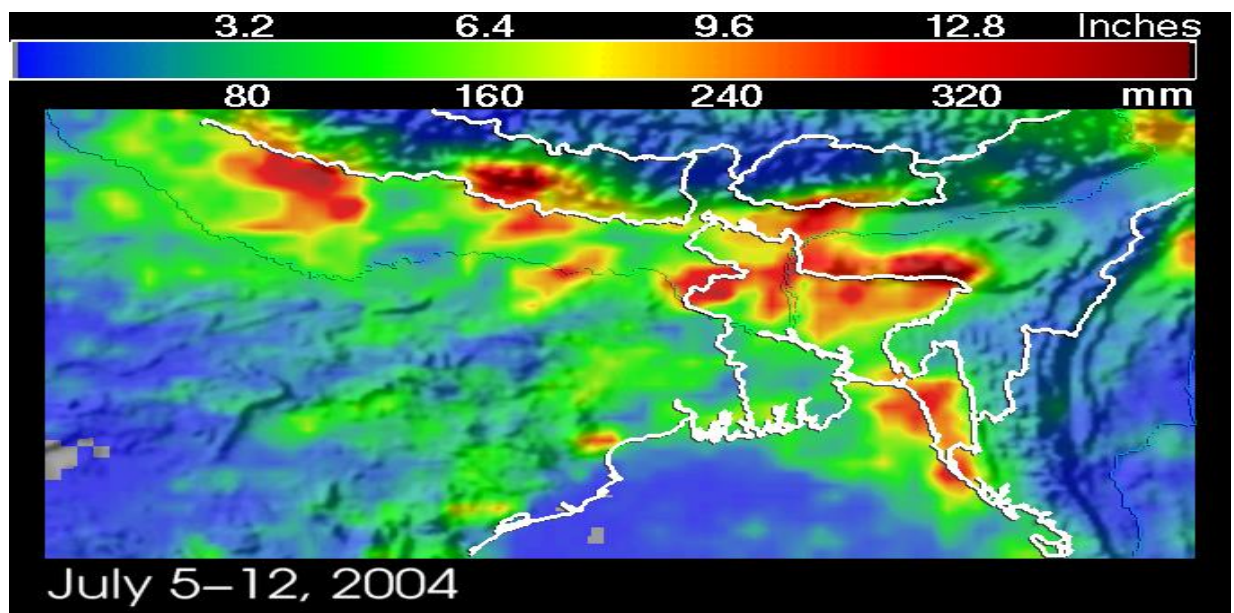


Figure 3.11. Floods in India and Bangladesh: Rainfall Totals of Nepal, India and Bangladesh on July 5-12, 2004 measured by TRMM Satellite (NASA Earth Observatory, 2004).

On July 22, 2004, the Moderate Resolution Imaging Spectrodiameter (MODIS) flying onboard NASA's Aqua satellite captured the image of rising river waters in India at Figure 3.12 while Brahmaputra River in India and Bangladesh were flowing at dangerous high levels. Dark blue represents flood's sign and water while darker green areas along river are saturated with water. Also, vegetation is bright green while clouds are light blue, and the bright white streak along the left edge of the image was formed when MODIS captured the reflection of sun off of water on the ground.

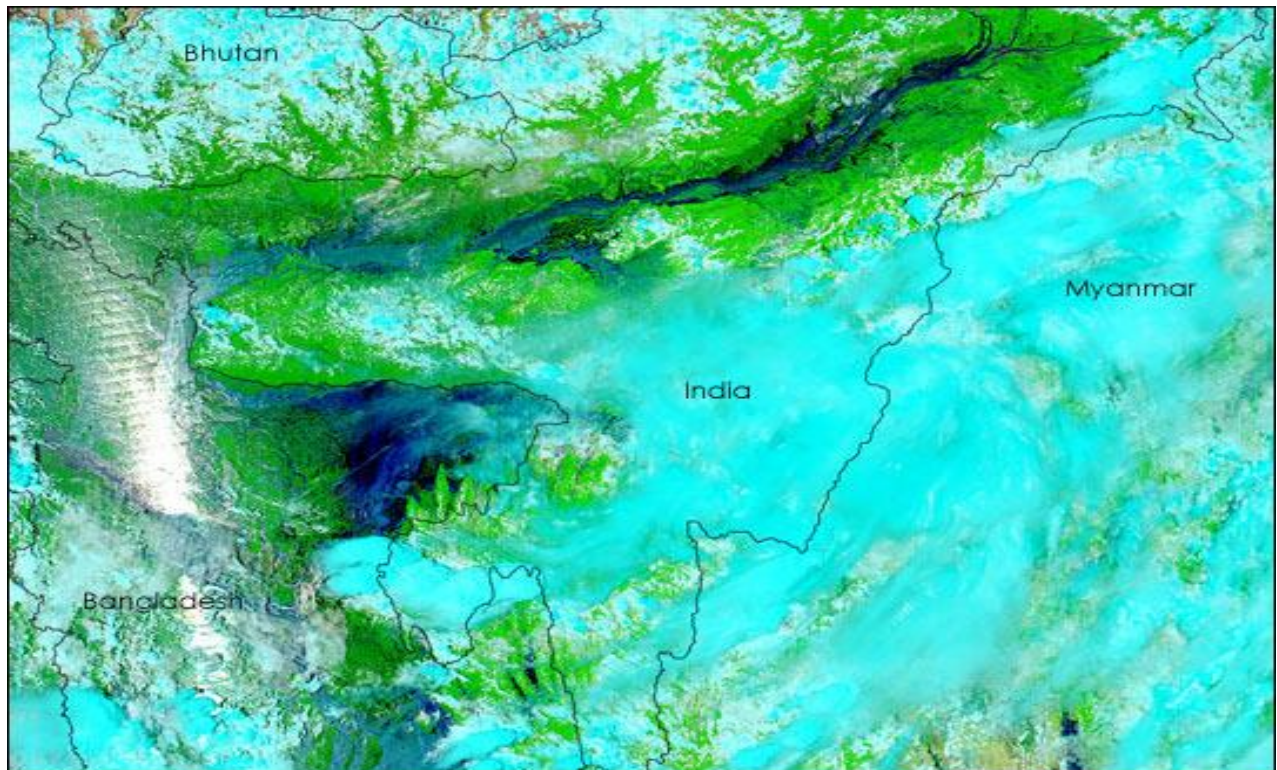


Figure 3.12. Flood image captured upon Brahmaputra on July 22, 2004 by MODIS's Aqua Satellite.

On December 26, 2004, an undersea earthquake with magnitude 9.1 struck the coast of the Indonesian island of Sumatra. A series of immense ocean waves triggered by this quake reached across the Indian Ocean and devastated coastal areas. Indonesia, Sri Lanka, India, Maldives and Thailand were major countries that affected from tsunami. According to Geological Survey Statistics, 227,898 people were killed or listed as missing and presumed dead (CNN, 2017).

Andaman and Nicobar island in India were affected by tsunami within minutes after earthquake. Wave height of Tsunami in those islands reported as 1.5 m at North Andaman Island, 8 m high in Great Nicobar Island, 10-12 m in Little Andaman Island, and 3 m in South Andaman Island (EERI Special Earthquake Report, 2005). Deadliest flood losses in coastal areas occur due to tsunami. All cities that surrounded by ocean or sea in the world must have tsunami and coastal management plans to reduce flood risks or losses. Major losses in coastal areas come from tsunami events, and

earthquake is an early warning for tsunami events. The earthquake around 6.0 might lead to local tsunamis that are small or less destructive in general but coastal and tsunami management services must be ready always even in small magnitude earthquakes, which might lead to possible local flood events. Generally, earthquake below 7.0 or 7.5 do not trigger destructive tsunami; in other words, the destructive or great tsunamis generally occur after the earthquake of 7.5 or greater than this magnitude. Keep mind that coastal management and tsunami management services and relief workers must be ready always against tsunamis or local floods in coastal areas, especially after an earthquake in the magnitude of 6.0 minimum even if the quake does not bring local floods or tsunami.

In 2005, southwest monsoon caused to death of 1,532 people in India. According to Flood Situation Report 27 July 2005 of Government of India, the coastal Maharashtra was affected by unprecedented rains and the most affected areas were the Metropolis of Mumbai and districts of Thane, Ratnagiri and Raigad in this state. The Konkan Railway submerged at many places and train service cancelled. Mumbai-Goa National Highway and Mumbai-Pune Express Way were submerged at some places and traffic movement stopped. Air traffic from and to Mumbai, power supply and telephone services disrupted as well. Thousands of people were stranded in the state and Indian government requested the support of Army, Navy and Air Force to launch the search and rescue operations. Air force helicopters and naval boats were used to distribute food packets and for the evacuations. Many relief camps were established for affected people by government. While the previous highest recorded rainfall in Mumbai was 300 mm, new record became 944 mm rainfall for 12 hours in Mumbai due to 2015 South Asia Monsoon, and 736 mm rainfall was recorded in Thane and many towns in this district remained under the water for a long time. Landslide events occurred in Ratnagiri and Raigad. About 100-150 people were trapped inside the debris due to landslide. House collapse was reported in the Ratnagiri as well. Except for those districts, other some districts were also affected from floods too. Overflow in Dudhna River occurred as a result of release of water from Dudhna dam; however, no deaths have been reported in Parabhani but 19 villages were affected by flood water because of heavy rain. The Godavari River flowed so close to its danger level of 354 m and 100 mm rainfall recorded in Nanded district. In Goa state, 11 people lost their lives, train services did not operate during the events, especially south-central railway from Karnataka side was affected due to a landslide, and there were two relief camps in district which sheltered nearly 467 people. In Uttar Pradesh state, Ghagra, Rapti, and Gandak rivers flowed above their warning level. For example, River Budhi Rapti in Sidharth Nagar flowed at 85.71 m as against the danger level of 85.65 m. In Bihar state, Bagmati River at Benibad flowed at 48.89 m as against the danger level of 48.68 m. In Assam state, Brahmaputra, Puthimari, Beki and Sankosh rivers flowed above their warning levels. For example, River Brahmaputra flowed at 105.05 m as against the danger level of 104.24 m. 13

people were reported as dead and 93 houses damaged. In West Bengal, Ganga River at Farakka flowed 22.32 m as against the danger level of 22.25 m. Hundreds of people shifted to safer places due to erosion in river Ganga. In Himachel Pradesh state, cloud burst events occurred, 3 persons have been reported died and 4 persons got injured. Also, houses were completely damaged while 4 houses damaged partially in the state. In Gujarat state, Narmada Dam's high flood level was 110.64 m at dam site but water level reached the 112.16 m which overflowed at 1.52 m. Total 213 deaths and 11 missing occurred due to drowning, collapsing of house walls or trees and sweeping. The state government deployed 1,012 medical teams, 559 medical officers, and 3,266 paramedics to the districts in the state. Diarrhea, Gastroenteritis and malaria conditions increased in the affected areas although no outbreak of disease reported. More than 200 technical teams are engaged for the disposal of carcasses and 14,075 carcasses were disposed of by teams. Tarpaulins and sheet were provided to the affected people for temporary shelters. Death relief paid to the affected people in 140 cases and ration kits were distributed to the affected families. Financial assistance, which includes cash doles, household kits and damaged or partially damaged house assistance were paid to meet the needs of affected people according to South West Monsoon 27 July 2005 Report of India (Flood Situation Report of Government of India, 2005).

In 16 June 2013 India flood, more than 5,700 people died according to figure provided by Government of Uttarakhand, which is northern state in India. A month later from catastrophe, government or authorities expressed that there are 5,700 missing people in the events so those people were presumed as dead and the families of missing people may get compensation around 500,000 Rs (approximately 8,350 USD) per victim but official state that the exact number of deaths may never be known. For the news of BBC world, 5,748 missing people were available in the catastrophe (BBC News, 2013). Cloudbursts, glacier lake bursts and unprecedented heavy monsoon were reasons of the 2013 floods for some sources but the region experienced 340-370 mm rainfall within 24 hours. Those values do not seem so unprecedented because Uttarakhand recorded single-day rainfall several times; for example, 450 mm in 1995 and 900 mm in 1965. It can be stated that runaway growth of tourisms, building projects and dams together with unchecked proliferation of roads, hotels, shops and houses in ecologically fragile areas were major reasons for damages and losses so much than the precipitations. Blasting the rocks, placing the enormous turbines in the tunnels, destroying soil-binding vegetation to build water channels or other infrastructures and carelessly dumping excavated muck were reasons for landslide and flood damages in the region. Many dams built on same river so close to one another that leave no scope for its regeneration. Dams steal water from local people while they alter the hydrological cycle and natural course. Hydroelectricity dams disrupted the water balances in Uttarakhand. Ten of thousands of tons of silt, boulders and debris from dam construction

did not find outlet and the routes they flowed in past including ravines and streams were blocked with sands and rocks (Bidwai, 2013). The upper Himalaya territories of Uttarakhand and Himachal Pradesh, which is inaccessible relatively in the northern India, are home to several major and historic pilgrimage sites, tourist spots and trekking trails. Those northern territories include snow covered mountain that may melt under the heavy precipitation together with forests that attract heavy precipitation. All of these flood reasons occurred simultaneously for four consecutive days from 13 to 17 June 2013. Chrobari Glacier, which is at height of 3,800 m, melted due to highly monsoon rain precipitation and blasted the Mandakini River, which caused to heavy floods near Kedarnath, Rudraprayag, Uttarakhand, Himachal Pradesh and Western Nepal. Kedarnath town was one of most affected places. Even though Kedarnath temple's itself was not damaged, its base was inundated with water, mud and boulders from landslide so many losses occurred, many bodies found on after the disaster were cremated, and temple was closed to pilgrims for one year. Destruction of bridges and roads left behind about 300,000 pilgrims and tourists trapped in the valley and tens of thousands of people were stuck in various affected region due to blocked or damaged roads, some people were stranded for more than 3 days without food. There were huge amount of tourists in the region because of summer so this situation badly affected the number of losses or missing and also the warning by the India Meteorological Department were not offered wide publicity to inform pilgrims or tourists beforehand, leading to thousands of people to be caught unaware, which is one of other reasons of huge of loss of life in the flood according to sources. Approximately 110,000 people were evacuated by security forces and villagers suffered from various types of health problems such as fever, diarrhea and vomit because of being dependent of drinking fresh water (Tiwarly and Mohan, 2013).

In 2015 South Indian floods, more than 500 people lost their lives from November to December. Death number is not more than 1,000 to be deadliest but explaining the 2015 floods might be useful. Majorly affected states were Tamil Nadu and Andhra Pradesh. Unplanned or illegal urban development, aging civic infrastructure, poorly designed drainage systems and inadequate levels of flood preparedness were main reasons in the flood losses or damages. There are more than 150,000 illegal structures in the city, according to city's municipality. 490 mm rain on 1 December fell to the Chennai, which is the capital city of Tamil Nadu. This rainfall was highest in 100 years. The Southern Railways cancelled major train services and Chennai International Airport was closed. Several city hospitals stopped functioning due to power supply suspension in the city and 14 patients died after power and oxygen supply failure in a city hospital because of flooded generator room in Chennai's Madras Institute of Orthopedics and Traumatology (MIOT) (Janardhanan, 2015). Approximately 57,000 houses suffered from structural damages. Thousands of affected districts continued to lack basic supplies during the period because of uncoordinated distribution of relief materials although the

state government sent rescue teams and tons of relief materials. Lorries that carry relief materials stopped and looted by survivors as well (Yamunan, 2015).

In 2017 flood season from June to September, over 1,200 people lost their lives. At least, 379 people died due to flood in Bihar state and thousands sheltered in relief camps away from their inundated homes. India prime minister pledged a relief fund of 78 million USD according to Aljazeera News. A disaster management official in Patna, which is the capital city of Bihar state, expressed that, “2017’s farming collapsed due to floods and we will see a sharp rise in unemployment for the news.” At least 88 people in neighboring Uttar Pradesh died due to floods. A federal ministry official in New Delhi overseeing the rescue and relief operations told that 850 people killed in six flood-affected states in the past month, June 2017 (Aljazeera News, 2017). Drowning, sweeping, wall collapse, landslides and electrocutions were major death reasons in the flood events.

2018 Kerala floods in India started in July and caused to death of 483 people, 14 people are still missing and nearly one million people have been evacuated until now. It is new flood of this year and death number might rise. According to BBC news, nearly 22,000 people were rescued and approximately 725,000 are living in 5,645 relief camps (BBC News, 2018). For the report of Emmanuel Hospital Association report, more than 300,000 farmers are affected and incidences of suicide are reported. 221 bridges, more than 10,000 km of roads and more than 20,774 houses have been damaged. Efforts are required for the prevention of outbreak of water borne diseases for the report. Many tethered animals drowned as well. There were 54 dams available in Kerala, 34 of those dams filled their capacity and opened for water releases. Rising temperature caused to fluctuations in the monsoon winds that carry moisture from Arabian Sea and lead to the extreme rains over the regions. Kerala is under severe drought threat after heavy rainfall now. Water levels in the ponds and wells recorded a significant low, especially in the high ranges of Idukki district come down by 20 feet (almost 6.1 m) in just a matter of 15 days after flood (Sawarjya, 2018).

3.1.2.3. Bangladesh floods. Bangladesh has extensive coastlines, and it is situated on Ganges Delta and many distributaries of the rivers flow into the Bay of Bengal; therefore, the country is very prone to flooding, especially to the coastal and riverine floods. The country is under the effects of monsoon rainfall from March to September each year. Except for the monsoon, rainfalls from Himalayas together with snowmelt floods from the Himalayan mountains contribute to the water levels or speeds in the rivers, especially in the Ganges, Brahmaputra and Meghna. Population density of the country is extremely high, and this situation makes the country extremely prone to disasters as well. 1970 and 1991 Bangladesh cyclones killed more than 100,000 people according to NOAA (History Canada,

2018). Nearly 80 % of the country is floodplains and major deadliest floods in Bangladesh are the floods of 1974, 1987, 1988 and 1998 floods. Agricultural industry benefits from small scale floods in the country because some crops need floodwaters to grow, and also small-scale floods are natural irrigations that remove artificial irrigation systems, which is costly and time consuming to build. Small scale floods remove salt deposits that accumulate on fields during evaporation and prevent the infertile lands through this way so it can be stated that small scale floods are useful for Bangladesh to sustain the agricultural production or industry.

1974 floods in Bangladesh caused to deaths of 1,987 people, nearly 52,720 km² areas were flooded and 1.4 million ton of crops were damaged. Total financial loss was 239 million USD in the USD value of 2018 against BDT. Those damages were directly; however, there were damages indirectly; for example, floods due to monsoon in Bangladesh caused to famine indirectly and death numbers reached to 20,000. For a study prepared by University of Colorado, severe famine in Bangladesh from 1974 to 1975 is caused by severe monsoon flooding, which destroyed a significant majority of the annual rice crop. This led to an escalation in crop prices, an unemployment spike and the erosion of purchasing powers for farmers. For the result of this study, earlier childhood exposure to acute malnutrition affects males and females differently, and there is evidence of positive selection for males born during the famine. They are 0.48 standard deviation taller and obtain 1.89 more years of completed education on average in the presence of famine. Boys in their early childhood years show evidence of being negatively influenced by the adverse health shock of famine (Kagy, 2012). From the result of this study, it is possible to express that flood damages might even affect the tall of boys indirectly.

There are total 15 reports of UNDRO for 1987 Bangladesh floods. Information in the reports can be summarized like that; On 5 June, 1987, cyclonic storm, which formed in Bay of Bengal, accompanied tidal wave up to 1.83 m above normal and inundated low-lying islands crossed the Hatiya, Swandwip, Patuakhali, Bhola regions in Bangladesh. Heavy rains in along southern region caused the flash floods in a few areas. Tidal surge did not give damage to human lives due to precautionary measures taken by Government for the report no 1 of UNDHA. 1987 Flash floods affected northwestern region of Bangladesh such as Rangpur district, Noakhali, Mymensing, and Syhlet. Crops in those areas were under the water but situation was under the control by measures of Government. Red Cross Bangladesh provided milk powder, cloth, cooking and eating utensils, biscuits and medicines. Overall flood situation seriously deteriorated following heavy rains 30/31 July and onrush flood water from upper regions affected 3.5 million people, especially Rangapur, Netrokona, Gaibandha, Noagaon, Kurigram, Jamlpur, Cox's Bazar, Chittagong and Noakhali

districts. Major rivers were above danger level and many protection embankments together with 650,000 acres crops were damaged, and road links especially from capital to the northeast region were disrupted due to overflow and collapse of culverts for the report no 3 of UNDHA on 3 August. 104 deaths were reported on 6 August for the report no 4. 520 miles long flood protection embankment were completely washed away in 27 places, many unpaved roads were damaged, and bridge destruction disrupted road communication between capital and northwest region so temporary bailed bridges were installed. Major rivers were still above the danger level. Government requested international assistance and 1,285 diarrhea cases were reported in mainly most affected areas of Bogra and Gaibandha for the report no 7 on 19 August. For the report no 12 on 7 September, total 23.22 million people were affected and total areas under flood were 18,972 miles². Nearly 2.53 million acres of crops fully and 1.98 million acres partially, 939,557 houses fully and 790,762 partially, 15,208 km unpaved roads fully and 1,623 partially, 1,090 educational institution fully and 1,520 partially, and 1,100 bridges and culverts were fully damaged (UNDRO, 1987). Total death numbers were 1,657 in 1987 Bangladesh floods (Dewan et al., 2003).

1988 Bangladesh floods caused by tropical cyclone lasted 20 days from August to September. Return period of the flood was estimated at 50-100 years. 52 % of the country's total areas were flooded. 2,379 people lost only due to flood and 3.2 million tons of crops were damaged (Dewan et al., 2003). 6,240 people lost their lives due to cyclone and floods on November after September floods of 1988, and the speed of wind was 200km/h. Cyclone together with floods caused synergic damages to the Bangladesh in the effects of winter monsoon after summer floods so cyclone control and prediction are very significant in the flood management. 1988 cyclone was one of the worst tropical cyclones in Bangladesh history. Most of death occurred in Khulna district.

In 1998 Bangladesh floods, two-thirds of the country was inundated for eleven weeks started in July. Bangladesh receives between 1,000 and 5,000 mm of rainfall and about 80 percent during the June to September monsoon season. Nearly 30 million people were affected and caused to over 1,000 people deaths. Together with India, death numbers reached to 3,838. Rice and crops production were disrupted. Bangladesh requested and received 200 million USD emergency assistances from International Development Association (IDA) and 135 million USD from International Monetary Fund (IMF) to deal with the macro shock and to finance critical imports such as flood and fertilizer (Shah, 1999).

3.1.2.4. Pakistan floods. There are two great floods in Pakistan that have more than 1,000 deaths until now. One of these floods is 1950 Pakistan floods. 2,900 people lost their lives and over 100,000

homes were destroyed, which caused to 900,000 homeless people during monsoon season. Lahore city of Pakistan was worst affected area where the Ravi river, which is one of six rivers of the Indus river, flooded (Dawn, 2011).

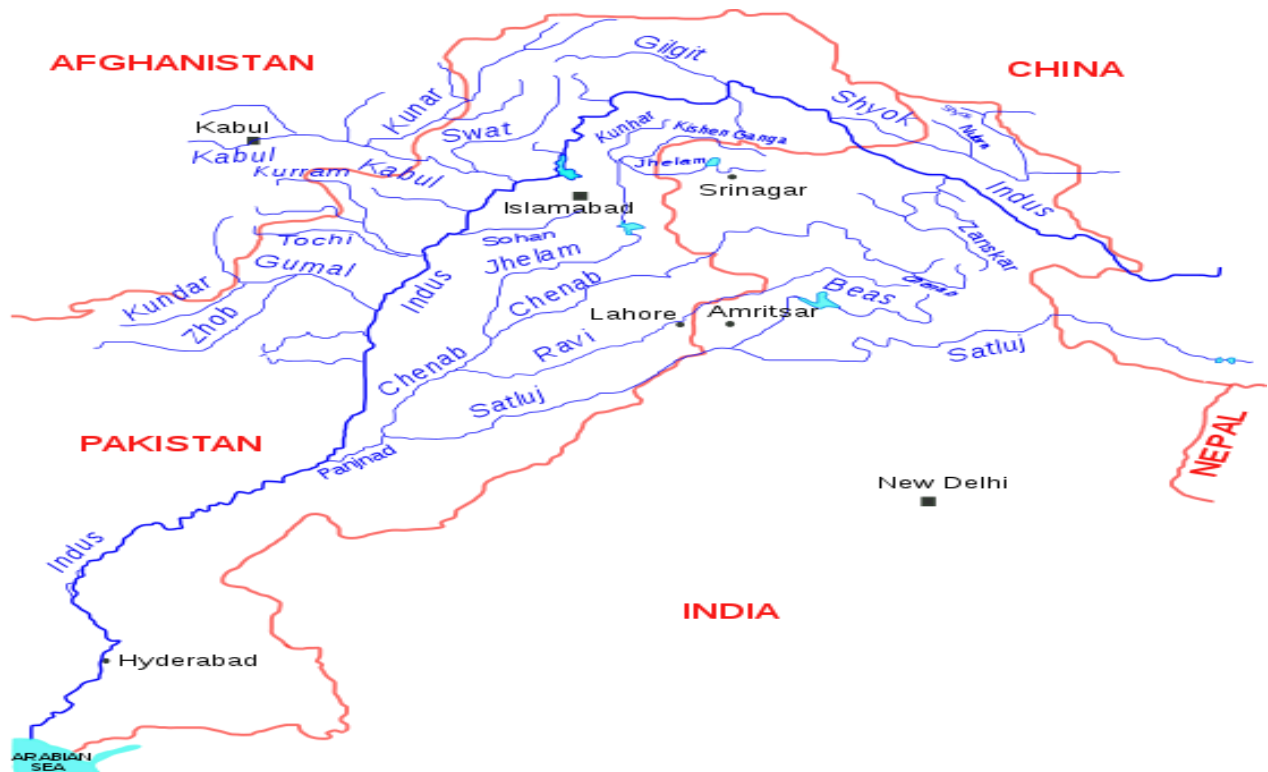


Figure 3.13. Indus River and Tributaries, (Kmhkmh, 2009).

The other deadliest flood in Pakistan is the 2010 Pakistan floods that killed more than 1,781 people. The floods occurred between late July and August due to monsoon, which affected Indus River Basin. Mostly affected regions were Khyber Pakhtunkhwa, Sindh, Punjab and Balochistan regions of the Pakistan. Above 90 % of deaths were in the Khyber Pakhtunkhwa regions and Saidu Sharif and Risalpur cities in Khyber Pakhtunkhwa received 471 mm and 431 mm respectively in the floods of July according to Pakistan Weather News (Pakmet, 2010). Looting of the aid convoys by hunger-stricken people occurred in Pakistan 2010 floods too (Dawn, 2010). Flood managers and state organizations must focus on the looting events in relief efforts and find solutions to it. All relief efforts need coordination before the disaster. There were claims that people became without food and water for four days and that meal sent by district governments were not enough. People were waiting for two hours in queue without getting anything due to disorganization in Pakistan floods. All of relief activities must be planned and coordinated well before the disasters dependent on population of districts in the Natural Disaster Emergency Action Plans (NDEAP); otherwise, such as problems, looting and attacking events occur after disasters due to disorganizations. International Labor Office (ILO) reported that the floods may cause to losses of more than 5.3 million jobs in Pakistan as a result

of the worst ever floods in the history of the country; therefore, productive and labor intense job creation programs are urgently needed to lift millions of people out of poverty that has been aggravated by flood damage in Pakistan (ILO, 2010). Productive and labor intensive jobs are very significant and required to finish the famine or poverty of humans and it is duty that governments must focus on productive job creations to meet the needs of people against poverty and famine both for the preparation before the catastrophe against disaster and for elimination of damages, famine and poverty after disasters. More than 20 million people were displaced in the flood events. Many of those suffered from various medical maladies such as at least 700,000 cases acute diarrhea, 800,000 acute respiratory infections, nearly a million of skin disease and almost 183,000 suspected malaria cases, UN reported, according to CNN news. The floods that ravaged Pakistan caused to an estimated 9.7 billion USD in damage to homes, roads, farms and other parts of southwestern Asian country, the World Bank and Asian Development Bank announced (CNN, 2010).

3.1.2.5. Afghanistan flood. In 1992 Afghanistan floods, nearly 3,000 people lost their lives. Local officials stated that a flash flood that thundered down a river valley in northern Afghanistan killed at least 400 people within minutes. The Shutul River swollen by heavy rains in the surrounding Hindu Kush Mountains burst and swept away hundreds of homes in Gulbahar district, which is located 76 km north the capital Kabul. People clung to the roof of mosques and water razed the marketplaces.

According to Reuters, a town official expressed that in less than two minutes everything was destroyed. A torrent of large boulders, trees and mud, up to 30 feet (9.1 m) high destroyed several villages in the nearby Kalotok and Ghorband valley. About 1,000 homes were destroyed and countless acres of crops and miles of irrigation canals were choked with mud. An eyewitness said that trees and boulders swept downstream by the Shutul River piled up on one side of bridge and eventually broke it. The people who saw the flood coming had time to get out or to climb a mosque but those who were sleep or did not know were washed away by floods (The New York Times, 1992). Afghanistan is mountainous country; therefore, accessibility to settlements is so difficult when flood or natural disaster occur. Search and rescue teams may always live problem to save the people from disasters because of this reason. Remote central regions of Afghanistan witness recurrent flood and drought events; on the other hand, southern parts of the country are drought prone. Major death reasons in flood events are drowning, fatal injuries, venomous snakebites, electrocution and contamination by toxic material in Afghanistan.

3.1.2.6. Iran flood. A storm with unusually heavy rains led to massive flooding across Iran. More than 10,000 people were killed in the disaster (Sepahban, 2014). A sudden storm washed a mountain

shrine in Farahzad, Iran, into a gorge on September 17, 1954 and 2,000 pilgrims worshipping in the shrine were swept and lost their lives. There were dozens of cottages designed to house pilgrims or worship to the shrine. On the night of 17 September, 3,000 pilgrims were in there for worship, and torrential rainstorm hit the region, uprooting trees, unleashing mountain streams, sending torrents of water cascading down the mountainside and it felt to the bottom of the gorge, where it was rapidly blanket by rain waters, rivers and streams, which combined to flood the gorge. It was a synergic flood obviously and over 2,000 pilgrims drowned within minutes. Most of bodies carried miles and downstream remained unrecovered for a long time (Davis, 2008).

3.1.2.7. Vietnam flood. Severe flood of Red river killed more than 100,000 people on 1 August, 1971. The flood event occurred during Vietnam War so few details about disaster are available. Information from North Vietnam might not be reliable and accurate in that time due to the war. The Red River which flows near the capital city of Hanoi experienced a 250-year flood and torrential rains easily overwhelmed the dike system around the heavy populated delta areas, which is not far above sea level. Thousands of people were killed directly and the flood wiped out of valuable crops that caused to further hardships during war (History Canada, 2018). There are many claims that it was a man-made disaster during war time so much than natural one. Hanoi is vulnerable to flooding even today though many more reservoirs have been built since years. Red river level reached to 41 feet (12.5 m) and the river was the 6 feet (1.8 m) above the level of dikes; in other words, the river was about 33 feet (10.5 m) above the heads of Hanoi's one million people (The New York Times, 1971). About 35 % to 45 % of the autumn rice crop was lost, and total rice output for the year fell to the lowest level (CIA report, 1972).

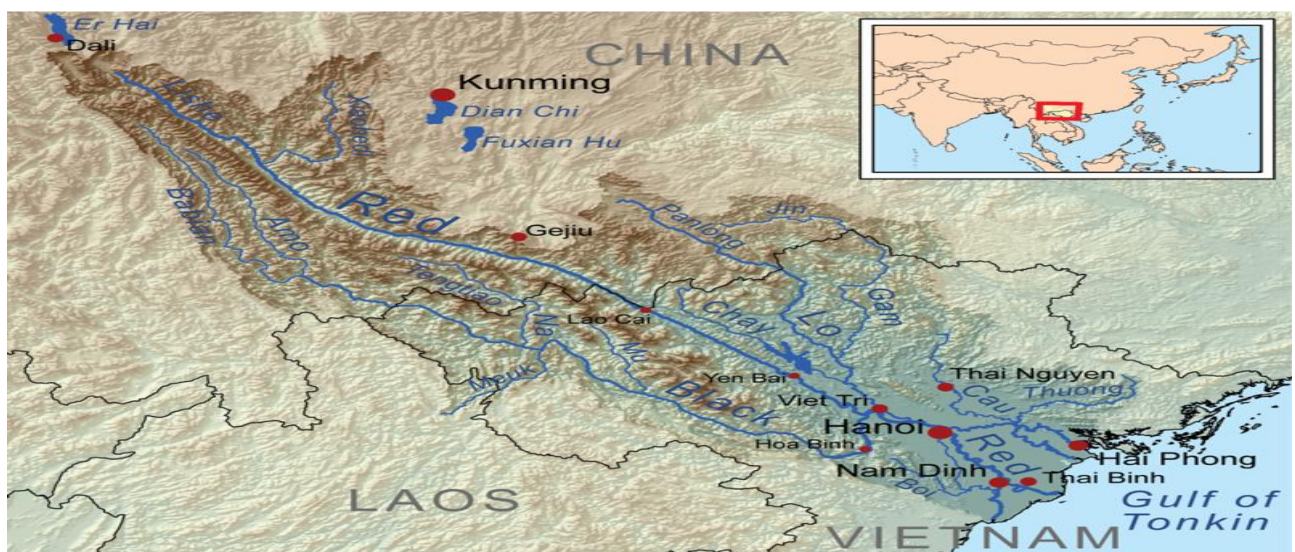


Figure 3.14. Red River Drainage Basin (Kmmuser, 2015).

In the map, it can easily be observed that Hanoi, which is the capital of Vietnam, remains in the intersections of both confluence zone where main streams come together and the divergence zone where the streams flow away or apart. Settlements or cities that remain in the intersections of convergence and divergence zone of flows like that are the great flood risk regions. Especially under the heavy precipitation conditions, catastrophe is inevitable result in such as regions.

3.1.2.8. Japan floods. 1953 Japan flood hit northern Kyshu and more than 1,000 people were either dead or missing. Nearly 1 million suffered from flood. The flood created mudslide as well. Together with Kumamoto, Wakayama, Kizugawa cities, death numbers reached to 2,566, and also more than 1,000 mm rainfall recorded on Aso and Hikosan mountains, which caused to floods of many of the rivers including the Chikuga River (Gotoh et al., 2014). Total 450,000 houses were flooded in the 1953 Japan Flood.

Typhoons are massive storms that might ravage everything with high winds and storm surges. Typhoon Vera, which the speed of it was 305 km/h, hit Ise Bay in Japan and caused the deaths of more than 5,000 people in the 1959. The Typhoon Vera left more than 1.5 million homeless in the 1959 (Gotoh, et al., 2014). Lowest recorded pressure in The Typhoon Vera was 895 mbar. Typhoon Vera is the deadliest flood in the Japan history and brought a strong storm surge. The storm surge destroyed numerous flood defense systems, inundating coastal region and sinking ships in the year 1959. Relief efforts were slow in the event due to the spreading of disease and blocking debris. The epidemics of dysentery and tetanus were reported in the region after the catastrophe.

3.1.2.9. Philippines floods. 2006 heavy rain caused to large mudslide in Philippines on 4-17 February, 2006. Heavy rains pounded the area for two weeks. Majorly affected region was southern Lyte. Official death was 1,126 in the mudslide event.

According to CBC news, about 1,500 people were missing from the Guinsaugon village area of St. Bernard town, which was completely covered by as much as 9 m of mud. In 1991, a landslide on the island killed 6,000 people as well. A witness told that it sounded like the mountain exploded and whole thing crumbled. It was tragic that an elementary school which includes 246 students and seven teachers buried in the village due to mudslide. In rescue efforts, heavy equipment did not work in the mud which was up to 9 m in some areas; therefore, people used their hands to dig for survivors. Helicopters, navy ships and a military plane rushed to the island but rainy made the rescue efforts difficult. 3,000 evacuees were at municipal building due to morning landslide that affected two other

villages. There were the reports of a mild earthquake which was magnitude 2.6 on Richter scale around the time of the mudslide (CBC news, 2006). Philippines applied for international assistances. Major relief materials were tents, blankets, cooking utensil, water purification tablets, temporary shelter materials, mosquito nets, medicines, hygiene articles, emergency trauma kits, rubber boats, ropes, clothing and flashlights. A provincial governing board expressed that many residents left the area a week ago from the disaster because of landslide threat but residents were making their way back while rain started to ease in the region before mudslide events. Residents had left the region due to up to ten smaller landslides before the mudflow in the vicinity of St. Bernard; however, after evacuation, the authorities should have controlled entries to the village and not have allowed the residents to come back to their homes until the hazard finishes completely.

There were some claims related with the reasons of mudslide or landslide in the region, for example, a congressman in Philippines expressed that logging and mining done in the area three decades was main reason of this mudslide or landslide events. Some opponents did not accept the idea of this congressman; they said the region was green and forested area sufficiently so logging and mining were not reason because logging was banned in 2004 by the president of Philippines. The main reason was just heavy precipitation for the opponents, not logging and some claimed that coconut trees which have only shallow roots were culprit in the mudflow. According to BBC news, typhoon Thelma in Philippines caused to the floods and more than 5,000 drowned on November 1991, up to 200 people died in landslides in southern Lyte on December 2003, and about 1,800 people killed after a series of storms in northeastern part of the country (Buckley, 2006).

TRMM satellite which monitors rainfall over the global tropics recorded about 30 inches (762 mm) in the northern tip Mindanao on 4-17 February, 2006, in Philippines, which dark red color in the map shows the rainfall highest record of 762 mm. Rainfall total was 20 inches (500 mm) in the southern Lyte, which small orange area in the north part of red color shows the rainfall of 500 mm in the map. The green color around surrounding areas in the maps represents the rainfall of 250 mm. According to Nasa Earth Observatory, excessive rain on 4-17 February may be link to the ongoing La Nina, which is associated with above-normal sea surface temperature and stronger trade winds in western pacific, and this pattern can significantly enhance rainfall across the western pacific region (Nasa Earth Observatory, 2006).

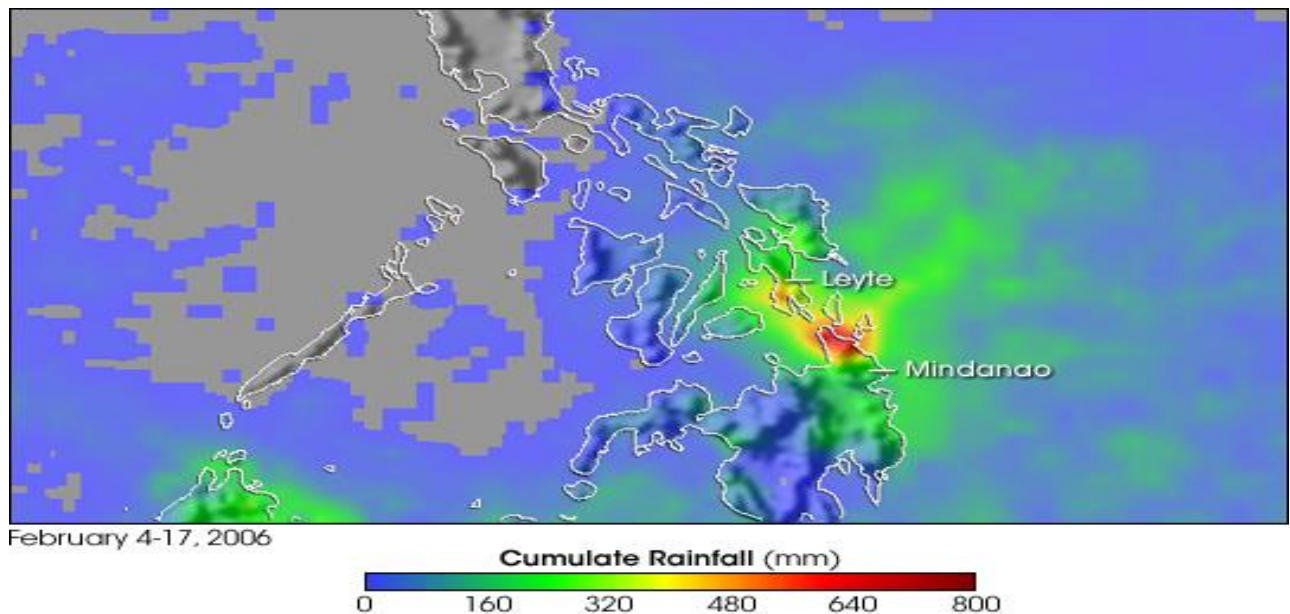


Figure 3.15. Flooding in the Southern Philippines: Rainfall Totals of Philippines on February 4-17, 2006 measured by TRMM Satellite (NASA Earth Observatory, 2006).

Tropical storm Washi brought heavy rains, overflowed rivers, caused to flash floods and swept away whole villages built on sandbars and riverbanks in the southern Philippines from December 16 to 18, 2011 according to the article of The Telegraph. The regional civil defense chief confirmed that death toll was 1,453 and the stench of death pervaded the region. The chief told that there were so many bodies being found, floating in bays. If not for the small islands in the bay, they would be in the Pacific already. More than 376,000 people were displaced by the storm (The Telegraph, 2011).

3.1.2.10. Russia flood. 10,000 people lost their lives in 1824 St. Petersburg flood in Russia due to storm surge. The Neva River's water level reached a record height of 4.20 m above sea level. The flood was the most destructive flood the city had ever witnessed. Vasilevsky Islands suffered from flood mostly; many animals drowned, roads were washed out, and the rising water damaged sewage system; therefore, sanitary condition became so worse. It took a decade to recover from enormous damages the 1824 flood created. This delay triggered unsanitary conditions of the St. Petersburg and facilitated the spread of cholera, such as during the first cholera epidemic in 1831 (Barabanova, 2014).

3.1.2.11. Guatemala flood. In October Guatemala experienced a week of heavy rain from a stalled tropical cyclone in 1949. Flash floods and mudslides occurred and death toll was 40,000 (Gunn, 2010).

3.1.2.12. Venezuela flood. Continuous severe rainfall from 8 to 19 December 1999 caused landslide, debris flow and flash floods in eight states of Venezuela. The state of Vargas was the most severely damaged. According to Civil Defense Agency of the state of Vargas 40,160 houses were affected and 20,000 houses completely collapsed. There were 214,000 affected persons and 30,000 deaths occurred in Vargas tragedy (Takahashi et al., 2001).

Death numbers are not accurate in the event. Many bodies were buried under the mud and washed into the sea. Rainy season in coastal Venezuela normally lasts from May to October so the extreme rainfall was unusual for December in the region. Total 3 days rainfall along the coast at the international airport at Maiquetia was 911 mm. Hourly rainfall from 6 to 7 am on the morning of December 16 measured 72 mm/h. Daily total rainfalls were 380.7 mm and 410.4 mm for December 15 and 16 respectively (Blair et al., 2001).

3.1.2.13. Peru floods. In 1941, approximately 5,000 people lost their lives in Huaraz city due to melted ice or glacial lake outburst flood in Palcacocha Lake in Peru. Melting period typically occurs from May through July, the driest and sunniest months of the year; therefore, avalanches and calving events occurs frequently in this lake during this summer period. Two more glacial outburst floods between 1941 and 1950 killed another 5,000 people in the Cordillera Blanca mountain range. Mountain people as well as the millions of people living downstream who dependent on freshwater from the mountains to survive are under the threat of Glacial lake bursts around the world (Byers and Recharte, 2015).

On January 10, 1962, an avalanche on the slopes of an extinct volcano killed more than 4,000 people in Peru. An additional 10,000 farm animals killed and millions of dollars in crops were destroyed. Mount Huascaran has a 6,705 m height from sea level in the Andes Mountains. Beneath the mountain there were small villages and the all of them were buried in the avalanche. The towns of Ranrahirca and Huarascucho were buried under 12.2 m of ice, mud, trees, boulders and other debris. The avalanche finally ended at the Santa River, where it stopped the water flow and lead to the flooding in nearby areas (History, 2009).

3.1.2.14. Caribbean floods. The floods on 24-25 May, 2004 in Haiti and Dominican Republic caused to death of 2,000 people and thousands of homes nearly. The hardest hit area was around the town of Jimani which is in the border of Haiti and Dominican Republic in the Hispaniola, Caribbean. The Soliel River overflowed its bank before dawn on the morning of 25th of May 2004 catching the town

by surprise. Total rainfall 18-25, May 2004 exceed 550 mm, which is highest total along the border between Haiti and Dominican Republic and over the northeastern parts of the Dominican Republic (NASA Earth Observatory, 2004). Floods led to malaria outbreak in the region.

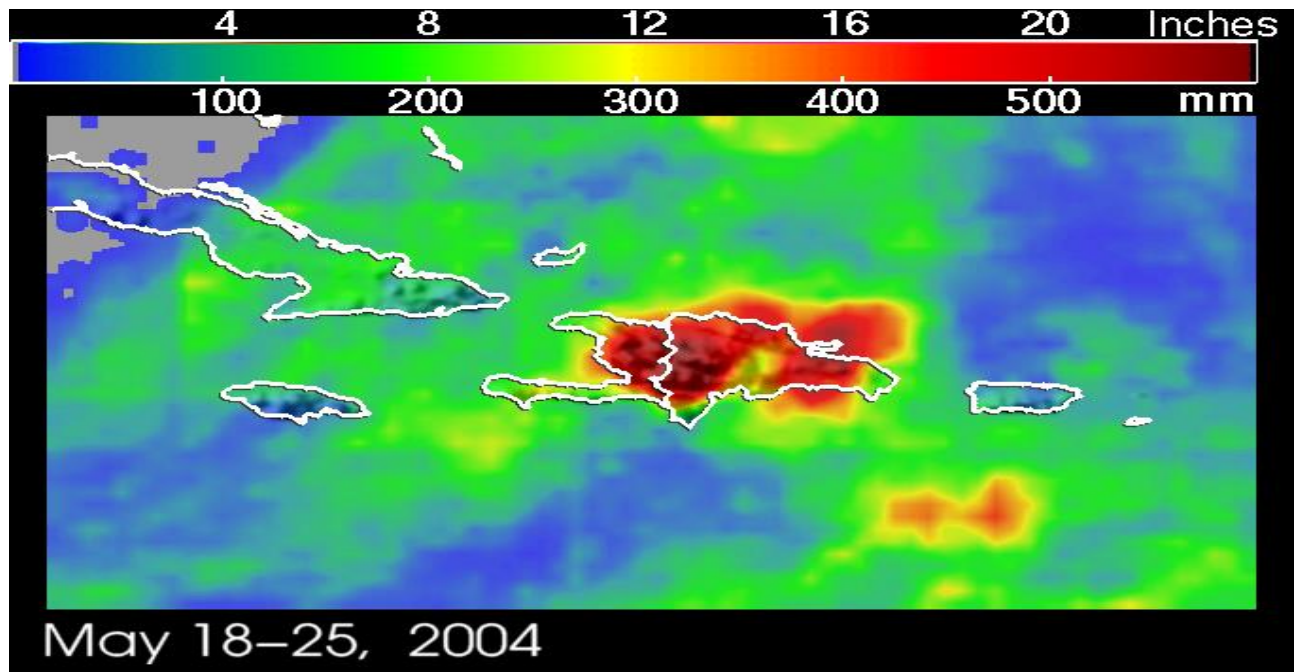


Figure 3.16. Flooding in Haiti and Dominican Republic: Rainfall Totals on May 18-25, 2004 measured by TRMM satellite (NASA Earth Observatory, 2004).

3.1.2.15. Johnstown flood. In 1889 Johnstown flood, 2,209 people lost their lives and more than 750 victims were never identified in this USA flood. According to statistics, 124 women and 198 men were left widowed, 1,600 homes destroyed and nearly 17 million USD property damage occurred in this dam failure flood.

The distance between the dam that failed and Johnstown was 22.5 km and the dam contained 20 million tons of water before the release. Flood lines were the 27 m above the river level while the waves that hit Johnstown were measured 10.6-12.2 m high and the speed of the waves was nearly 65 km/h. The force of flood swept locomotives weighing 77 tons as far as 1.5 km.

Nearly 3.74 million USD was collected for the Johnstown relief effort within USA and from 18 countries, which was the first major peacetime relief effort for the Red Cross. The piles of debris at stone bridge covered 30 acre and any people who survived the floodwaters lost their lives in the fire that broke out in debris trapped at the stone bridge. An eternal flame burns nearby in memory of the flood's victims (JAHA, 2018).

3.1.2.16. Northsea flood of 1953. North western heavy storm together with a spring tide created a storm tide in Northwest Europe and hit Netherland, UK, Belgium and Scotland on the night of February 1st, 1953. The waves and flood overwhelmed sea defenses and extensive flood occurred. Total 2,551 people lost their lives and of which 1,835 were from the Netherlands, 307 from England, 28 from Belgium and 19 from Scotland. More than 230 people lost their lives in watercraft at sea, including 133 of passengers aboard the Princess Victoria ferry (Encyclopedia Britannica).

72,000 people were evacuated and 200,000 hectares of soil flooded. 200,000 cattle drowned, 40,000 houses and 3,000 farms are damaged in the region. After the flood, Netherland launched Delta projects or Delta works as massive construction efforts against flood risks. Low pressure, high tide and wind caused to the water level rise above mean sea level; for example, in some location, water level more than 5,6 m above sea level. 91 km of levees were heavily damaged in Zuid-Holland with holes of up to 1 km and 10 km of levees are heavily damaged in Noord-Brabant. Southern province Zeeland was most affected area because most of casualties occurred in this province and nearly 38 km of levees were heavily damaged in Zeeland with holes of up to 3.5 km (Delta Works, 2004).

3.1.2.17. Italy flood. Dam Vajont in Italy which collects the waters of a small mountain torrent to generate hydroelectricity was the tallest dam of its kind in the world, which has 262 m high, 27 m wide and 22.11 m thick at base while 191 m wide and 3.4 m thick at the top. On 9 October, 1963, a landslide occurred due to approximately 2,286 mm heavy rain and lead to deaths of 2,000 people in Italy. Massive landslide came crashing down from Mount Toc and caused a huge pile of dirt and rocks to plunge into reservoirs at about 113 km/h. The impact of debris created immense wave of water to rise as high as 91 m above the level of dam, workers living alongside the dam were killed instantly and the displaced water crashed over the dam and into Piave River. It stormed down the river and destroyed the town of Langarone within minutes. The engineer of the dam project was summoned to the court to answer questions about what was known of the geology of the area prior to the dam's construction; however, he killed himself before his scheduled appearance (History, 2018).

3.1.2.18. Algeria flood. The 1927 Algerian flood killed 3,000 people and it was deadliest flood of the Africa continent. Northwest cities of the country such as Mostaganem and Oran were major affected cities in the 1927 flood. Dam broke, many houses and bridges are carried away and train with 300 passengers is marooned. The cloudburst and a cyclone in North Africa caused to disaster in 1927 (The New York Times, 1927).

3.1.3. Other Past Significant Floods on Continents

Death tolls of those floods are less than 1,000 deaths and more than 100. The study will categorize those floods dependent on continents.

3.1.3.1. North/Central America floods. Remarkable flood events in North/Central America until today occurred in USA, Mexico and Puerto Rico majorly. The number and the frequency of significant flood events increased in North and Central America, especially after 2000s due to the growing tropical cyclones or hurricanes in recent years.

Table 3.5 shows significant floods in North/Central America. Death tolls of those floods are between 100 and 1000. The table 3.5 at bottom is useful to understand the flood risks in the continent.

Table 3.5. North and Central America Floods.

Name	Year	Cause	Death Number	Remarkable Notes
Great Flood of 1913 USA	1913	Moist air, snow precipitation, rainfall, tornadoes, hails, sleet, high wind, storm system	Nearly 650	250,000 people became homeless; Storm size, its duration and existing ground condition contribute to extensive flooding; The storm damaged bridges, railroad trestles, telegraph and telephone poles.
Mexico Floods	1999	Saturated Soil Tropical Cyclone 1,038 mm rainfall	636	Flood caused to thousands of landslides; 39 rivers overflowed; the floods washed crocodiles into streets; and the rains occurred for about two weeks before the worst of precipitation began.
St. Francis Flood USA	1928	Dam Failure	Nearly 600	Leakage and Cracks appeared on dam before the event.

Great Mississippi USA	1927	Heavy Rain	About 500	The Cumberland River exceeded 17.1 m, a level that remains a record to this day
Ohio River Flood USA	1937	Water level Rise Rainfall	385	Martial law was declared.
Great Dayton Flood USA	1913	Rainstorm Soil saturation	More than 360	The flood damaged the city's central business which developed within 1.6 km of the convergence of its three tributaries Stillwater River, Mad River and Wolf Creeks in Miami River.
Black Hill Flood USA	1972	Rainfall (380 mm)	238	Over 1,335 homes and 5,000 automobiles were destroyed.
El Salvador Flood	2009	Low pressure system and heavy rains (483 mm near St. Vicente Volcano)	199	Light and moderate rain before the heavy rain; 108 Landslide events occurred; 18 bridges were affected; Flood washed entire harvest and up to 10,000 people were in need of food assistance.
Puerto Rico Flood	1985	Tropical Wave, Storm System, Heavy Rain (804 mm at peak) which is the amount of nearly of the annual precipitation.	180	The tropical wave spawned low pressure areas in the north of Hispaniola that became Tropical Storm Isabel; Several stations were reported 100 year flooding; A large slab of sandstone detached from a hill, moving about 110,000 m ³ material down the hill; Many cars were washed away and six cars drove into a gap; Floods shut down 11 water filtration plants; and state of emergency declared.

Los Angeles Flood USA	1938	Orographic precipitations from Pacific storms	115	Massive debris flows of mud, boulders and downed trees occurred.

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

3.1.3.2. South America floods. Remarkable flood events in South America until today occurred in Brazil, Peru, Colombia, Argentina, Ecuador and Chile majorly. Brazil includes rainforests; therefore, attracts more rain while Peru is under the risk of snowmelt flood so much and exposed to snowmelt flood with avalanche and glacial lake outburst flood in general. Table 3.6 shows significant floods in South America. Death tolls of those floods are between 100 and 1000. The table 3.5 at bottom is useful to understand the flood risks in the continent.

Table 3.6. South America Floods.

Name	Year	Cause	Death Number	Remarkable Notes
January 2011 Rio de Janeiro Floods and mudslide Brazil	2011	Heavy rain	903	The cities that human casualties are located in a mountainous area; many buildings are directly exposed to landslide hazard because of the steep terrain.
1987 Villatina Disaster Colombia	1987	Heavy Rain	640	Landslide occurred. It was landslide disaster so much than flood.
1982 Peru Flood	1982	Heavy Rain	532	Mosquitos due to flood, and people got sick
1967 Brazil Flood	1967	Heavy Rain Sea surface temperature	434	Record rains are more likely when sea surface temperature over the nearby moisture regions are at record high level.
1966 Brazil Flood	1966	Rainfalls in short period of time flash flood	375	Much of population in the area lived in shacks and shantytowns that were constructed on steep hillsides.

1983 Peru Flood	1983	Heavy rain	364	The country's infrastructure suffered from the torrential rain and mudslides, with 258 bridges down, 6,000 km of highways, and 10,000 of rural roads damaged.
1958 Buenos Aires Flood Argentina	1958	Heavy rain	360	Argentina suffered one of its worst flooding. 500,000 persons left homeless.
Quebrada Blanca flood Colombia	1974	Torrential rain	300	Landslide and mudflow were problems in Colombia
Pampayacta flood Peru	1963	Heavy rain	300	Landslide and rain swept the highlands of southern Peru.
1988 Rio de Janeiro Brazil	1988	Torrential rain	290	Leptospirosis outbreak occurred.
La Josefina Ecuador	1991	Heavy rain Landslide	250	Landslide dam at La Josefina in Southern Ecuador.
2010 Rio de Janeiro Brazil	2010	Extreme weather	249	Approximately 10,000 homes which were shanty town majorly were under the mudslide risk.
1971 Chungar landslide, avalanche and flood Peru	1971	Earthquake	200-600	Andes Mountains prompted a landslide along the slopes of a mountain near Chungar; The landslide lead to massive amount of dirty water to plunge into a lake that located above Chunger; The dirty water from lake flooded down the hillside toward Chunger caused avalanche of snow, mud and rock along the way.

1974 Santa Catarina and Tubarao Flood Brazil	1974	Torrential rain	199	Flood displaced 60,000 of Tubarao's total population of 70,000.
Huigra Ecuador	1931	Heavy rain	190	Landslide buried track workers along the Guayaquil and Quito railroad.
2010 Colombia Floods	2010	Unusually heavy wet season	174	The floods and landslide affected 70 % of the country and left homeless more than 2.2 million people.
2004 Brazil Floods	2004	Heavy rain	165	Floods cut fruit productions in 15 states of Brazil by an estimated 10 %, causing overall economic losses of USD 303 million.
1991 Antofagasta Chile	1991	Heavy rain Mountain crumble	128	Flood left 91 homeless and resulted in 16 missing, apart from material losses of 70 million USD.

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

3.1.3.3. Africa floods. The types of natural disasters mostly reported in Africa are generally epidemic, flood and drought while most deadly ones are drought, epidemic and flood respectively; therefore, flood management concept in Africa must focus on epidemic and drought issues so much. African climate is hot compared to other continents so it is great possibility to expose to water losses in this climate. Drought can generally be observed in the rivers as a signal for future famine or future floods. Except for this, after flood events, epidemic disease can arise, spread around and affect African population. Such as problems can be observed in all continents due to floods or drought but the risk is high for Africa compared to others.

Table 3.7. Africa Floods.

Name	Year	Cause	Death Number	Remarkable Notes
2001 Algeria Flood	2001	Downpours	827	Algerians remained under the 3 m mud; Densely populated (57,700 per km ²) Bab El Qued affected; Mudflow, rubble and debris flood were results that destroyed high buildings and ramshackle homes and overturned cars; and thousands left homeless by the flood which followed a long drought that caused to water rationing in the country.
2000 Mozambique Flood	2000	Heavy rain that lasted for five weeks, Cyclone Eline	800	As of 2016, people were still living in recovery shelters with fluctuating water supply; Some areas received a year's worth of rainfall in two weeks; Malaria, cholera and diarrhea affected the regions owing to residual waters and killed the humans; The flooding disrupted water supply and roads; the combine or synergic effect of preceding flood and Eline cyclone left about 463 000 people homeless including 10-12 % of this number were children 5 year old or younger; dinghies and boats used to rescue humans and 29 rescue helicopters rescued nearly 14 200 people from the disaster.
2006 Ethiopia Flood	2006	Heavy downpour	705	Many houses were swept away as people slept; Some of the deaths were due to crocodiles.

1991 Malawi Floods	1991	Heavy Rain Flash flood	700	These flash floods were the impetus for the development of legislation to address disasters in the country
1969 Tunisia Flood	1969	Continuous Rain fell for 38 days	540	Tunisia had 4.5 million population and 300,000 became refugees in 1969, and 70,000 homes destroyed.
1987 South Africa	1987	Rainstorm for 5 days	506	50,000 people became homeless; 500 million USD damage occurred; and rainstorm wrecked four aqueducts supplying water to the Durban which included 1 million populations; therefore, household supply hobbled.
2018 East Africa Floods Affected countries; Rwanda, Kenya, Somalia, Burundi, Djibouti, Ethiopia and Uganda	2018	Heavy rainfall Cyclone Sagar Dam failure	500	The flood occurred following a year of severe drought; major deaths were due to landslide in Rwanda, which disrupted road and cut off vital trade for landlocked country; In Kenya, due to mudslide, building collapsed and 238,290 people were displaced; the floods caused to the Patel Dam failure, which lead to 48 fatalities in the country; Somalia was hit by cyclone sagar, 31 people lost their lives and 80 % of livestock were killed in the country; In Uganda, latrines flooded in poor areas, greater breeding of mosquitos and cholera outbreak occurred in the country.

Marrakesh Flood Morocco	1995	Rainstorm	230	Most of the victims were trapped in cars and swept along the rivers of mud that come from Atlas mountain into villages in the south of Marrakesh.
1995 KwaZulu-Natal Flood South Africa	1995	Heavy rain Riverine Flood	154	Umsunduzi river and its main tributary, the Slangspruit burst their banks due to heavy seasonal rain; the victim all lived in the Imbali squatter settlement.
2010-2011 Southern Africa Floods Affected countries; South Africa, Mozambique, Zimbabwe, Namibia, Botswana, Zambia and Malawi	2010-2011	Above average rain, Linked to La Nina	141	Air force was brought in to aid in evacuating residents through air lifts in South Africa; Property damage and crop damage in the country was nearly 52 million USD and 145 million USD respectively; In Mozambique, red alerts were issued along the several country's rivers as they neared flood stage. Residents living along the Limpopo River were evacuated due to fears of possible repeating 2000 Mozambique flood as the river arose to its alert level; A flood related bus crush killed four people in Zimbabwe. In Botswana; daily activities in Kalamare and Shoshong river's nearby areas were disrupted which forced the schools to close.
Laingsburg Flood South Africa	1981	Maximum 425 mm rainfall and average 175 mm	104	Buffalo river burst its banks; All the bridges leading to town were blocked so relief teams reached 24

				hours later from the event to rescue humans; there were some claims that flood victims buried in a mass grave in the town.
2018 Nigeria Floods	2018	Niger and Benue rivers burst their banks	Min.100	Severe floods occurred over two weeks. NEMA declared state of emergency on 17 September 2018.

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

3.1.3.4. European floods. Table 3.8 at bottom shows major floods in Europe, which death tolls are between 100 and 1000.

Table 3.8. European Floods.

Name	Year	Cause	Death Numbers	Remarkable Notes
Rubi Flood Spain	1962	Heavy rain Flash Flood	915	200 mm of rainfall in two hours.
Lisbon Flood Portugal	1967	Heavy rain Flash Flood	464	30-31 mm of rainfall per hour; Most victims were sleeping at home in the small river catchment around Lisbon while flash flood hit.
Malpasset France	1959	Dam failure	423	The breach created 40 m dam break wave that carried large chunks of the concrete walls some weighing up to 600 tons, which the speed of the wave was 70 km per hour; Total death toll's 135 were children under the age of 15 and 27 individuals never identified in the disaster; Dam and two villages affected by disaster were close to the highway construction site so there were allegations that explosions during building the highway caused shifting of the rock base of the dam;

				Weeks before the breach, Cracking noises were heard and some leaks occurred on the right side of dam but there were no urgent measure to take.
North Sea flood Germany	1962	Low pressure system, Storm tide, European windstorm	347	315 people killed in Hamburg. Mostly affected residential area was Wilhelmsburg in Hamburg that is 100 km away; 200 km/h wind speed occurred; The floods lead to 50 dyke breaches and officials raised alarm for the city.
Grenada, Almeria, Murcia Flood Spain	1973	Torrential rain Flash Flood	272	Some areas were exposed to 203 mm in six hours; The rains came unexpectedly after a devastating six months drought; Many victims in Granada were trapped in their beds by sudden flood.
Val di Stava	1985	Dam failure	268	180,000 m ³ of mud, sand and water were released into the Rio di Stava valley and toward the village until reaching Avisio River, which is 4,2 km away; The speed was 90 km per hour; An investigation into the disaster found that dams were poorly maintained and safe operations were not enough so ten people found guilty in the verdicts.
Görmeç Turkey	1992	Snowstorm Snowmelt flood	261	Snowstorm caused to avalanche or snowslide in the southeastern part of the country in the rugged mountains along the Iraq border.100 soldiers lost their lives and many were missing on the icy mountainside.

Sarno Flood Italy	1998	Two days torrential rains	159	Volunteers were searching the rivers of mud up to two meters; unchecked property development, decades of ransacking the lands, sprawling construction, abandoned forestry maintenance and too close homes to the rivers or to the landslide areas were reasons for the losses and damages; rescue operations were slow and uncoordinated, and local, regional and central governments blamed each other.
Aberfan Debris Flood Wales	1966	Heavy rain, Pile of coal or mining waste rocks on mountain slope and water saturated debris	144	Heavy rain (171 mm) caused to slide the wastes (110,000 m ³) from downhill as slurry. The debris flood engulfed a junior school in the region that caused to death of students and teachers; Residents of villages suffered medical problems and half of surviving children experienced post-traumatic stress disorder.
Central European Flood or Millennium Flood Czech Republic, Poland, Germany	1997	Heavy rain, Oder and Morava river basins flooded, Genoa low pressure, Flash flood	114	Precipitation was very high (300-600 mm); Water levels rose by up to four meters in half a day; 680,000 houses, 4,000 bridges(45 destroyed), 2,000 km of railways, 14,400 km roads were affected; It was worst flood in the history of the Poland; Poland declared a day of national mourning; In Czech Republic, 2151 flats and 48 bridges were destroyed.

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

In 2014 from 13 May to 27 May, Southeast Europe floods caused to death of at least 86 people. Death tolls were unclear in the year 2014. Serbia, Bosnia and Herzegovina, Croatia, Romania, Hungary, Slovakia, Austria, Czech Republic, Poland, Macedonia affected from floods due to low pressure in 2014 southeast European floods. Bosnia and Herzegovina and Serbia suffered the greatest damage, which the rain was the heaviest in 120 years of recorded weather measurements (Sucic and Sekularac, 2014).

3.1.3.5. Asian floods. Table 3.8 at bottom shows major past floods in Asia, which death tolls are between 100 and 1000. The main reasons of heavy rains in Asia are Monsoon rains. Major people lose their lives in flood events due to extreme rains triggered by monsoon in Asia. Major flood events are like that;

Table 3.9. Asian Floods.

Name	Year	Cause	Death Number	Remarkable Notes
Ishaya Japan	1957	Massive rain	992	One amateur radio operator expressed that 1,000 dead in Ishaya city alone.
Iruka pond flood Japan	1868	Dam Failure Heavy Rain	941	Dam holding the second largest reservoir of the country collapsed
Tokyo and Kobe Flood Japan	1938	Heavy rain	933	Two days of typhoon, tornadoes, earthquake, heavy rain and flood.
Karachi Flood Pakistan	1977	Heavy rain	848	203 mm of rain in just 12 hours
North Korea Flooding	2006	Heavy rain	844	South Korean aid group estimated that 10,000 people are missing and 1,5 million people became homeless
Vietnam	1999	Series of storm, tropical storm	793	The flood caused to 290-490 million USD economic losses in the region

Taiwan	2009	Typhoon Morakat	677	An entire village was buried at the southern country of Kaohsiung.
Seoul Flood South Korea	1972	Heavy rain	672	452 mm rain measured in Seoul.
Luzon Flood Philippines	1972	Southwest monsoon	653	479 mm of rain fell in Baguio
North Korea Flooding	2007	Heavy Rain	610	The flooding submerged or washed away more than 11 percent of the country's rice and corn fields.
Kobe flood Japan	1967	Massive rain	517	Flood affected Kobe, Kure and Agano river, massive rain and landslide occurred.
2018 Kerala Floods India	2018	Low pressure, Heavy rain, Large discharge from dams, landslides	483	At least, one million people were evacuated.
2016 China Floods	2016	El Nino, frontal boundary	449	280,000 hectares of cropland was destroyed and state damage was 5.73 billion USD.
Western Japan Flood	1972	Heavy Rain	445	The crop loss was estimated at 472 million USD.
Tamil Nadu Floods India	2015	Northeast monsoon	442	Milk, water and vegetables are sold ten times more than their usual price
2002 Nepal Flood	2002	Torrential monsoon rain	429	Rains cut off some roads leaving villages accessible only by helicopter.
1969 South Korea Flood	1969	Torrential rain	408	Landslide occurred in affected areas.
1993 Iran flood	1993	Heavy rain	407	Flash flood and landslide occurred at Isfahan and Bandar Abass

1998 South Korea Flood	1998	Heavy rain	405	248 mm were measured, the disaster left more than 121,000 people homeless
Lebanon Flood	1955	Flash Flood	400	100 mm rain within two hours in Tripoli, Lebanon
Thailand and Malaysia Floods	1988	Torrential rain	386	301,000 people were displaced and 172 million USD damage occurred
Yemen Flood	1996	Heavy rain	347	1.2 billion USD damage occurred.
South Korea Flood	1987	Torrential rain	345	Dozens of landslides occurred
Sumatra Flood Indonesia	2003	Heavy rain, flash flood, landslide	313	The flash flood hit in the early hours as most people slept; extensive illegal logging activities in area were blamed for disaster.
Nagasaki Flood Japan	1982	Thunderstorm	299	Local government was caught completely off guard when a violent thunderstorm struck the city.
Maian Flood Jordan	1966	Heavy rains, storm	259	The bridge over Wadi Wahida on the Ma'an- Agapa highway was overtopped and destroyed about 20 minutes after storm started.
Tajikistan Flood	1998	Heavy snowfall, Persistent rains and snowmelt	255	The flood triggered mudslides in the mountains and 44,000 people became homeless.
Gujarat Flood India	2017	Low pressure systems, monsoon	240	Gujarat received 559.4 mm rain.

2009 Philippine Floods	2009	Tropical Storm Ondoy, Typhoon Ketsana	235 unclear	A month's worth of rainfall fell in just 6 hours; 126,721 hectares of rice farming land destroyed. Death Numbers might be 464 in the country
Balochistan Flood Pakistan	2007	Cyclone Yemyin	228	300,000 homeless people in 14 districts of Balochistan. 34 basic health units in Labella flooded
2012 North Korean Floods	2012	Tropical Storm Khanun	227 unclear	63,000 homeless people occurred and 442 mm of rain recorded in North Phyongan province. More than were 330 killed for some sources
2018 Japan Floods	2018	Heavy downpours Meiyu Front	225	Deadly floods occurred in Kansai region which was struck by a deadly earthquake three weeks prior. 1,852.5 mm of rain accumulated in ten days in Shikoku.
2017 China Floods	2017	Heavy and sustained rains	203	Water levels in more than 60 rivers in Southern China were above the warning levels due to heavy rainfall
South China Floods	2008	Torrential rain	200	Torrential rains with landslides lasted for 20 days
Tajikistan Flood	1992	Torrential rains	200	Mud and rockslide in Pamir mountain occurred

Salang Avalanches Afghanistan	2010	A series of at 36 avalanches struck and damaged the Salang Tunnel due to heavy wind and rain.	172	3.5 km of roadway in the Salang Tunnel was buried, thousands were trapped in their vehicles and the disaster cut off one of the major travel links to Northern Afghanistan
Krasnodar Krai Floods Russia	2012	Intense storm	171	Six months of rains fell in two days. The flood hit the region around 2 a.m. when most residents were asleep. The flood wave reached to 7 m
Izumo Flood Japan	1964	Massive rain	128	Record-breaking rain on the Sea of Japan coast caused landslide in Izumo and Shimane
2010 Ladakh Floods Pakistan and India	2010	Cloudburst and heavy overnight flood	125 unclear	Flash floods, mudflows and debris flood occurred due to cloudbursts, 255 death and 29 missing were available for some sources, not clear
Jeddah Flood Saudi Arabia	2009	More than 70 mm of rainfall in four hours	122	Many of victims were drowned in their cars. At least, 3,000 vehicles were swept away
2007 Jakarta Flood Indonesia	2007	Torrential rains	119	Four meters floodwaters displaced 340,000 people. Those who killed in the disaster either sucked by powerful currents, electrocuted when they came in contact with live electricity lines or fallen ill.

Masuda Flood Japan	1983	Heavy rain	117	Very heavy rain, following a landslide resulted in a devastating flood in Masuda and Tsuwano, Shimane
1990 South Korea Flood	1990	Heaviest rainfall in 70 years	114	The Seoul was swamp by 381 mm of rain in 24 hours.
2002 Russia Flood	2002	Heavy rain	110	Nearly 86,000 people were evacuated in southern Russia, many of them by helicopter. A burial site for cattle was infected with anthrax. Officials vaccinated all cattle in the region against anthrax. Russian health officials were worried about intestinal infections and Hepatitis A.
2015 Myanmar/Burma	2015	Torrential rains Heavy Monsoon Deforestation caused by logging Mismanagement of irrigation projects	103	Most of casualties were reported from Irrawaddy Delta
2016 Sri Lankan Floods	2016	Torrential rain and gale caused floods and landslides	101	Drought before flood event caused power cuts but uninterrupted power supply was given after the flood due to high water

*The sources of information are the collection of various global online news centers, various archives and Wikipedia.

3.1.3.6. Oceania floods. Flood deaths in Oceania do not seem like other continents. Death numbers seem low in records when compared to other continents although the continent is exposed to tropical cyclones. It is not easy to show a flood event in records that include more than 100 deaths in Oceania. Deadliest recorded event in Oceania is enormous storm surge event in 1899 due to cyclone Mahina. Cyclone killed over 300 people, most probably, up to 410 but the death toll is not clear. Cyclone Mahina created the largest storm surge on record, generating 13 meters high surge (Kerr, 2014).

3.1.3.7. Antarctica floods. Antarctica is an indicator continent for future flood events in fact. Climate change causes ice melting and water level rise occurs globally due to melting ice in the continent. The major deadliest floods events in the world because of sea level or ocean level rise might be due to ice melting in the Antarctica continent. Antarctica stores enough frozen water to raise global sea level around 58 meters. If this water storage continent melts fast like that, the severe increases in the frequency of flood events globally are an inevitable result.

Scientists express that 3 trillion tons of ice in the last 25 years melted in Antarctica and melting ice in the region created around 8 mm global water level rise. According to the future projections of scientists, this rise may reach around 15 cm by the end of the century. According to an article of The Independent newspaper, Professor Andrew Shepherd from the University of Leeds concluded that ice sheet contributes 0.2 mm per year to sea level rise and in the past five years the contribution has stepped up to 0.6 mm per year, which is three times faster (Gabbatiss, 2018).

3.2. Tropical Cyclones

Tropical cyclones are rapidly rotating storm systems under the condition of low pressures. They can be characterized by a closed low level atmospheric circulation, strong winds and spiral arrangement of thunderstorms that produces heavy rain. Tropical cyclones are named as Hurricanes when they occur in Atlantic Ocean and Northeastern Pacific Ocean, and they are named as Typhoon if they occur in Northwestern or South Pacific Ocean or in the Indian Ocean. Tropical cyclones or strong winds can cause disasters, floods or deaths so they are significant in climate observations. Deadliest cyclone events can be observed in Table 3.10 at bottom.

Table 3.10. Deadliest Tropical Cyclones (NOAA).

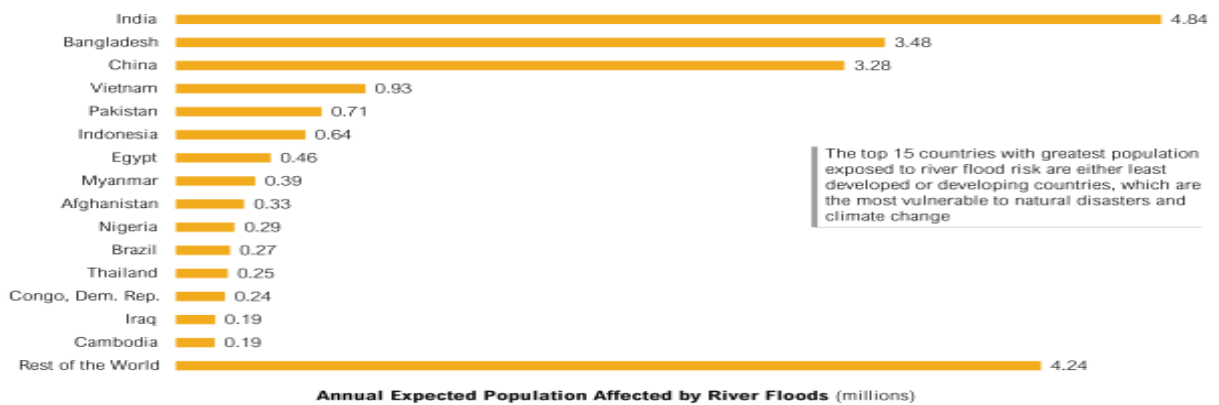
Name	Year	Region	Fatalities
Bhola	1970	Bangladesh	500,000
India	1839	India	300,000

Haiphong	1881	Vietnam	300,000
Nina	1975	China	229,000
Bangladesh	1991	Bangladesh	138,866
Nargis	2008	Myanmar/Burma	138,373

3.3. Riverine Flood Risky Countries

No doubt that flood history helps to determine flood risky regions or countries. A list of riverine flood risky countries around world can be observed in Figure 3.17 at bottom.

15 Countries Account for 80% of Population Exposed to River Flood Risk Worldwide



wri.org/floods

Sources: World Resources Institute 2015; Winsemius, H.C., et al., 2013; Ward, P.J., et al., 2013.

WORLD RESOURCES INSTITUTE

Figure 3.17. The Top River Flood Risky Countries (World Resources Institute, 2015).

4. FLOOD PARAMETERS AND EARLY WARNING

Flood parameters can be defined as parameters that track water resources, weather events, topographic and sociologic features and environmental conditions that probably affect flood events and its damages directly or indirectly. To understand the behaviors or the characteristics of those parameters to identify the patterns or the limits are crucial in flood management to assess the available situations and risks, to make predictions, to form solutions, to prevent negative effect, to benefit from positive effects and to warn early. Those parameters can be categorized as meteorological, hydrological, topographical, environmental and sociological parameters basically. Those parameters as pre-flood studies must always be open to questioning or criticism to identify the limits or boundaries, to determine available risks, to adapt the new changes in the limits or in the patterns and to produce new parameters or categories to bring positive results. In this part, those classified parameters will be explained. Flood predictions and early warnings must be based on those parameters. Precautions or measures must be taken always dependent on the clues provided by those parameters as well. The study categorized the flood parameters into four main groups.

4.1. Meteorological Flood Parameters

Meteorological flood parameters are the parameters that give clues about possible flood events or risks due to weather changes or events. Observation, data, values or limit values of meteorological parameters at bottom must be recorded in the databases as MIS.

4.1.1. Rainfalls

In flood management and control, rainfall, which is a main component of water cycle, must be perceived as abundance or richness to benefit instead of a meteorological event that causes to flood disaster in order to be able to reach positive results. Therefore, rains are abundance and water resources that must be collected and diverted for the use in the areas such as irrigation of gardening or crops, habitat for ecosystems, drinking water aims, hydroelectric energy production, recreational aims and industrial production activities. Those resources must be used in the sustainable ways without damaging environment. If engineers can create good sustainable water systems to collect and to use rain waters in such as activities, it is possible that flood disasters or losses may be a history completely in the future and people or countries may want rainfall always for abundance or richness. In flood management, it is important to know where rainfalls occur. This abundance or rains in the

world occurs so much near the equator or in the tropics in generally between Tropic of Cancer in the Northern Hemisphere (23.5 degrees) and the Tropic of Capricorn (23.5 degrees) in the Southern hemisphere, especially where northeast and southeast trade winds converge (Inter Tropical Convergence Zone). However, instead of bringing abundance, most deadly flood events occur in this convergence zone in general due to high rainfall, lacking of disaster management plans or poor quality of rain collection systems. Even this offered equator or geographical location information due to latitude on earth are an early flood warning for the countries that remain between 23.5 degrees northern hemisphere and 23.5 degrees south hemisphere; therefore, those countries must always be ready and proactive against flood events in this convergence zone.

Almost all flood events' origins are due to rainfalls so it is very significant to know rainfall formations, meteorological and geographical characteristics of the regions to understand where/when/how rainfalls may occur. Researching the rainfall formation or frequencies, the limit values and duration of rainfalls is a prediction study in the scope of the three PPPs. Where rainfalls occur, flood risks are in there or around there really; therefore, managers must research where rainfalls occur and exhibit rainfall limits or characteristics of a region for flood predictions and precautions. Those limits might change always so when changes occur, revision and adaptation are required depending on new limit values. Meteorological knowledge is required as priority to show where rainfalls may occur so much; therefore, knowing formation of rainfalls is significant to explain the locations.

It is a clue that where atmospheric water vapor and condensation events in the atmosphere, rainfall or its possibility is in there basically. Monitoring the occurrence of water vapor and direction of water vapor in the atmosphere will point out the rainfall regions when condensation event occurs. Around four fifth of total precipitation on earth rains over oceans while one fifth precipitates over land; therefore, it can be expressed that coastal regions, coastal cities or island countries will attract more rain than inlands theoretically. In other words, flood risks are high in the coastal regions or the islands than inlands under the normal conditions. Water becomes vapor from the surfaces of fresh waters, seas or oceans due to temperature difference between water and air as a result of heat transfer. After that, vapor moves to other locations through the effect of wind or cloud direction and the density differences among air or air masses. In conclusion, water vapor contacts with particles in the air, condenses and rains. Typically, water in the atmosphere are produced by evaporation and consumed by condensation so those processes must be followed well to understand the rain formation. Condensation in air occurs when water vapor contacts with liquid or solid surface or cloud condensation nuclei, which are the small particles that typically around 0.2 μm . Small particle matters

are required for condensation in the air to rain; therefore, monitoring the small particle matters in the air is necessary to understand where rainfall may occur. Where small particles came together with water vapor in the air, rain will occur in there theoretically as a condensation result. Condensation nuclei may be ice, dust and salt to form clouds. For example, sea salts from ocean wave sprays, dust or clays, sulfates from volcanic activities, soot or black carbon from forest fires, dimethyl sulfides produced by phytoplankton, oxidation of sulfur dioxide and secondary organic matter formed by oxidation of volatile organic carbons might behave as cloud condensation nuclei or particles in the air. The number and type of cloud condensation nuclei or particles can affect the amount and lifetimes of precipitation. Therefore, monitoring those particles and their amounts together with the amount of water vapor are helpful to predict locations, durations and amount of rainfalls. Confluence zones of winds, especially severe ones, which carry great number of those small particles in the air, are signs for rainfalls that most probably lead to flood events.

Water vapor in the air must reach to saturation at first to rain so dew point must be known. Dew point is a temperature that air must be cooled to reach saturation with water vapor. When air cools to its dew point through contact a surface that is colder than air, water will condense and the temperature of the surface that is at or below the dew point temperature of atmosphere will bring rain. Therefore, knowing the dew point temperature of the air and the temperature of surfaces momentarily will inform about rain, for this reason, they must be known and accepted as flood parameters. Those parameters may early warn related with heavy rains and floods, especially for flash flood events. Dew point gives information about the amount of water vapor present in the air or moisture. The amount of water vapor present in the air is described as humidity. Humidity or moisture in the air must be accepted as flood parameter because of warning the rainfall too.

Density, pressure, volume expansion of the air depending on elevation must be monitored to track the rainfall to predict. They are very helpful meteorological flood parameters to warn, predict and understand the rainfall. For example, heated air expands and volume of it increases as it becomes less dense. Less dense air means “rise”; therefore, air rises above high pressure air masses due to becoming less dense or expanded. Having reached area with low density air, it further expands and starts to cool due to losing energy. After cooling air crosses the dew point, moisture in the air accumulates as clouds. If there are enough moisture and cooling together with particles or condensation nuclei, precipitation or rainfalls occur as a result. This mechanism can be described as adiabatic cooling while the reverse of it is described as adiabatic heating. In the adiabatic heating, cool or less dense air starts to sink and temperature increases due to the pressurized molecules becoming agitated, vibrating and increasing in heat depending on descending elevation. This

mechanism is named as adiabatic heating. Adiabatic mechanisms are not dependent on heat or mass transfers but on elevation; however, convective mechanism or convective rains depends on heat transfer, especially on hot days. On hot days, the ground surface gets heat unequally and causes the warmer air to lift as colder one comes to take its place; thus, vertical air currents or movements can develop enormous velocities under these conditions, which cause the rainfalls in the form of showers. The air becomes more heated compared to surrounding areas in convective mechanisms so the air lifts. Cumulus or cumulonimbus congestus, and cumulonimbus are convective rains' cloud types. Convective rains or showers are generally high intensity and short duration rainfalls; therefore, they are significant in the warnings for flash floods, which occur suddenly or in the short period of time. Rainfalls that does not lead to floods are important for early warning too because they increase the moist contents of surfaces and following rains after the rainfall, even low intensity and short duration ones, may lead to tremendous floods due to exceeding saturation on surface. Heavy rainfalls generally become via convective mechanisms, especially in tropics and rainfall duration is short generally as convective rainfalls so frequencies of convective rainfalls and their boundaries or limits are pathfinders related with flood events, especially for flash flood predictions. Conductive cooling may occur when air contacts with cooler surfaces, especially by blowing from liquid water surface to colder land or air; therefore, monitoring surface temperatures are helpful to track rainfalls. Monitoring the amount of infrared radiations is helpful to understand rainfalls too. If the amounts of infrared increase in the air or surface underneath while decrease in the surface due to emission, the change is the sign of rainfalls and named as radiational cooling. When moisture is added to air via evaporation, it might cause to cool the air to wet bulb temperature until reaching saturation and this mechanism is named as evaporative cooling as the reverse can be named as evaporative heating. Monitoring evaporation and evaporative cooling are required to follow water adding or loses and track the rainfall. Evaporations from surface waters, cool or dry air moving over warmer waters, wind convergence into areas of upward motion, transpirations from plants, rising air over mountains and precipitations can add water vapor to air so those contributions must be monitored to the track rainfalls. Shortly, adiabatic, convective, radiational and evaporative cooling are four main mechanisms to cool the air to the dew points to track precipitations. The reverse of those mechanisms is significant too to explain meteorological events. Mountain regions or hillsides are significant to track rainfalls because they are generally exposed to consistent winds and orographic liftings. Raising air motions are exposed to adiabatic cooling and condensation so precipitations occurs on windward side as leeward side remains drier and warm generally owing to removing moisture in raising air, which is called rain shadows. The dry wind that occurs in leeward side of the mountain range is called foehn. Figure 4.1 represents orographic lifting and rain shadow at bottom.



Figure 4.1. Orographic Lifting and Rain Shadow (Bariot, 2007).

Frontal precipitations generally occur due to frontal systems surrounding in the middle latitudes between 23° and 66° in two hemispheres or low degrees. They are named as extratropical cyclones in the literature and defined as a boundary that separates masses of air of different densities. Front movements are due to Coriolis effects and the horizontal differences in atmospheric pressures so following the atmospheric pressure in the air are significant to predict the rainfalls. Geographic characteristics such as mountain regions and large bodies of warm water causes to slow down the fronts, leading to rain; therefore, geographical characteristics must be exhibited well in the flood management to represent the regions researched related with weather events. Some fronts might not lead to precipitation but wind shift in fronts occurs owing to density, temperature or pressure differences. Cold fronts and occluded fronts usually move from west to east as warm fronts move poleward. Also, cold fronts and cold occlusions are two times faster than warm fronts and warm occlusions because of becoming denser than warm front. Cold fronts cause sharper changes in weather and lead heavy thunderstorms or rains as low pressure areas because of wedging warm fronts. Cold front may be preceded by dry line, which separates moist air from dry desert air, or squall lines, which is a line of thunderstorms forming along or in front of cold front as fog can occur before warm fronts passes. Clouds ahead of the warm fronts are mostly stratiform that is a uniform low-level cloud such as stratus, especially nimbostratus characterized by horizontal layering. Stratiform precipitations show extensive horizontal development but little vertical movement so they exhibit relatively continuous and uniform intensity as steady rains, which is different than convection or rain showers. As warm fronts approach to clouds, the rainfalls increase gradually. Warming and clearing are usually fast but thunderstorm may continue even after the passages. Occluded fronts occur in the mature lowpressure areas as a cold front overtakes a warm front, which leads to separation of warm mass

from cyclone center. There are two types of occluded fronts: cold occlusion and warm occlusion. In cold occlusion, the cold front passing warm front is colder than a cooler air in front of warm front, and plows under both air masses. However, in warm occlusion, the cold front passing warm front is warmer than the cool air in front of warm front, and rides over the cold air mass as lifting the warm air.

When the cold air equals or exceeds the saturation with surface temperature of water or lands, it may rain depending on atmospheric conditions or great amounts of water vapor may join to air from surfaces than normal values to rise back or the rain might occur adiabatically depending on elevation. Thus, it can be expressed that the frequency and the tremendous velocities or severity of vertical air movements are the signs of heavy rainfalls or its severity in the atmosphere due to differences in the values of densities, pressures, temperatures, elevations, speed or velocities and heat or kinetic energies dependent on the amount of small particles or cloud seeds, atmospheric water vapor (humidity) or moisture, weather fronts and geographical features.

Forests and vegetation are significant in flood management and control. Evaporation rate from forests greatly exceeds evaporation from water areas under the conditions of sunshine or summer; therefore, forests attract rains or moist from water resources such as sea, ocean or lake or river. Evaporation is low rate in deserts so air directs toward water resources. In winter time, solar energy is insufficient to sustain forest evaporation at rates higher than water resource; thus, water or sea attracts air from lands or forests. Forest losses with time will lead to arid conditions and evaporation losses and under this condition, air flows to the coasts. When a region is forestry region and close to sea or ocean or water resource, this region attracts moist and water vapor from sea or ocean and expose to heavy rainfalls. Where forests, mountain, oceans or sea in a region are, heavy rains are close to those places due to the evaporation rates, the water vapor attractions or the water vapor directions. Theoretically if the direction of water vapor is toward lands from coasts, forests and land areas or settlement places that are close to those areas will take precipitations or heavy rains. Under the reverse conditions, from lands to the coasts, coastal regions or settlements will take heavy rains or rainfalls as a result.

Plant types that absorb more waters or rainfalls and transpiration mechanisms are significant in flood management too because plants absorb water from soil, and they offer natural flood control opportunities owing to active and passive absorption in roots, stem and leaves. Native plant types that are suitable for the climate of the region and that include high absorption rate in roots, especially passive absorption rate will be helpful to eliminate flood events due to absorbing rainwaters or water

from soil. For example, willows (*Salix*) need more water to sustain its life; therefore, they must be used as flood control plants or trees in the highly flood risk regions due to absorbing rainfalls or other water resources, which remove pollutants from environment as well. Types of trees, shrubs, vines and groundcovers together with soil type or characteristics are significant in the flood management control because of absorbing rainfalls or water resources, especially in highly flood risky areas. Plants types depending on water absorption level prevent erosion so that those who have high water absorption rate must be preferred as preventive plants because erosion makes the rocks or soil weak with time, especially in hillside or mountain regions, leading to landslide or mudslide under the conditions of rainfalls or the strong winds and such as plants will prevent erosion. As for transpiration, If the frequencies of rainfalls are very high in a region, the plants which have high transpiration rate must be preferred to release the absorbed rainfalls while under the condition of having low frequency rainfalls, the plants which have low transpiration rates must be planted in the flood and erosion control. Otherwise, overwaters upon plants via rainfalls may lead to plant deaths due to damaging roots of plants and sweep the plants or rotten roots of those plants at great levels via floods or erosion. Those plants might clog water ways which block water passes and cause flood events in rivers or channels as a result.

There are many methods to measure rainfalls. Rain gauges, ground based weather radars, earth observation satellites, TRMM (Tropical Rainfall Measuring Mission) and GPM (Global Precipitation Measurement) are some of methods to measure rainfalls. In flood management and control, the results of those measurements must be repeated and compared continuously with each other to reach reliable results. Conventional measurements such as rain gauge usage are very helpful to provide information about rainfall or its limits in local or regional base because major countries around the world may not have remote sensing technologies or satellites data because of lacking of space technologies. Cooperation with technological advanced organizations such as NASA, JAXA and ESA are very useful for the countries to warn early, to cope with climate change problem, flood disasters or natural disasters to minimize losses or damages until they become advanced in the field. Aqua, Aura, CALIPSO, CryoSat, Cloudsat, Deep Space Climate observatory, Global Precipitation Measurement, Grace Follow-on, Jason 3, SWOT and TRMM are significant satellites that provide information related with climate, precipitation and water levels on earth. Flood managers must benefit from information provided by those satellites or radiosondes always to warn early and to minimize the risks of floods or natural disasters.

Rainfall intensity is very significant to warn early in flood management and control. Eq.1 at bottom shows heavy rainfall threshold quantities at standard times. When rainfall exceeds those

values at specific time, no important whether the rainfall will cause to floods or not, flash flood warning must be given by authorities to the officials and teams immediately as red alert. It is too late warning type among early warnings when compared to other parameters but it is very decisive warning type. Between 5 minutes and six hours (360 minutes), the warnings must be given or announced as flash flood warning because flash floods become suddenly. Of course, there might be meteorological warnings for a possible heavy rainfall before the rainfall start via radar, remote sensing or satellite observations and other predictions but those warnings might not be available before too. No important whether the warnings before is available or not, those equation threshold values must be official flash warnings for the heavy rainfalls to activate teams or officials. After rainfall exceeds those threshold values, all officials and teams dependent on emergency action plans prepared before have to be active on their duties in the red alert level with this flood warnings announced by the authorities. In fact, those heavy rainfall threshold quantities inform that activities which are needed to implement during flood events must start immediately because most probably flood events due to heavy precipitation will occur in the region. In conclusion, the threshold warnings come to meaning that all equipment, rescue teams or other attendant personals must be ready now in their place or work for the action.

Sometimes flood events might even occur below this threshold values; therefore, Flood Color Limit System was developed in this study. If flood events become below the heavy rain threshold value, it means that those places are not successful in the flood management and control, which is a red alert warn for those places or city managers. Flood prediction is not important for those places because any intensity of rainfall can lead to flood events in there, even small or light rainfalls can cause flood losses and damages in such as places. Those places as red alert highly risk regions and the management authorities of those places have to take flood measures 7/24 without stop so much than other places to minimize available risks until increasing the capacities of the places to the upper color or heavy rain threshold values that will not damage to those places. Red alert warnings will not finish for such as places until they reach to a condition that heavy threshold values that do not cause to flood events in there as a result of preventive measures taken via continuous three PPPs. To discover the color or warning light, meteorological measurements are required for those places, especially total monthly rainfalls, maximum daily rainfalls and total maximum rainfall by yearly are required to determine the color or light or its optimum limit values, of course, the warning color relies on flood occurrence in those threshold values. Flood Warning Color Limit system was developed to increase the capacity of cities or places and reach optimum or secure threshold values as minimum. Even this color limit might not be enough under the unstable conditions; however, it will be helpful to increase the capacity of cities or places or infrastructure as indicator points or color or quality

limits. Eq.4.1 at bottom obtained from the webpage of Turkish Meteorological Service, which helps to determine threshold rainfall values. Flood Warning via heavy rainfall threshold quantities at standard times;

$$R_T = \sqrt{5t - \left(\frac{t}{24}\right)^2} \quad (4.1)$$

R_T : The amount of rain (mm) as threshold value.

t : Rainfall time as minute.

R values must be compared with R_A value;

R_A : Actual rainfall measurement during rain

If $R_A \geq R$, warning must be given immediately to the officials, staffs and teams compulsorily. Until first 360 minutes (6 hours), warnings are accepted as flash flood warnings for the equation. After 360 minutes, warnings are not accepted as flash floods or flash flood warnings but accepted as other type of flood warnings dependent on the locations when flood event becomes real in the region. Such as warnings at above are the acute or short-term flood warnings to activate personals or teams or officials under rainfall conditions. After rainfall finishes, the rainfall values must be evaluated with a report and be compared with the threshold values at bottom. The color or light of the places must be determined dependent on this report, which is a kind of evaluation for the regions or settlements. This warning concept is a chronic or long-term warning to minimize risks, to rehabilitate low quality managements and to increase the capacity of regions or settlements or cities against flood disasters.

Table 4.1. Heavy Rainfall Threshold Quantities at Standard Times (Turkish State Meteorological Service).

Time, t as minute	Threshold value, R_T as mm	Time, t as minute	Threshold value, R_T as mm
5	5.0 Flash F. Warning	240 (4 hour)	33.2 Flash F. Warning
10	7.1 Flash F. Warning	300 (5 hour)	36.7 Flash F. Warning
15	8.6 Flash F. Warning	360 (6 hour)	39.7 Chronic F.W.
30	12.2 Flash F. Warning	480 (8 hour)	44.7 Chronic F.W.
60 (1 hour)	17.1 Flash F. Warning	720 (12 hour)	52.0 Chronic F.W.
120 (2 hour)	24.0 Flash F. Warning	1080 (18 hour)	58.1 Chronic F.W.
180 (3 hour)	29.0 Flash F. Warning	1440 (24 hour) daily	60.0 Chronic F.W.

Daily heavy threshold value (60 mm) for the heavy rainfalls in the table is a result of calculation from the Eq.1, which bases Tropical Rainforest Climate (Af) in the Köppen Climate Classification. The climate classes of all the regions, cities or settlements dependent on Köppen Climate Classification must be determined in the PPPs, which will be useful in the flood management and control if settlements or regions were not classified by climatically until now.

Main death reasons in flash floods are the time for the warning the people is so short but early warning within maximum 5 minutes can be made with this equation during rainfall under the condition of good rainfall measurement and data transmission systems via rain gauges, and also it is possible to make flash flood warnings until the end of six hours (360 minutes). The flash flood early warning problem becomes history with this threshold values together with flood warning limit system under the condition of good measurements and educated teams or personals.

Warnings should not only be made for the staffs, official personals, managers or teams to activate them but also they are required for public or citizens or tourists or places; therefore, warnings must be announced for the public or people via state or national meteorological information web sites, online press services, TV channels, radio stations, warning by SMS or GSM through telecommunication companies, and social media such as Facebook, Twitter or others as well. Public must be informed about what to do under the threat or disaster conditions via authorities. Contact information or request for help must be available and ready always for emergency conditions. Websites must be updated and active 7/24 to inform and report the available situations continuously.

Heavy rainfall or not, all rainfalls must compared with this threshold equation offered at above and evaluated dependent on it because sometimes flood events or its damages can even occur below this threshold values in a region; it means negative sign and red alert or color for that place so it is under the great flood risks, which is a chronic type of warning for the place that need long term special focus. Such as the region types need great rehabilitation, pre-flood activities, measures, especially structural ones together with during and post-flood activities, to minimize the available risks. When maximum daily rainfall is less than daily threshold (60mm) and floods do not occur below this value in the region, the color is white, which shows settlement has low maximum daily rainfall than the threshold values and infrastructure prevents the rainfalls. Sometime flood events or its damages might not be even upon this 60 mm threshold values in a region which means positive sign and the warning colors will be either orange or yellow as alert color dependent on conditions or events for the region.

Maximum daily rainfall value during measurement periods must be determined in the region. If flood events or damages occur between below the daily maximum value and above the threshold value of the equation at above, the color or light of alert is orange color for the region. Such as type of regions need both structural and non-structural measures equally. If the flood event does not even occur in the range between the above threshold value and the below maximum daily value as it occurs above maximum daily rainfall value, it means yellow alert or light as warning color. Non-structural measures are required so much than structural ones for this color group to reach upper color and to sustain the secure situation. Managers must realize that yellow color that exceeds maximum daily value is a new situation and a new daily record anymore, therefore; old maximum daily rainfall value must be updated for new one. Under this record condition, the new maximum daily precipitation value is very significant. If the new maximum daily value is less than the highest average rainfall month value during measurement periods, the color or light is yellow and the situation is stable, which means non-structural measures can cope with major problems until new daily records come. But if the new maximum value is more than the highest average rainfall month value during measurement periods, it means the color or light is yellow again but situation is unstable which means climate change occurs in there slowly. Under those conditions, structural and non-structural measurements will start to be not enough to cope with the problems anymore owing to broken highest monthly record. Green-environmental and sustainable solutions are required in every action for such as regions or cities or location or settlements after this time as an obligation. Those regions may be under the great risks anymore with this new broken record or changing regime or limits as well. Measures must be taken in the region dependent on threshold values of minimum green light or alert anymore because of the growing unstable condition.

All daily, weekly, monthly, yearly, minimum, average and maximum rainfall values of the regions or settlements must be recorded continuously. Average monthly rainfall values in a year must be calculated to determine the warning colors. The average values of three average highest rainfall months during measurement periods are significant especially because the total average value of three heaviest rainfall months during measurement period is a standard threshold value for green alert or light in this study, which is called Maximum Three Months' Total Rainfall Value for Green Light. Rainfall collection systems in a region must have a daily capacity which is equal to the total value of those three average heaviest rainfall months during measurement periods to express the infrastructure is enough optimally to meet extreme or uncontrollable heavy rainfalls that will probably lead to deadly flood events. All flood infrastructures in a place must be in the level of this green light value as optimum standard.

Sometimes even this green light standard this study developed might not be enough because there are places that may expose to four, five, or six months' rains in one day on earth due to the effects of climate change or other factors. The highest six months' total value during measurement periods is another threshold value for such as regions or places, which is called Maximum Six Months' Total Rainfall Value for Blue light. If a maximum daily rainfall is higher than the highest three months' total value of green alert or light during measurement periods, the situation is a new unstable condition. Risk for the region is blue color anymore and the measures, especially structural ones, must be taken dependent on the highest six months' values. The increasing of the daily capacity of rainfall collection system to the blue light level might be useful to benefit from rainfalls better under this changing condition. Broken records with minimum the highest total three months' value during measurement periods are the sign of moderate climate change in a region.

Sometimes even this blue alert color or standard might not be enough because there are places under the effect of climate change or other factors that may lead to more than six months' rains in one day on earth. If a maximum daily record is more than the value of highest six months, the situation is accepted as highly unstable and climate change occurs very fast in the region with this extreme broken record, which is called Maximum Yearly Total Rainfall Value for violet color. All flood measures, especially structural ones, must be taken dependent on total year value with this changing limit or new imperial violet limit. The probability of repeating such as new great record value more than six months will be minimum possibility for a long time although limit values widen in the region. If a maximum daily record is a year value or more than the value of one year and does not lead to flood disaster, the situation is secure for the settlements or region but the speed of climate change is extreme or superfast in there with this record. All flood measures in this limit must be taken dependent on new imperial violet record as new total year value after updating the old one. Climate change researches by scientists must be carried out in such as places especially, to follow the extreme events or its effects to the population or the regions.

Significant things are to adapt to the new changes in the regions or locations. Infrastructure, irrigation, industrial and transport systems, building types, energy systems, economical activities, and almost all plans or management systems must be regulated and revised according to this changing rainfall limits; therefore, following this changing rainfall limits or bands are significant for the adaptation to new conditions or environments. To meet such as changing limits and flood risk assessment needs, the study put the flood color warning limit system in order from red to violet dependent on decreasing wavelength of the light. Optimum precaution or extremely highly secure limit value against a daily measurement result or a daily reference is violet color value, which is the

maximum yearly limit in this flood color limit system. If the places or regions or infrastructures are adapted to flood violet light or color limit values, it means there is a minimum flood risk in those places because of being low wavelength, divine, imperial and precious color. Violet color or light have been very precious color always because, in ancient world, many Byzantine and Macedonian emperors from Justinian to Alexandre Great wore this color as imperial color. This imperial flood limit color system created in this study to reach the optimum violet values as an ideal goal to minimize possible flood risks, to take effective measures, to determine and increases the quality of flood management or control actions and to benefit from rainfalls at maximum scale can be defined as Anil Imperial Flood Warning Color Limit System. Anil means the god of air and wind in Sanskrit language and it is similar to the writer's Turkish name Anıl so it is suitable to define the flood color limit system in this name.

To give an example how the system works; for instance, on 20 October 2018, a flash flood event after rainfall in a worth of year in one day occurred in Qatar, which is the sign of Violet color limit for Qatar. Most probably the region's flood color was blue light because of one year's rainfall leading to the flood or low probability of flood risks due to desert condition. Abu Hamor in the capital Doha recorded 84 mm of rain in less than 6 hours in the event. It is a sign that Qatar moves away from desert climate toward a climate that has higher precipitation. It is a positive, precious and violet limit development for a desert country that lives water shortages in fact. In desert countries, rain collection system is very significant to benefit from rainwaters, especially for drinking water usage although rain probability is extremely low. With this new record, Qatar must build a rain collection system which includes a daily capacity in the value of a year at least, which is 84 mm of rain as violet value limit now after the rainfall and flood events on 28 October. This violet value, 84 mm is optimum or ideal limit value for Doha anymore with this broken record. Most probably is that this record will not be broken for a long time although the limits widen. Therefore, infrastructure must be designed minimum according to this imperial violet limit to make the city safe against flood risks and to benefit positively and effectively from floods or rainfalls without any damages or loses. If this change is managed well and adaptation occurs, the new record condition is very precious development for a desert country that lives water shortages. Violet imperial limit values transform the negative conditions or perceptions related with changes to the positive idea to benefit from this changing condition via forming a limit standard value to produce solutions, to warn early, to inform manager or officials, to evaluate the available situation to act logically to save lives, to minimize the risks or damages and to adapt to the changing conditions. Imperial Flood Color Limit System works in this concept basically.

Table 4.2. Anil Imperial Flood Warning Color Limit System.

Flood Color or Light	Warning, Limit indicators, meaning
	RED ALERT: Floods events occur below threshold values of Eq 1. If $R_T > R_A$ causes flood, it is chronic red alert for the region. It means extremely highly risks so flood damages are inevitable. Continuous structural, non-structural, PPPs and flood emergency plans are required to minimize the risks and qualify. To qualify to the upper color, minimum five rainfall events equal or above heavy rainfall threshold values should not cause to any flood damages in the regions. Such as regions must have warning sign in red color on road to inform public or tourists. They need special interest so officials or teams or managers have to be proactive always.
	ORANGE ALERT: If $R_T < \text{Flood occurrences} < R_D$ as it does not occur below the R_T, it means orange alert for the region. Such as type of regions need both structural and non-structural measures equally. If a place in this category is exposed to flood events two times below R_T, the color falls to the red color back and changes must be updated in the region immediately. If three consecutive rainfall events between R_T and R_D together with rainfall that is more than R_D do not cause to flood events in the region, the orange color or light qualifies to yellow limit in the region. New record and color change must be updated as new yellow limit.
	YELLOW ALERT: Floods occur above R_D value. If there are five flood events below yellow limit (R_D), the color falls back to orange color. If the new record is less than the highest month rainfall (R_{M1}) during measurement periods, it is yellow stable (non-structural measures are enough). If the record is more than R_{M1}, the region must be prepared by managers to the highest three months' total rainfalls (R_{M3}) as green limit to be optimum or secure and to qualify to the green color because climate change occurs slowly in there.

	GREEN ALERT: If two consecutive rainfall events in the value between R_{M1} and R_{M3} in yellow color limit and a rainfall that is more than R_{M3} do not cause to flood events, the color qualifies to the green light limit which is very secure and optimum flood standard. After reaching this color, the region must be prepared to the highest six months' total rainfalls (R_{M6}) as blue limit to be optimum or secure and to qualify to the blue light or color because climate change is moderate in this limit. If there are three flood events below R_{H1} in green limit, the green color falls back to the yellow color. The value which is more than R_{M3} becomes equal to R_D if color falls back to the lower yellow limit.
	BLUE ALERT: If a rainfall event in the value between R_{M3} and R_{M6} together with a rainfall event that is more than R_{M6} do not cause to flood events in a green color region, the limit or light qualifies to the blue light which is much more secure than green light. After reaching this color, the region must be prepared to the twelve months' total rainfalls which mean yearly total rainfalls (R_{IL}) as imperial violet limit to qualify to imperial color of violet because climate change is very fast in this limit. If there are two flood events below R_{M3} in blue color, the color falls back to green limit or alert.
	VIOLET ALERT: If a rainfall event that is equal or more than R_{IL} value does not cause to a flood event, the limit becomes color violet as imperial value. The situation is maximum stable or optimum imperial secure condition for flood security. The speed of climate change is extreme or superfast in there with this record. All flood measures must be taken dependent on new imperial violet record as new total year value after updating the old one. This is imperial violet color and maximum secure limit.

* R_T : The amount of rain as threshold value, R_A : Actual rainfall measurement during rain, R_D : Maximum rainfall daily value, R_{M1} : the highest month rainfall, R_{M3} : The highest three months' total rainfalls, R_{M6} : the highest six months' total rainfalls, R_{IL} : Yearly total rainfalls (Imperial Limit).

4.1.2. Temperature

If the region's all months has an average temperature of $18\text{ }^{\circ}\text{C}$ or higher, this region will show characteristics of tropical rainforest climate, tropical monsoon climate and tropical savanna climate, which the flood risks are very high climates due to attracting more precipitations, especially in the tropical rainforest climate that attracts minimum 60 mm rain for each months of the year as highly flood risk group. Average temperature values of months and the year are significant arbiter which determines climate types in Köppen classification system when compared with rainfall regime; therefore, maximum, minimum and average temperature values of day, month, and year must be known very well to determine the limits of climate and track rainfalls for the predictions or warnings. Temperature and precipitation values must be compared always, especially in the spring and summer seasons as indicators. Flood events mostly occur in spring and summer seasons in those three climates.

Higher sea temperatures are a sign of rainfalls, which means more evaporation or water vapor into air. Following and comparing the temperature values of water and air are very significant to track rainfalls or flood events because water vapor transfer, heat exchange, evaporation, hot air movements due to temperature differences are determinative in rainfall occurrences. Temperature lessens with elevation, which decreases $1\text{ }^{\circ}\text{C}$ for each 200 m elevation from sea level. When water vapor is added to the air, it will rise because of low density until losing its all energy in the air. After losing its energy, it will start to sink and cool to dew points or lower. After contacting with cloud seeds or particles in the air, water vapor condenses dependent on dew point, elevation, temperature falls, the amount of water vapor in the air, and the amount of condensation cloud nuclei or other particles. Knowing and following the dew point temperature, the water vapor temperature in the air, and the temperatures of water, air, objects, ground surfaces or lands, particles or cloud condensation nuclei in the air are significant to track rainfall for the warning, especially in the mountain, the forest, the sea or ocean, in the confluence zones of fresh waters and in the confluence zones of winds.

T_{ITDL} means ideal temperature difference limit for the rainfall warning. To calculate T_{ITDL} , average monthly water temperature is subtracted from one of monthly minimum, average or maximum air temperature values during measurement period dependent on the latitude of sea. After that, each subtraction results are added and divided by 12 to calculate the value of T_{ITDL} . If $T_{\text{average Sea}} - T_{\text{average air}}$ now that is called T_{ASDA} equals or exceeds T_{ITDL} , it means a harbinger of rainfall, which may lead to flood events dependent on intensity of rain. Such as bigger difference occurs in autumn seasons especially. The amount of water vapor, vertical air movements, the speed or direction

of winds, dew point, fronts, particles or condensation cloud nuclei and geographical features are detrimental too. More differences or intervals between T_{ASDA} and T_{ITDL} come to meaning that the amount and intensity of rain is bigger or heavier. This difference is a harbinger of rain and average monthly $T_{Sea} - T_{Air}$ is directly proportional to the monthly precipitation of the region. If there are deviations to the monthly precipitation related with direct proportion, deviations are not due to temperature differences but other factors, maybe density, pressure, geography, latitude, or measurement period difference. To calculate T_{ITDL} in coastal cities, minimum or average air temperature values for the cities in Black Sea and Marmara Sea, average air temperature values for the cities in Aegean Sea and in Mediterranean Sea might be selected as reference to balance air temperature deviation because of latitude difference. Following temperature difference between sea and air, in addition, temperature difference among ground surface, objects, air, sea and fronts are precious efforts shortly to predict rainfalls or possible flood events for a region via temperature flood parameter. Table 4.3 is a calculation example of ideal temperature difference limit in İstanbul.

Table 4.3. Ideal Temperature Difference Limit (T_{ITDL}) Determination for İstanbul.

İSTANBUL	Average Marmara Sea Temperature (T_{Sea}) $^{\circ}C$	Average Minimum Air Temperature in İstanbul (T_{air}) $^{\circ}C$	$T_{Sea} - T_{air}$ $^{\circ}C$	Precipitation mm
January	9.0	3.1	5.9	106
February	7.9	3.1	4.8	77.7
March	8.4	4.2	4.2	71.4
April	11.0	7.6	3.4	45.9
May	15.0	12.1	2.9	34.4
June	19.8	16.5	3.3	36.0
July	23.2	19.4	3.8	33.3 (deviation)
August	24.0	20.1	3.9	39.9
September	22.0	16.8	5.2	61.7
October	18.6	12.9	5.7	88.0
November	14.9	8.9	6.0	100.9
December	11.6	5.5	6.1	122.2
Average Values	Average: 15.5	Average:10.9	$T_{ITDL} = 4.6$	68,1

Deviation of July in the table is about measurement period difference between the sea temperature and air temperature, which are not same years as measurement period. In Table 4.3, it is possible to observe that temperature difference between sea and air is direct proportional with the precipitation of the city except for a month deviation in twelve months of the years.

$T_{ITDL} = 4.6$ in İstanbul was calculated from the table at above through eq.4.2 at bottom.

$$T_{ITDL} = \frac{\sum_{i=1}^{12} (T_{Average\ Sea} - T_{Minimum\ or\ Average\ or\ maximum\ Air})}{12} \quad (1) \quad (4.2)$$

$$T_{ASDA} = T_{Sea\ as\ average} - T_{Air\ as\ average\ value} \quad (2)$$

$$T_{Air\ average} = \frac{T_{max} + T_{min\ in\ air}}{2}; \quad (3)$$

$$T_{ASDA} \geq T_{ITDL} \quad (4.3)$$

If T_{ASDA} is higher, it means the rainfall or food warning by temperature.

This equation is called sea and air temperature difference equation and makes a prediction for possible rainfall event and a warning to activate flood officials for flood events via temperature difference between sea and air. Early warning can be given as flood temperature parameter via a result of the equation. From table at above, for İstanbul, if $T_{ASDA} \geq 4.6$, rainfall warning must be given as flood early prediction via temperature differences between sea and air. If T_{ASDA} increases, intensity of rainfall will increase too; therefore, heavy rainfall or flood risk increases with T_{ASDA} as directly proportion. Higher sea temperature means more intensity rainfall dependent on eq.4.3. It can be expressed that in the above of 4.6 interval value for T_{ASDA} , higher sea temperature is directly proportional to the rainfall or precipitation as higher air temperature is inversely proportional dependent on eq.4.3.

Rainfall events are complicated, which does not occur due to temperature difference always. Rainfall events might occur suddenly below the ideal difference limit at equation; in that time, acute warning must be given as Anil imperial alert color system for flash rainfall and the place must be evaluated with a report dependent on flood occurrences or not. A chronic flood evaluation is especially required after the rainfall if there is no imperial color chronically for the place before.

Sometime rainfall might not occur above the difference value at equation even though it is expected, in that time, temperature flood warning was given already as an expectation or a prediction and official must be ready until threat ends. Especially scientists must be active to research the reasons of this highly temperature difference without rainfall which might be a sign of future disasters such as earthquake, pollution, climate change or others. Until difference between two decreases the below of ideal temperature difference limit, the warning must continue without stop, even without rain. Shortly, flood parameters and their equations or formulas are a part of prediction dependent on flood management concept of continuous three PPP; therefore, they are prediction studies. Such as new approaches like at above equations or systems must be developed always and evaluated continuously in the regions to make better predictions against rainfall or flood events in the scope of continuous three PPPs.

4.1.3. Dew Point and Relative Humidity

Dew point is a significant temperature to evaluate condensation in the air; therefore, dew point is an indicator parameter to track rainfall. When the air cools to the dew point, it becomes saturated with water vapor in the air. Higher dew point means more moisture in the air as lower one is less. At dew point temperature, evaporation equals to condensation for water vapor in the air. As below the dew point, condensation becomes greater and rain occurs, so dew point is a distinctive temperature for rainfalls. Below the dew point temperature, rains occur as a result; for this reason, the dew point must be known and used as early warnings parameter for the rainfalls and floods.

Dew point becomes equal to air temperature in the early hours in general due to lowest temperature. After early hours, temperature starts to increase due to heat from sun and rainfalls probability decreases in general as a result; however, temperature of air may decrease from dew points in the lowest temperature hours instead of increasing. Therefore, fogs or cloud formation or great rainfalls can occur in early hours when the temperature further decreases from minimum temperature of day or dew point. Major people are at sleep during the early hour periods and many deadliest flood events occurred in early hours while people are at sleep. The amount of particulate matters or aerosols that will act as condensation nuclei, especially at lower atmosphere during those hours, may be very significant for the rainfall intensity dependent on the prevailing wind direction, proximity to the ocean or sea, elevation, pressure difference and possible supersaturation condition, which means temperature is below the dew point and water vapor acts as condensation nuclei, especially in the devoid of the small particles in high elevation. High elevation regions will expose to more water vapor than lower ones due to pressure difference or low-pressure condition under the equal

temperature and equal dew point.

Dew points are measured by hygrometers. The measurement of dew point is related with humidity which is the amount of water vapor in the air. Relative humidity is the ratio of partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature, which is expressed as percentage, in the other words; it is a percentage ratio of vapor pressure to the saturation vapor pressure at same time. If there is no directly measurement instrument for relative humidity, it can be calculated via known wet bulb temperature, dry bulb and pressure values. Wet bulb temperature (T_{wet}) is measured by a mercury thermometer with the bulb covered by the end of muslin wick and the other end of muslin wick immersed in water as Celsius. Evaporation of water from the muslin cools the temperature of thermometer below the dry bulb or air temperature (T) $^{\circ}\text{C}$. After determining two temperatures by thermometer, barometer is used to measure the pressure (P) and expressed as (hPa). The values are used and relative humidity (RH %) is calculated from eq.4.4 and eq.4.5 at bottom. Eq.4.4 and eq.4.5 in this study obtained from Australian's National Meteorological Service (Abbot and Tabony, 1985). T_d in the eq 4.5 is dew point temperature as $^{\circ}\text{C}$. Conventional relative humidity charts can be prepared from those two equations to use practically as well dependent on choices of the managers. Figure 4.1 is just an example of such as conventional relative humidity chart at the bottom.

$$RH \% = \frac{100 \left[\exp \left[1.8096 + \left(\frac{17.2694 T_{wet}}{237.3 + T_{wet}} \right) \right] - 7.866 \times 10^{-4} P (T - T_{wet}) \left(1 + \frac{T_{wet}}{610} \right) \right]}{\exp \left[1.8096 + \left(\frac{17.2694 T}{237.3 + T} \right) \right]} \quad (4.4)$$

$$RH \% = \frac{100 \exp \left[1.8096 + \left(\frac{17.2694 T_d}{237.3 + T_d} \right) \right]}{\exp \left[1.8096 + \left(\frac{17.2694 T}{237.3 + T} \right) \right]} \quad (4.5)$$

T_d (dew point) can be calculated simply after finding relative humidity as well, which is called simple approximation

$$T_d = \left(T - \frac{100 - RH}{5} \right) \quad (1) \quad T \text{ values are as } ^{\circ}\text{C}; T_d \text{ values are calculated with this way.} \quad (4.6)$$

$$RH = 100 - 5 (T - T_d) \quad (2)$$

Eq.4.6's second equation comes to meaning that every 1 $^{\circ}\text{C}$ difference between air temperature and dew point will lead to 5 % decrease in relative humidity. If $(T - T_d)$ become equals to zero,

relative humidity will equal to 100, which means saturation between air and dew point temperature. If temperature continues to fall, condensation will occur as result. If $(T - T_d)$ value is larger or RH is low, it means the faster the rate of net evaporation near ground surface. At same time, high wind speed increases net evaporation as well except for higher $(T - T_d)$. When RH is high, net evaporation becomes slow as a result. It is possible to follow evaporation and condensation from this difference for water and flood management. Early warning through dew point parameter or values can be made to activate flood officials from those equations at above when compared $T - T_d$ values. Except for this it is possible to find the saturation water vapor mixing ratio in the air from dew point Table 4.4 at bottom. Figure 4.2 is a helpful figure to predict relative humidity from temperature difference between dry bulb and wet bulb at same time. After finding relative humidity from Figure 4.2, it is very easy to calculate the dew point from eq4.6 and the saturation mix ratio dependent on the calculated dew point from Table 4.4.

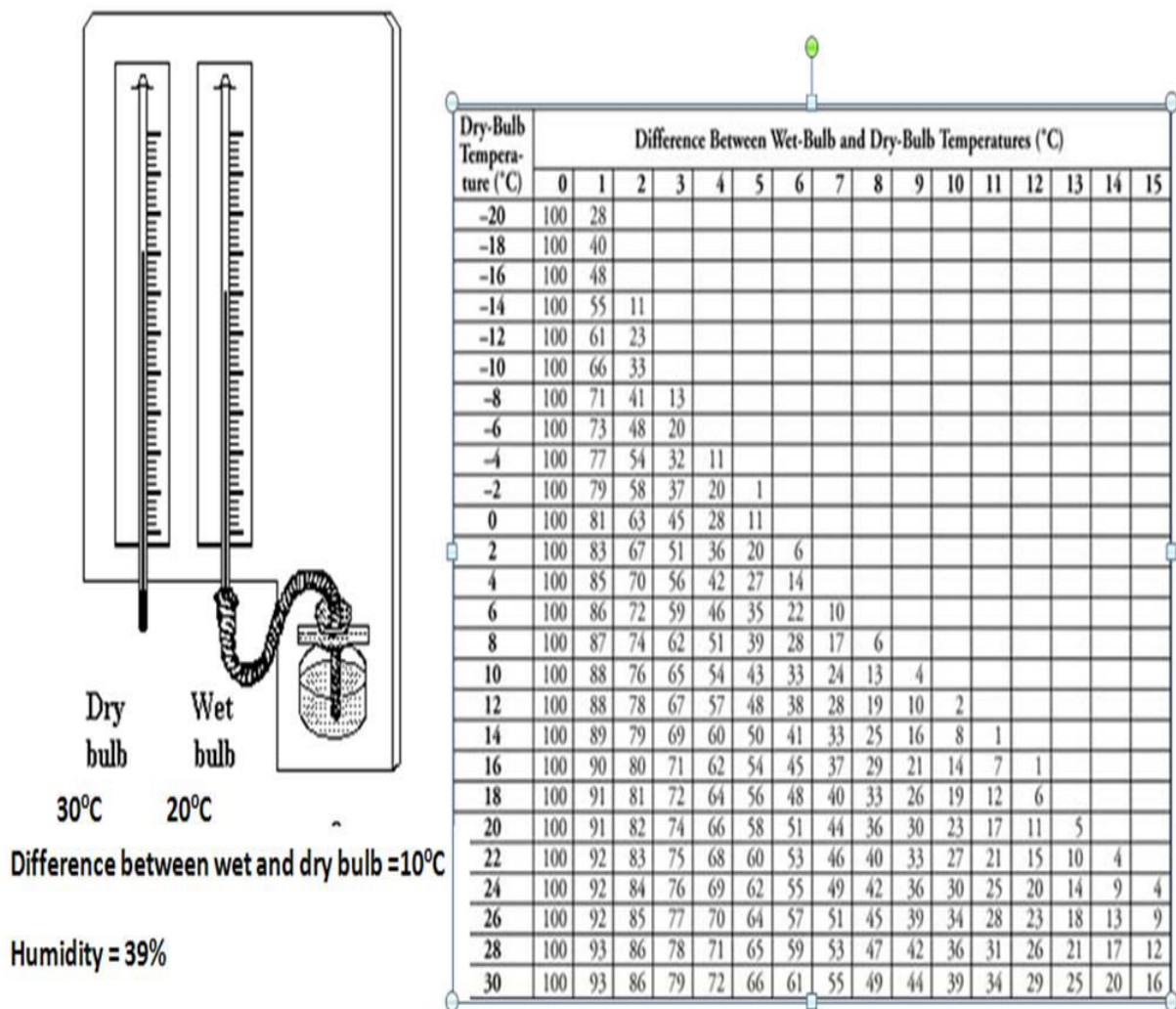


Figure 4.2. Relative Humidity Determination via Dry Bulb and Wet Bulb Temperatures (Source: Wordpress.com).

Table 4.4. Dew Point Temperature v.s Saturation Mixing Ratio (Arizona University).

Temperature or Dew point (C ⁰)	Mixing Ratio or Saturated Mixing Ratio (g/kg)
-40	0.1
-30	0.3
-20	0.8
-10	1.8
0	3.8
5	5.4
10	7.6
15	10.6
20	14.7
25	20.1
30	27.2
35	36.6
40	49.0

4.1.4. Lapse Rate

Lapse rate can be used to predict instability in the air, which may cause to thunderstorms or rainfalls. In lapse rate, positive value indicates the temperature decreases with height as negative value indicates the reverse. There are three types of lapse rate: dry adiabatic lapse rate (DALR), moist adiabatic lapse rate (MALR) and environmental lapse rate (ELR).

ELR is actual air temperature and observed at any height, which varies in space and with time. 6.49 K/km is defined as standard atmosphere lapse rate from sea level to 11 km by International Civil Aviation Organization. From 11 km up to 20 km, the constant temperature is -56.5 C⁰. ELR can be calculated with eq 4.7 easily.

$$\text{ELR} = - \frac{(\text{Final Temperature} - \text{Initial Temperature})}{(\text{Final Altitude} - \text{Initial Altitude})} \quad (4.7)$$

Air parcels are unsaturated and cools as it rises in dry adiabatic lapse rate (DALR). Approximately 9.8-10 C⁰ decreases occur for 1 km, which is nearly 1 C⁰ for each 100 m. As air parcel rises, it expands and cools with height because density and pressure decreases until reaching saturation. There is no moisture in this rate so it is dry adiabatic. DALR = 10 or 9.8 C⁰ / km.

After reaching saturation, the rising air follows the moist adiabatic lapse rate (MALR). MALR is dependent on moist in the air. More moisture in the saturated air or the atmosphere means more latent heat releases, which is necessary to change the phase of a substance from gas to liquid as a result of condensation. Low moist adiabatic lapse rate means more moist air. MALR can be calculated with the equations at bottom.

$$\Gamma_{MALR} = g \frac{R_{sd} \cdot T^2 - H_v \cdot r \cdot T}{c_{pd} \cdot R_{sw} \cdot T^2 - H_v^2 \cdot r \cdot \epsilon} \quad (4.8)$$

At the equation;

Γ_{MALR} : Moist adiabatic lapse rate, K/m,

g : Earth's gravitational acceleration = 9.8076 m/s²,

R_{sd} : Specific gas constant of dry air = 287 J/kg. K,

R_{sw} : Specific gas constant of water vapor = 461.5 J/kg. K,

H_v : Heat of vaporization of water = 2 501 000 J/kg,

T : Temperature of the saturated air, K,

C_{pd} : Specific heat of dry air at constant pressure = 1003, 5 J/kg. K.

ϵ : Dimensionless ratio of $\frac{R_{sd}}{R_{sw}} = 0.622$

r : Mixing ratio of the mass of water vapor to the mass of dry air,

r value at eq.8 can be calculated via the eq.9 at bottom

$$r = \frac{0.622e}{p-e} \quad \begin{array}{l} e: \text{ Water vapor pressure of saturated air.} \\ p: \text{ the pressure of saturated air,} \end{array} \quad (4.9)$$

The source of the equations of lapse rate above is from American Meteorological Society.

When air temperature equals to dew point, it means air reached the lifting condensation level, which can be calculated by multiplying the temperature difference at ground 125 m/ C⁰. If ELR < MALR, the air is stable which means cloud formation is unlikely so there is no rainfall warning.

If MALR < ELR < DALR, the air is unstable conditionally. If the unsaturated air may not rise to the lifting condensation level, it means low vertical movements in the two directions and stable air parcel so rainfall will not occur. Or, if the saturated air may rise to the lifting condensation level, the

air is either be paused via an inversion layer of convective inhibition or continue to rise until reaching to the level of free convection, which the temperature of air parcel along the moist air is warmer than the environment on further lifting which means the air is unstable. After reaching there, the air enters the free convection layer where deep, moist convection occurs, which may lead to thunderstorms or cumulus. Cumulus congestus clouds or cumulonimbus clouds can be formed due to deep, moist convection, which is rainfall warning for a place. After the temperature of the air parcel becomes equal to the environment, it means equilibrium level where convection stops and the air becomes stable. The rise of cumulonimbus will stop after reaching equilibrium level.

If $DALR < ELR$, the air is unstable absolutely which means parcel of air will gain vertical movement in two directions both below and above the lifting condensation level; therefore, the likelihood of cumulus clouds, showers and thunderstorms are high because of being unstable. This unstable air conditions especially occur in the afternoon while major flood events occur in the afternoon due to heavy precipitation too. Thank that major people do not sleep in the afternoon but keep in mind that flood events might start suddenly in any hours of a day. Managers must aware that when floods occur in early hours or the sleep hours of people, death numbers or losses or damages can be very high.

4.1.5. Atmospheric Pressure

Atmospheric pressure limits or characteristics of a location must be known. The minimum, average and maximum atmospheric pressure of the region must be recorded always to determine those limits. Especially sharp decreases in pressure must be followed very well because low pressure is related with rainfall. Recording the amount of rainfalls or precipitation against pressure value in the flood events may offer meaningful result and be helpful to determine the resist capacities of the locations against highly rainfall values. For example, 40 mm or lower rainfall might cause to flood event in a region while even 200 mm rainfall through very low-pressure values may not cause to any flood events in the other region due to powerful resist capacity developed by long-term quality city or location management plans. Pressure values versus rainfall amount might be helpful to observe this resist capacity of the region.

Standard atmospheric pressure value is 1013, 25 mbar at sea level. Pressure values above or below this value must be followed well continuously because high pressure is a sign of hot or normal weather as low one may be a sign of cold, rainfall, high wind speeds or storms, which will probably lead to flood events. Lower atmospheric pressure values are observed in the center of tropical storms

and tornadoes in general so the pressure can be used as an early warning system, especially low-pressure values below a certain limit value. Precious efforts are to find the certain limit values; therefore, it is very significant to determine those values in regions to make better flood predictions; the minimum pressure that does not cause to any rainfall, the maximum pressure that lead to rainfall, rainfall amount as pressure decreases below maximum pressure that causes rain, which pressure value against the amount of rainfall caused the flood events in the region, average monthly pressure values of the years, the changes of pressure values due to elevation, the sharp pressure decrease values from higher value to lower one, the amount of rainfall in the pressure difference in the sharp decrease, and how much rainfall occurred due to this sharp pressure difference to uncover the pressure flood limits of the regions. When actual pressure values are close to those determined values as a result of long term measurements, pressure flood warning might be given via this way, especially by sharp falls in barometer below those determined values, which are an absolute early warning for flood events because of signaling rainfall events before. Each measured pressure values must be marked on a table dependent on whether rainfall and flood events occurred or not as pre-prediction studies before because each those values are an indicator for a pressure limit value in a region shortly and a flood harbinger basically.

When pressure differences are high among different air masses, wind velocities will be high naturally and this result will create high speedy storm events so following pressure differences in the air mass are very significant for early warnings. If those highly pressure differences are feed by other major wind directions or confluence zones of winds, highly rainfalls may occur as a result because more wind flow from different places in a confluence zone means more condensation nuclei in the air, which triggers rainfalls. Calculation of pressure of the air is helpful to calculate moist lapse rate as well. When moist lapse rate is low, the air includes more moisture and unstable condition in the air increases, leading to thunderstorms or precipitation. Atmospheric pressure decreases by elevation; therefore, highly elevation region will expose to much more rainfall than lower elevation regions theoretically; thus, flood events, landslide and mudflow are originated from the high places generally so much in the direction of lower elevation ones. Accumulation of water, rock and mud will be high in the lower areas because of attracting those waters or materials from high elevations regions that includes low pressure as relativity. About 11.3 or 12 mbar decreases occur at each 100 m in the low altitude (1000 m) above sea levels typically; however, regular reliable pressures measurement, rainfall or flood observations versus the pressure measurements are required to unearth pressure limit values of a region. Equations at bottom compute pressure at various heights (US Standard Atmosphere, 1976 barometric formula).

$$P = P_b \left[\frac{T}{T + L(h - h_b)} \right]^{\frac{gM}{RL}} \quad (4.10)$$

Where

P_b : Static Pressure (Pa).

T : Standard Temperature (K^0).

L : Standard Temperature Lapse Rate (K/m).

h : Height above sea level (m).

h_b : Height at bottom of layer (m).

R : Universal gas constant (8.3144598 J/mol/K).

G : Gravitational acceleration (9.80665 m/s²).

M : Molar mass of earth's air (0.0289644 kg/mol).

$$P = P_b \left[\frac{-g.M(h-h_b)}{R.T} \right] \quad \text{Eq.4.11 calculates the pressure without lapse rate value.} \quad (4.11)$$

4.1.6. Vapor Pressure

As the temperature of water increases, the kinetic energy of the molecules increases and the number of molecules transitioning into a vapor increases, which means increasing vapor pressure. Therefore, vapor pressure is an indication of evaporation rate because water vapor is supplied to the air from ocean, sea, lakes, wetland surfaces or plant transpiration. Vapor pressure is the amount of pressure exerted by water vapor in the air and is a way to measure humidity in the air at a given temperature. The water vapor pressure is the partial pressure of water vapor in any gas mixture in equilibrium with solid or liquid water. Increasing of water vapor in the air is related with an increase in the humidity of the air. There is a maximum amount of moisture that can be in the air for a specific temperature at same time, which is called saturation vapor pressure. Saturation vapor pressure increases more rapidly when temperature increase and at saturation vapor pressure, relative humidity is 100 %, which warns the rain as water vapor indicator in the condensation point. Warm air can hold much more water vapor than the cold air, as a result, warm air thunderstorms produce more rain than cold air thunderstorms; therefore, warm and humid regions produce more yearly rainfall compared to cold or dry regions, which means more flood risky. Shortly, following humidity and vapor pressure values are very helpful to make prediction and warn early. Saturation vapor pressure can be calculated easily and accurately via Tetens equation at bottom.

$$P_{\text{svp}} = 0.61078 \exp \left(\frac{17.27 T}{T + 237.3} \right) \quad (4.12)$$

P_{svp} : Saturation Vapor Pressure, kPa

T : Temperature, $^{\circ}\text{C}$

After calculating saturation vapor pressure values, dry-bulb and wet-bulb temperature can be converted into water vapor pressure by using psychrometers to calculate relative humidity from equations at bottom. P_{svp} as kPa must be multiply by 10 to convert it into mbar or hPa to use in the equations.

$$P_{\text{wvp}} = P_{\text{svp}} \cdot T_{\text{wet}} - P_{\text{total}} \cdot K \cdot (T_{\text{dry}} - T_{\text{wet}}) \quad (1) \quad (4.13)$$

P_{wvp} : Water vapor pressure as mbar or hPa

P_{svp} : Saturation vapor pressure as mbar or hPa

P_{total} : Ambient pressure as mbar or hPa

T_{dry} : Dry bulb temperature

T_{wet} : Wet bulb temperature

K : Psychrometer constant, $0.000662 \text{ } ^{\circ}\text{C}^{-1}$

After finding water vapor pressure in the air, it is easy to calculate Relative Humidity from equation at bottom

$$P_{\text{wvp}} = P_{\text{svp}} \frac{RH}{100} \quad (2)$$

After calculating relative humidity in the air, dew points can be calculated from eq.4.5 and eq.4.6 as well. When the air temperature is equal or below dew point temperature, early warning must be given immediately to make the officials ready against a flood event. In a rainfall event, flood managers and officials must be ready always even if flood event does not occur with this early warning, which is a pre-flood activity again. However, after rainfall reaches or exceeds the heavy rainfall limits, the officials must be active in the work until threat finishes, which is during-flood activities. After threat finishes, post-flood activities start until making the affected region stable. Objective official flood report must be written and archived as compulsory in the post flood activities to use this data or documents in the flood studies to take better measures against future's flood or natural disasters. Those compulsory reports or documents are an early warning concept for next flood

disaster in the region and a lesson or experiences for the other places too.

4.1.7. Density

The density of air decreases with increasing altitude and changes with temperature, pressure and humidity. High density or cold air sinks as low density or warm air rises. Density of air is the mass per unit volume of the atmosphere. Air density is 1.225 kg/m^3 at 1013.25 mbar and 15°C . Ideal gas law can be used to calculate the density dependent on temperature and pressure.

$$\rho = \frac{p}{R_{sd}T} \quad (4.14)$$

ρ : Air density kg/m^3 ,

p : Absolute pressure Pa,

R_{sd} : Specific gas constant for dry air $287.058 \text{ J/kg} \cdot \text{K}$

The density of air decreases with water vapor because of the less molar mass of water.

$$\rho_{ha} = \frac{p_d}{R_{sd}T} + \frac{p_{wvp}}{R_{sw}T} = \frac{p_d M_d + p_{wvp} M_{wv}}{RT} \quad (4.15)$$

p_d : Partial pressure of dry air Pa,

ρ_{ha} : Density of humid air kg/m^3 ,

R_{sd} : Specific gas constant for dry air, $287.058 \text{ J/(kg} \cdot \text{K)}$,

T : Temperature K ,

p_{wvp} : Pressure of water vapor Pa,

R_{sw} : Specific gas constant for water vapor, $461.495 \text{ J/(kg} \cdot \text{K)}$,

M_d : Molar mass of dry air, 0.028964 kg/mol ,

M_{wv} : Molar mass of water vapor, 0.018016 kg/mol ,

R : Universal gas constant, $8.314 \text{ J/(K} \cdot \text{mol)}$

To calculate the density in the equation above, p_{wvp} can be calculated from eq 4.13. Saturation vapor pressure, p_{svp} , at eq.4.13 can be calculated from eq 4.12. Density at different heights can be calculated from pressure values calculated at eq 4.10 or eq 4.11 as well. Density change means unstable weather. Cold air sinks due to being denser while warm air is less dense and rises, which causes vertical movement in the air. If warm air is moist and density difference is high between air

masses, vertical movement in the air is very high, which means cloud formation, precipitation or rainfall; therefore, early flood warning can be made to activate flood officials via density differences.

4.1.8. Wind

There are three types of global winds: trade winds (easterlies), westerlies and polar easterlies. Trade winds are the winds between 0° and 30° latitudes in the two hemispheres. The easterly winds converge at an area near the equator called the Intertropical Convergence Zone, leading to narrow band of clouds and thunderstorms due to the intense solar heat which warms, moistens the trade winds and triggers vertical movement in the air. Therefore, persistent showers and storms occur in tropic and rainforests, which are great flood risk regions. For example, Southeast Asia monsoon is a seasonal, moisture-laden trade wind. Westerlies are the winds between 30° and 60° latitudes in two hemispheres. There are large horizontal movements or swirling in middle latitudes so much instead of vertical movements. Winds in this latitude interval rotate clockwise around higher pressure area due to the Coriolis effects in northern hemisphere, which is called anticyclone. The weather is fair and clear sky in such as areas. On other hand, winds in this latitude interval rotate counter-clockwise around low pressure area in northern hemisphere, which is called extratropical cyclones or mid-latitude cyclones. The weather is associated with bad weather, fronts and strong winds in such as areas, which are high flood risk regions. The direction of rotating for both high and low pressure is reverse in the southern hemisphere of the northern hemisphere's rotating direction. Westerlies are fed by the wind from horse latitudes 30° - 35° and polar easterlies, which are the winds that come from east between 60° - 90° latitude. Polar highs create strongest polar easterlies when westerlies are weakest in summer time. The reverse occurs in winter time.

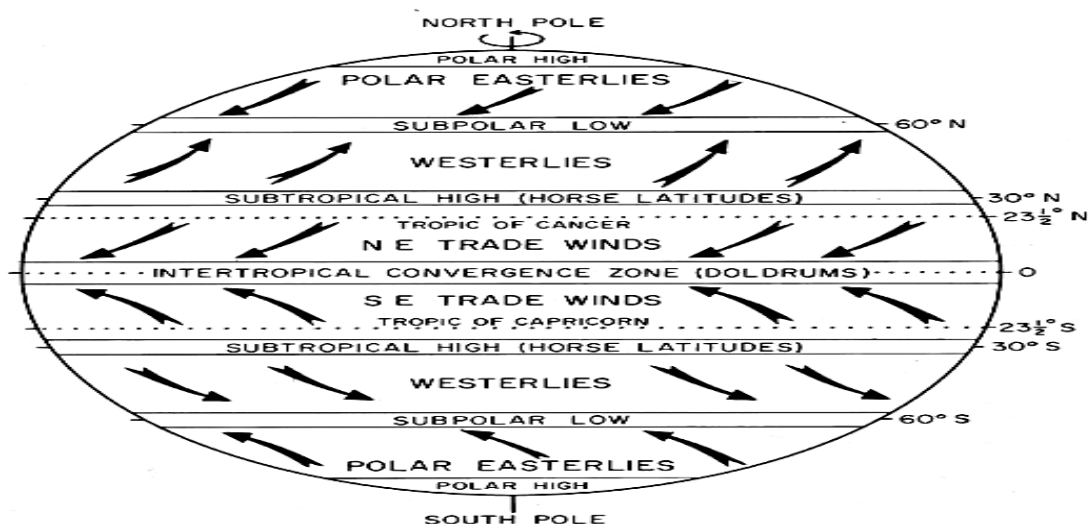


Figure 4.3. Global Wind Pattern (Source: GuernseyDonkey.com).

Wind speed and direction limits must be determined in the region so those parameters must be measured hourly for each day to discover the dominant wind direction and the dominant wind speed intervals. Local winds such as anabatic, katabatic, sea breezes, lands breezes, fohn and other local winds must be followed as well. Anemometers can be used to measure the wind direction and speed. Under condition of rainfall and flood events, the wind direction and the wind speed must especially be recorded and those values must be published in the official flood reports. Recording wind speeds can be significant in the warning of coastal floods because wind speeds affect wave height in the sea or ocean. When the water height due to high wind speed reaches to critical level, coastal flood warning must be given to activate coastal flood officials. A wind speed versus water height scale can be developed dependent on measurements in the coastal region, or Beaufort scale may be used because strong winds might cause storm surges in the region. Depending on wind speed, coastal flood warning can be announced. Critical water levels must be determined at first dependent on seawalls or other defense systems or tidal changes in a location to make coastal flood warning in the coastal cities via wind speeds.

Continuous coastal studies or efforts in the coastal regions are required to develop quality early warning systems against possible storm surge or tsunamis. Tidal gauges can be used for storm surge while seismic coastal warning system must be used for tsunami events due to earthquake or volcanic eruption. When an earthquake event minimum 6.5 magnitude in the Richter scale or the wind speed in the gale level in Beaufort scale occurs, no important that those natural events or high wind will cause to floods or tsunami in the region, coastal flood warning must be given compulsorily to activate officials and emergency services. Strong winds bring heavy rainfalls as well; therefore, flash flood warning can be given if threshold rainfalls are broken too except for coastal flood warning.

People must be sent away or evacuated from coastal regions via warning sirens to prevent the losses under the condition of possible tsunami or flood events due to the disasters such as earthquake or volcanic eruptions and when the strong winds reaches to typhoon or hurricane levels in Beaufort scale or to higher categories in Saffir-Simpson scale. Roads that go to coastal regions must be stopped immediately via Highway directorate when warnings occur. Hurricane winds can be categorized by Saffir Simpson scale and evacuation plans from coastal area must start dependent on the categories. Shortly, all coastal cities must have a coastal management plan, an evacuation plan and an early warning system to save the lives of humans in the possible coastal floods because of high strong winds such as storm, typhoon or hurricanes. Except for coastal floods that come from strong winds, the plans must include possible tsunami events due to earthquake or volcanic eruption or asteroid strike too. Coastal flood warnings can be made by wind warning via using Beaufort, Saffir-Simpson

or the other scales developed by the measurements in coastal areas.

Table 4.5. Beaufort Modern Scale (Met Office, Royal Meteorological Society).

Beaufort Number	Description	Wind Speed km/h	Wave Height m	Probable Wave Height m
0	Calm	< 2	0	-
1	Light air	2-5	0-0.3	0.1
2	Light breeze	6-11	0.3-0.6	0.2
3	Gentle breeze	12-19	0.6-1.2	0.6
4	Moderate breeze	20-28	1.0-2.0	1.0
5	Fresh breeze	28-38	2.0-3.0	2.0
6	Strong breeze	39-49	3.0-4.0	3.0
7	High wind, near gale	50-61	4.0-5.5	4.0
8	Gale	62-74	5.5-7.5	5.5
9	Strong Gale	75-88	7.0-10.0	7.0
10	Storm	89-102	9.0-12.5	9.0
11	Violent Storm	103-117	11.5-16.0	11.5
12	Hurricane	≥118	≥14	14+

Table 4.6. Saffir-Simpson Scale

Category	Wind Speed km/h
Category 1	119-153
Category 2	154-177
Category 3	178-208
Category 4	209-251
Category 5	≥252

Saffir-Simpson scale may be not enough. Tidal characteristic of the location must be known before. For example, in which hours of the day the water or sea falls and rises dependent on the

gravitational pull of moon and sun and the changing level from mean sea level must be determined in the coastal regions at first. If hurricane occurs in the time or the hours of high waters due to tides, flood waters and its damages will become so high due to both high tidal water and storm surge, which is called storm tide. Wind speed and the direction, rainfall amount the strong wind brought, water height or level the wind caused during hurricane, the frequencies of strong winds and waves in coastal areas, the amplitude of waves during strong winds, angle of the wind's approach to the coastal region, pressure levels and coastal floods must be measured or recorded to remove Saffir-Simpson scale's insufficiency. Dependent on those values, evacuation plans can be designed for that coastal region because the level of the storm surge or storm tide effects will not be same for each coastal region. Special wind, water height, wave and alarm scales which represent the only that coastal region can be created via this way. For each hurricane category, a measurement and warning system and evacuation plan must be developed by managers. To give idea, 10 km evacuation from coastal region for category 4 and nearly 10-18 km evacuation for category 5 can be required in the coastal regions. Inland flood warning must be given after storm surge due to the hurricane or typhoon because storm surge penetrates the inland well. For example, "during Hurricane Ike the surge moved inland nearly 30 miles in some locations in southeastern Texas and southwestern Louisiana" (Berg and Rhome, 2013). Hurricane often creates 6 m height wave and can reach nearly 160 km inland by high winds. High winds can create tornadoes as well. Fujita scale can be used for the rating tornado intensity dependent on the preferences but the scale will show wind damages without rainfall or pressure and water height values.

Table 4.7. Fujita Scale.

Fujita Category	Wind Speed km/h	Damage Category
F0	64-116	Light damage
F1	117-180	Moderate damage
F2	181-253	Significant damage
F3	254-332	Severe damage
F4	333-418	Devastating damage
F5	419-512	Incredible damage

4.1.9. Flood Cloud Types

It can be possible to make early warning for flood events from observed cloud types. In low altitudes, Cumulonimbus clouds are the precursors for heavy downpours. The other name of this type of clouds is the towering thunder clouds, which can be observed in the heights from 600 m to 13.7 km but in generally in low levels. Figure 4.4 shows a typical cumulonimbus cloud.



Figure 4.4. Cumulonimbus Cloud (International Cloud Atlas, WMO).

Cumulus congestus that is low-level cloud observed between 600 m to 1 km can lead to brief showers which may cause flash flood events in the region. Figure 4.5 shows typical cumulus congestus clouds at bottom.



Figure 4.5. Cumulus Congestus Cloud (International Cloud Atlas, WMO).

Nimbostratus is the cloud between 600 m and 5.5 km but they are observed at high-levels in generals. Other name of nimbostratus is the rainy-day clouds because of being moderate to heavy rains. It is moderate to snow too. Nimbostratus is the sign of continuous rainfall so it is a flood warning cloud. When this cloud is observed, chronic flood warning must be given due to being continuous rainfall or flood risk. Figure 4.6 shows typical nimbostratus cloud at bottom.



Figure 4.6. Nimbostratus Cloud (WeatherOnline.uk).

Those three cloud types at above can create flood risks; therefore, flood warning must be given when they observed in the sky. Stratocumulus and Altostratus, which are low level and middle level clouds respectively, lead to light rainfalls; however, the probability of rainfalls is very low compared to the cloud types at above. Flood events might occur due to such as cloud types too if the soil or surface is very close to saturation level with water due to previous rainfalls or repetitive rains before. Figure 4.7 and 4.8 show the stratocumulus and altostratus cloud types.



Figure 4.7. Stratocumulus Cloud (Met Office.gov.uk).



Figure 4.8. Altostratus Cloud (Met Office.gov.uk).

4.1.10. Snow Levels or Heights

Snow heights or snow accumulation must be observed and recorded in the regions, especially in the mountain regions during winter times and spring time. Warning heights or volumes must be determined dependent on the limits of snow accumulation and topographic characteristic because snow accumulation can lead to avalanche or snowmelt floods in the region. Especially snows accumulate during winter time will melt in spring due to rainfall, which can lead to snowmelt floods

or avalanches and increase the river or lake or fresh water levels, so riverine floods can occur due to snowmelts via rainfall during this period. Water levels in dams will probably increase too due to snow-melting or broken ice jams and high-water levels; therefore, dam management officials must be very careful against dam failures during this winter-spring period. High elevation regions will attract more snow theoretically. Relatively low elevation regions near the high elevations will be exposed to snowmelt floods, riverine floods, maybe avalanche. If the location is close to the mountain area, to the river areas or to the confluence zone of tributaries or distributaries of a river, the snow melt flood risks will be very high. Snowmelt and riverine floods together can damage the region so powerfully; therefore, snow levels, water heights and snow accumulation volumes or weights must be recorded and followed continuously. Snowmelt flood warning level must be determined and announced as well to activate officials and public. Shortly, to prevent the damages of a possible snow melt flood, ice jam breaks, dam failures and avalanches, the evacuation and disaster management plans must be ready before when avalanche and flood disaster risks are high in the region, and snow heights or levels and its limits must be followed continuously.

4.2. Hydrological Parameters

All river basins, lakes, coastal areas must have a hydrological parameter measurement system and stations. The rivers, tributaries and distributaries of the rivers must have a hydrological measurement stations minimum per 3 km, which includes rain gauges too. All stations must be followed as online. A website must be built to show real time data of these parameters for each water resource. Warning levels are required to be determined in those water resources by managers to warn early. Online warnings must be given from the website created. This website must be integrated into SMS, Radio, TV Channels, online news centers and social media such as Facebook, Twitter, Youtube or others to warn individuals and activate officials. Especially flood officials' mobile phone must take warning as SMS or a call when water level, speed, volume, flow or overflow and rain amount reach to warning levels. All data obtained must be recorded as Hydrological Information System (HIS).

4.2.1. Water Level

Water levels must be measured regularly in rivers, streams, sea, lakes, wetlands and ponds. Flood stages must be determined in the rivers especially. When a water level reaches alarm level, warning must be given, especially via internet web server; therefore, water level measurements must be shown in the website, and sensors must send periodic water level updates to there. Measurements must be accurate, reliable and precious as well. Sensors must allow the measurements in remote locations and

send the updates to the website from the remote areas, which must include wetland, ponds, dam, lake and sea water levels too. System must give warnings when the level reaches to the flood stage. Average monthly water levels must be recorded during measurement periods. Water diversion should not be made in the river if water level is below the average monthly level; otherwise, it means water losses. Recurrence interval table that include water level, rank, probability for each month during measurement periods must be calculated. Diversion can be made to collect and use water resources when the probability is 30 percent or below because those probabilities may cause flood; therefore, flood warning might be given dependent on characteristic of rivers. When probability is 70 percent or above, diversion should not be done and drought warning might be given for the river. Peak flows must be recorded too. If peak level is greater than 1 percent probability value or 100-year recurrence interval, flood management measurements or warnings for this location must be implemented dependent on this peak value as minimum. If peak value is lower than 1 percent probability value, flood management measurements or warning for this location must be implemented dependent on this 100-year flood value as minimum. When water level in dams reaches to 85 percent of maximum water level capacity, alarm must be given immediately for the water release. Otherwise, dam failure may occur. Below 50 percent of maximum water level capacity of dam, release or diversion should not be made; otherwise, it means water loses, and water scarcity risk especially if there is no future rainfall in the location.

$$\text{Probability as percent} = \frac{\text{Rank}}{\text{The number of data for the month} + 1} \times 100 \quad (4.16)$$

$$\text{Recurrence Interval} = \frac{\text{The number of data for the month} + 1}{\text{Rank}} \quad (4.17)$$

100-year flood can simply be calculated in excel table via comparing the recurrence versus water level values. Measurements must be taken minimum dependent on 100-year flow if peak flow is lower than 100-year flood. Assuming 500-year flood occurred in the region, new peak flow is minimum standard and measurement must be taken as this reference point. If flood damages occur below 100-years flood value in the location, chronic flood warning; in other words, red alert must be given to rehabilitate the location until minimum 100-year flood value does not cause to flood or flood damages in there. Sea water levels must be recorded dependent on Beaufort or other scales produced like the study talked in wind section before.

4.2.2. Volumetric Flow Rate

Volumetric flow rate must be measured in rivers or in channels continuously. Discharge contributions can be observed with this way. If there are so much discharges to the rivers or water resources, flood and pollution will be an inevitable result. When flood occurs in polluted or poor-quality waters, water-borne diseases may occur. Flow rate of discharges, discharge points, the flow rate contributions of river tributaries and distributaries into mainstream and flow rate of diversion channels must be measured continuously and controlled very well. Polluted waters such as municipal, domestic, industrial and agricultural wastewaters should never be allowed to discharge into natural waters such as rivers, lakes or sea. They must be collected separately, treated and reused instead of discharging into natural waters. This concept will minimize high volumetric flow rates and flood events in mainstreams so it will prevent water-borne diseases due to flood events or poor water qualities. All of industrial, agricultural, domestic and rain waters system must be collected, treated and reused separately to prevent high volumetric rates, flood events, disease, and pollution in natural waters. To reduce volumetric flow rate or flood event risks, building diversion channels, storage units or tanks, wastewater collection systems, treatment plants, rain water collection systems and reuse technologies must be accepted as structural measures in flood management due to decreasing volumetric flow rate in natural waters. Hourly, daily, weekly, monthly, and yearly volumetric flow rate characteristics must be determined in the measurement for locations. Volumetric flow rate characteristics of the region must be unearthed with continuous measurements. Recurrence interval must be calculated for volumetric flow rate too. When flow rate reaches warning levels, high volumetric flow rate of water must be diverted into channels and wetlands to decrease the flow rate and possible floods or flood risks. Diversion from fresh waters into channels, wetlands or ponds or storage area must be done for the water usage and flood control if flow rate is high. Diversion should not never be done when the flow rate is the below the monthly average volumetric flow rate during measurement period. Recurrence and probability percentage rules in water level section are valid for volumetric flow rate too.

4.2.3. Flow Velocity

Flow velocities must be measured continuously in the rivers. Possible flow velocities under future flood condition must be calculated on road or streets. Flow velocity above 2 m/sec damages to the structures or roads in general. Below 2 m/sec structural damages are so rare. If damages occur below 2 m/sec, it means structural materials are very weak. For example, structures can be exposed to damages below 2 m/sec when clay material is used; therefore, structural materials must be strong

and resistant against flow velocities, which can save lives and create extra time for evacuation. In shortly, resistant materials against high flow velocity must be preferred in building or structures. High flow velocity means more erosion and short time to save lives or evacuation. Slope means flow way for floods as high slope means high flow velocity. Flow velocities, flood velocities, the effect and the damages of water velocities against properties, materials, building, structures, infrastructures, roads, and cars must followed continuously too. Rainfall, water level versus flow velocities, flood occurrence dependent on the comparison tables and their damages against building, structures, materials, infrastructure, roads and cars must be brought into the open in the region via PPPs; therefore, continuous observation and data recordings are required. Flood early warning from flow velocity can be made via this comparsion tables when water reaches the specific flow velocities but observations by managers are required to make this table at first. Conventional formulas Manning might be used to calculate flow velocity, flow rate, and slope as well. Discovering flow velocity of river or water resource for each month is significant effort too. When flow velocity in river is higher than average flow velocity and reoccurrence probability is 30 % or below, flood warning can be made via flow velocity too.

$$\text{Manning} = Q = V \times A = \frac{1.00}{n} A.R^{2/3} S^{1/2} \quad (4.18)$$

Manning's n values can easily be accessed from the link of Forest Sciences Laboratory of Oregon State University at the bottom,

http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm.

4.2.4. Reynold and Froude Numbers

Reynold and Froude numbers must be followed in rivers or in other channels regularly and continuously. While flood events start, Reynold and Froude number must be recorded and checked especially, to determine the Reynold and Froude number characteristics in the rivers. After the observation and determination of the starter values of Reynold and Froude numbers for flood events in the mainstream, tributaries and distributaries of rivers, early and sudden flood warning can be done via those numbers easily anymore. Red alarm can be given for specific turbulent flow values after observation and calculation of this numbers. No doubt high Reynold numbers due to being turbulent flows and high Froude numbers which are more than 1 as critical or supercritical flows are precursors for the flood events. Color classification for those numbers from red to violet might be done dependent on the preference of the flood managers in the river basin areas. Of course, Froude and

Reynold numbers which starts the flood events and higher ones than this start point numbers must be red color dependent on this color system as lowest ones be violet color not to give permission to any complexity in the color scale.

$$Re = \frac{U.L}{\nu} \quad U: \text{Flow velocity, } L: \text{Characteristic length, } \nu: \text{kinetic viscosity of fluid.} \quad (4.19)$$

$$Fr = \frac{u}{\sqrt{g.l}} \quad u: \text{Average flow velocity, } g: \text{gravitational acceleration rate, } l: \text{wave velocity.} \quad (4.20)$$

Froude and Reynold numbers should be calculated and scaled or classified in the oceans and sea too to observe changes and warn early against possible tsunami or storm surges. Earthquake, volcanic eruption and asteroid strikes should be perceived as an early warning system for the close regions; therefore, wavelength values, periods, frequencies, wave speeds, angular frequencies and amplitudes of waves must be recorded continuously and regularly in the fault lines, in waters that include volcanic eruption risks due to the proximity, and in the coastal areas. A siren early warning system must be developed in coastal areas dependent on those values measured. Measurement or observation stations or sensors must be far away sufficiently from the coastal cities or locations and be close to the dangerous zones such as fault lines or active volcanic mountains in a safety position. Values measured in dangerous zone must warn and activate sirens immediately in the shores via remote sensing before hazard reaches to coastal settlements or shores or beaches. Evacuation plans designed before must be implemented immediately until waves strike to the shores. There is no doubt that such as concepts, implementation or activities planned before the disasters and the hazard will save lives and minimize the losses and damages under the condition of a possible disaster such as earthquake, volcanic eruption, asteroid strike, storm surge, dam breaks, coastal, riverine floods and tsunami events.

4.2.5. Sediment Transport and Shear Stress

Continuous measurement of sediment transport in the rivers or in the tributaries and distributaries of rivers can be helpful to prevent excessive siltation problem and blockages of structures due to accumulation of sediments. High sediment transport means high erosion rate at same time. When a river has high sediment transport, it means erosion occurs in the upstream regions and erosion control measures may be required in there. If there are settlements in the upstream regions which are close to streams, they can be under the great landslide or erosion risks due to this fluvial sediment transport. Aeolian sediment transport can make this landslide or erosion risk extremely highly if the region is exposed to strong winds too except for fluvial sediment transport. Rivers carry the sediments in the

size of sand and gravel in general but larger floods can carry the sediments in the size of cobbles, even boulders. Especially larger size of sediments, which the grain size of them are gravel or more than gravel size, can cause to injuries, deaths, structural or material damages; therefore, they must be measured and followed in the rivers continuously. Daily, weekly, monthly, seasonally and yearly sediment transport values of a river must be calculated and recorded. Those values may be required to understand when siltation or vegetation cleaning or removal operation must start in the river because excessive siltation and vegetation will lead to blockage of water ways or structures upon river and cause to deterioration of flood defense system assets, which mean an increased chance of breach. Channel roughness can be influenced and blockage potential of sediment transport may lead to destroy structures such as bridges or culverts. Therefore, regular measurement and observation of sediment transport in the rivers is significant to warn early about possible flood damages, especially via mudflows or the floods that carry high particle size or grain size of sediments such as cobbles, boulders or large boulders, which may lead to structure damages, property damages, injuries, and deaths in the flood events.

Organic matter transport must be followed because of blocking potential in the stream too. Especially in autumn, organic matters can be expected to mix into river so during the end of autumn or in the winter period, organic matters in the rivers may be high; therefore, clogging or blockages potential in the stream may be high, which means high flood risks due to blockages. Not only autumn or winter but also spring or summer season might include high sediment transport values; hence other seasons or months must be checked too. Removal or cleaning operations of organic material such as leaf litters, broken branches or dead animals etc. and of large high size sediments that include a blockage potential must be planned and implemented regularly and urgently especially when the river or stream reaches to the high sediment transport values. Trash Cats or hunters or trash skimmer boats can be used to remove this organic floated or large materials or waste materials that lead to blockage in the streams as flood risks. All those removal activities should be planned dependent on sediment transport values.

Shear stress is an indicator that shows how much force is required for water flow to start sediment transport via bed load and suspended load. Suspended load transport is related with small size particles such as fine sand, silt and clay which never touch the bed while bed load transport is consist of gliding, rolling and saltating particles, maybe gravel or bigger grain size than gravel is so decisive compared to small sizes. Shields parameter is a non-dimensional number used to calculate initiation of motion of sediment in flow. According to engineering studies, for gravel size, it is constant at 0.06, which becomes a simple function of grain size. Grain size of sediments from small to larger sizes can

be observed at bottom Table 4.8.

Table 4.8. Grain Sizes of Sediments (Source: ISO 14688-1:2002).

Sediment Name	Size Range (mm)
Clay	≤ 0.002
Silt	0.002-0.063
Sand	0.063-2.0
Gravel	2.0-63
Cobble	63-200
Boulder	200-630
Large Boulder	>630

$$\tau = \rho \cdot u_c^2 \quad (4.21)$$

τ : Shear stress,

ρ : Fluid density,

u_c : Characteristic velocity of turbulent flow.

Characteristic velocity of turbulent flow (shear velocity) can be calculated from eq.4.22.

$$u_c = \sqrt{g \cdot h \cdot S} \quad (4.22)$$

g : Gravitational constant,

h : River depth,

S : River slope.

Reynold number of particles can be calculated from eq.4.23.

$$Re_p = \frac{u_c \cdot D_p}{\nu} \quad (4.23)$$

u_c : Shear velocity,

D_p : Particle diameter,

ν : Kinematic viscosity.

Kinematic viscosity can be calculated from eq.4.24

$$\nu = \frac{\mu}{\rho} \quad (4.24)$$

ν : Kinematic viscosity,

μ : Dynamic viscosity,

ρ : Fluid density

Shields parameter and shear stress can be calculated from eq.4.25.

$$\theta = \frac{\tau}{g \cdot (\rho_p - \rho) \cdot D_p} \quad (4.25)$$

θ : Shear parameter,

τ : Shields stress,

g : Gravitational constant

ρ_p : Particle density,

ρ : Fluid density,

D_p : Particle diameter.

$$\tau = 970 D_p \quad (4.27)$$

Shear parameter is 0.06, which include almost all big grain sizes such as gravel, cobbles or boulders. For example, coarse cobble's parameter for USGS is 0.054 which is less than 0.06; therefore, the 0.06 parameter value will be very representative for all grain sizes. Density of particle ρ_p is 2,650 kg/m³ for quartz, which is most common mineral density in the nature or river and ρ is 1,000 kg/m³, which is the density of water. If the values are placed on eq.4.25 at above, $\tau = 970 D_p$ is obtained as eq.4.26, which can be used as sediment warning value dependent on diameters in the flood management and control. All grain size's shear stresses in Table 4.8 can be calculated from this equation.

In general, dangerous grain sizes start with very coarse gravel size, which is between 32-64 mm and fine cobble, which is 64-128 mm; therefore, diameters must be selected in those ranges as warning reference for big grain sizes. When diameters are selected for the very coarse gravel as 32 mm (0.032 m) and for fine cobbles as 64 mm (0.064 m), shear stresses (τ) are calculated as 31.04 N/m² for very coarse gravel and as 62.08 N/m² for fine cobbles as references. When actual shear

stress (τ_{actual}), which can be calculated from eq.4.27 simply, reaches to those reference values that calculated from eq.4.26., those very coarse gravels and fine cobalt sediments will start to transport in the riverbed as bed load so sediment transport warning can be given to activate officials to control the possible damages of sediments against properties, structures such as channels or bridges or culverts, transport systems, vehicles and lives.

$$\tau_{actual} = \rho \cdot g \cdot h \cdot s \quad (4.28)$$

ρ : Density of water, kg/m³

g : Gravitational constant, 9.81 m/s²

h : Depth of flow, m

s : Slope, m

If $\tau_{actual} > \tau$, sediments in the reference diameters start to move in the riverbed via flow and sediment warning must be given to officials via this way. The mass rate of transport per unit width of channel can be calculated from Meyer-Peter & Muller equation (Hickin, 1995).

Meyer-Peter & Muller equation

$$g_b = 0.253 (\tau_{actual} - \tau)^{3/2}, \text{ and } g_b \cdot w \cdot 86400 = Q_b$$

g_b : The mass rate of transport per unit width of channel, kg/m.s.

w : Channel wide, m

Q : Daily three-dimensional transport rate, kg/d

For each size ranges, in second, in minutes, hourly, daily, weekly, monthly, seasonal and yearly transport values can be calculated via this way. Except for warning, removal and cleaning operations can be planned and implemented dependent on those values calculated to prevent possible clogging or blocking because of highly sediment transport. No doubt that this early warning concept via calculation of sediment transport rates will prevent the damages especially originating from high grain sizes such as gravel, cobbles, boulders and large boulders via activating systems and officials.

4.2.6. Average Rainy Days Flood Warning Capacity

Average rainy days of the years must be recorded and ranked monthly. Current capacity of dams, river, diversion channels, wetlands or reservoirs, water channels and rain collection system must be

arranged dependent on the statistics of rainy days. Current capacity is calculated as percent volume. Average rainy days must be ranked for each month of the years during measurement periods. For highest rainy days of the month, dam current capacity should not be below 50 percent and no more than 85 percent; otherwise, water shortages may occur below 50 percent and dam failure risks will increase above 85 percent. These ranges are the warning levels of dams for highest average rainy days of the months during measurement periods. After reaching to 85 percent, the warning must activate the officials; thus, officials must control the dams against cracks or failures, evacuation plans designed in the region can be implemented when cracks are available through this way. Water release or diversions must be carried out by officials to decrease water level and to use the water for their aims. Table 4.9 shows average rainy days flood warning capacity of months from ranking of highest rainy days to lowest, which will be helpful to use water efficiently and minimize possible damages.

Table 4.9. Average Rainy Days Flood Warning Capacity of Months for Dams or Reservoirs.

Average Rainy Days Ranking of Months (Highest)	Minimum Warning %	Maximum warning %
1st	50	85
2nd	51	84
3rd	52	83
4th	53	82
5th	54	81
6th	55	80
7th	56	79
8th	57	78
9th	58	77
10th	59	76
11th	60	75
12th	61	74

The rules of water level, volumetric flow rate, reoccurrence interval and probability as percent the study discussed before are valid when diversion is required between minimum and maximum warning levels range. When the percent reaches to 85 for highest rank of rain days, all measure designed before must be implemented to reduce the probability of damages due to a possible release or dam failures. With this warning, officials must be active like as if dam failures will occur in the

area. Table 4.9 can be implemented for wetlands or ponds or other reservoirs too. As for diversion channels or pipes or rain water collection systems, the percentage as maximum values at Table 4.10 can be implemented as warning values for rainy days rankings; thus, clogging and flood risks may be prevented in some degree via this way. When the percent exceeds the warning values, activation of officials must start, and officials must decrease the water volume or level in the channels by pumping or discharging until reaching to the below the maximum warning percentage as secure level. Controlling or checking together with cleaning or removal operations may be implemented in channels against possible blocking or clogging events, which can be done dependent on sediment transport measurements, especially if the maximum percentage exceeds. Flood risks of channels can be minimized in the months which have highly rainy days via this way.

Table 4.10. Average Rainy Days Flood Warning Capacity of Months for Channels.

Average Rainy Days Ranking of Months (Highest)	Maximum warning %	Minimum controlling numbers in the month to clean or remove clogging or materials in the channels.
1st	30	12 times
2nd	35	11 times
3rd	40	10 times
4th	45	9 times
5th	50	8 times
6th	55	7 times
7th	60	6 times
8th	65	5 times
9th	70	4 times
10th	75	3 times
11th	80	2 times
12th	85	1 times

4.2.7. Climate Flood-Drought Index

To determine the degree of which days, months and years are flood risky and drought risky, this index can be used. To calculate the index, average monthly temperature values must be known and the average temperature of six coldest months and six hottest months must be calculated from those values at first. After determining those values, both the coldest months that are less than the average

temperature of six coldest months and the hottest months that are more than the average temperature of six hottest months must be listed with their monthly average temperature values. The average temperature of coldest six months minus the average temperature of months that are less than the average temperature of six coldest months will give the flood risk degree of those months. At same time, the hottest months which are more than the average temperature of six months minus the average temperature of six months will give the drought risk degree of those months. Each day in the coldest months will have 0.1 flood degree when the actual temperature is less than average monthly temperature. Total degrees of those days plus the flood risk degree of the month will give climate flood index for that month. On the other hand, if the temperature is higher than average monthly temperature, it means drought day, which will have 0.1 drought degree. The total degrees of all those days plus the drought risk degree of the month will give climate drought index for that month. Other months that remain between the average temperature of six cold months and the average temperature of hot months will have just 0.1 drought degrees for each day when the actual temperature is higher than the average monthly temperature and 0.1 flood degrees for each day when the actual temperature is less than the average monthly temperature. After that, determine the first risky months and second flood risky months, which are most probably highly flood risk months respectively as first and second. Add three for the first risky months and two for the second risky months to their calculated flood degrees to determine the climate flood risk index of those months. The numbers of first flood risky months are two: one of them is the first average monthly temperature which is higher little bit than the average temperature of six coldest months and the other one is the first average monthly temperature which is lower little than the average temperature of six hottest months. It is expected that unexpected flood events will be so high in those two months so much in general; however, flood degree must be compared too. The numbers of second flood risky months are two as well: one of them is the average monthly temperature which is the second temperature values which is higher little bit than the average temperature of six coldest months and the other one is the average monthly temperature which is the second temperature values which is lower little bit than the average temperature of six hottest months. If there are still months in the interval except for those risky months, add one to the degree of the other two months as third risky months. If there are still months except for third risky cities, inevitably, flood risks will be low in those months as drought risk is high.

For drought, which is same too, add three to their calculated drought degree for the first risky two drought months and two for the second risky two months. If there are extra months still, add one to their calculated degree to determine the climate drought index of those months. Drought degree of hottest months which is higher than average temperature of six month will be calculated like that. Drought degree minus 3.1 plus $(0.1 \times \text{the numbers of day which is lower than average temperature})$

will give the flood degree of the hottest months which is higher than average temperature of six months.

Flood warnings or predictions can be made from this index. Water losses or shortages can be observed and water management precautions can be taken dependent on this scale. Water abundance months can be observed too. Dams, channels, water storages area such as reservoirs or wetlands or ponds can be managed dependent on those values. When water abundance is very high, consumption must be increased so much to prevent possible floods and meet the needs of people without causing shortages. When water is lack, consumption must be minimized to prevent possible drought events or water shortages. Green areas or wetlands or suitable storage areas can be helpful to save water resources without causing water losses due to evaporation or drought.

Climatic trend towards drought or floods during measurement periods in the region can be observed from index values as well. Without adding first or secondary risk values such as three or two or one to the month's index, flood risk degree of months which are lower than the average temperature of six coldest are compared with drought risk degree of months which are higher than the average temperature of six hottest months. If drought value is higher than flood values during measurement periods, the trends points out water losses or shortages and forest fire risks. The trend in the region might be floods too when the region is in the cold or snowy climate, which means water level will increase due to melting in the future. On the other hand, if flood value is higher than drought values during the measurement periods, the trend will show water abundance or flood events in the regions, which are very high risks for unplanned, unsustainable and urban sprawl areas at same time. Therefore, water managers, city planners and state organization must manage and plan this abundance very well and logically in the regions to benefit from this positive development without exposing to the disasters. They must try to create sustainable solutions and prevent the available risks. Shortly, this index is a kind of early warning and warns the managers or authorities like that.

4.3. Topographical Parameters

Flood policies or measures need topographical determinations. Decisions in the implementation of flood management as priorities must be given dependent on topographical determinations in the topographical parameters.

4.3.1. Slope

Slope must be measured and recorded periodically in the regions or settlement places to take measures against possible flood damages. When the slope is high, flood waters will accelerate and sweep everything on its ways. For example, cars, trees, humans or other structures on roads are exposed to dragging or sweeping due to slope terrains. Slopes must be measured and high sloping regions must be shown in the maps. Floods measures must be taken in such as high sloping regions as priority because sweeping or dragging events under the condition of heavy precipitation or flooding will occur in such as regions. Streets, parking lot, rain water conditions, sewerage systems or green systems, landscaping and electric or cable systems must be designed depending on flooding risks due to high slope in the region.

Slope is a kind of elevation difference in fact. Water flows toward lower regions from top or high regions; in other words, the direction of sweeping and the accumulation of water or material or muds are the low or bottom regions of the slope when there is no blocking; therefore, cleaning and pumping operations of flood waters after flood events will be in this bottom or low regions so much. During or Post-flood activities such as searching and rescue operation must be designed in there. For example, it is so possible that missing corpses, animals or humans, significant materials or properties, and cars will be found in the lower parts of the slope when no blocking. Electrocutions in the flood events will be in this low regions or streets of slope so much due to the water accumulations as well. Flood equipment or devices that will be used in the work after flood events such pumps or portable generators must be close to the low regions of high slope due to low dragging probability and proximity to the accumulation area. They must be isolated well against possible landslides, sweepings, electrocution, water or flood events that will come from high regions of slope, and be ready always to use against possible flood or landslide or mudflow and dragging or sweeping events. When the length of slope is more than 500 meter in the settlement places, disaster emergency action plan must be prepared for such as regions. Well protected equipment stations, intervention, rescue and search teams must be placed to secure places, which are close to upper, middle and lower regions of slope in high flood risk regions. This concept in highly risky regions will save lives and prevent damages in the possible flood or landslide or mudflow events. Shortly, slope measurements and prepared slope maps via the measurements determine such as risky regions or streets or roads that need flood measures and plans as priority.

4.3.2. Elevation

The countries or regions that have low elevation are exposed to flood events so much, especially when they are so close to ocean, sea, lake, confluence zones of rivers and high mountains. Netherland is an example of such as low elevation countries, which has more flood event experiences in Europe. Knowing elevation in a region or settlements will be helpful to take measures in the flood management and control. Elevation data together with the data of topographical parameters must always be available in GIS to use by managers. Elevation difference in high elevation region is significant too to determine flood risk regions. Elevation mapping will be helpful to determine risky regions always.

Only elevation might be meaningless; therefore, elevation must be compared with average precipitation yearly to understand flood risk's degree. Anil Flood Risk Factor (AFRF) as meter can be calculated from the comparison of precipitation and elevation, which will be used in the calculation of flood rainy effect risks in the sociological parameter section. When elevation is low and precipitation is high, flood risks are high in the region, so Anil flood risk factor becomes high. Eq.4.29 shows how this risk factor can be calculated. If there is no information of minimum elevation in the region, average elevation values can be used in eq.4.29. When AFRF is divided by 21.9 (daily threshold rainfall value $60 \text{ mm} \times 365 \text{ days} \times 10^{-3}$), Eken Flood Ratio (EFR) as daily base is obtained as unitless which show the ranking of flood risks of sub-regions or the cities. EFR and AFRF do not take consideration the availability of flood prevention infrastructures and water resources such as lake, rivers and seas in the region; however, no doubt that flood infrastructure in the region minimizes flood risks while water resources increases the flood risks; therefore, both balances each other and supports the factor and the ratio. If EFR is high in the regions or cities of the country, flood risks are high as directly proportional in there and priority in flood management must be given to such as places. The equations at bottom can be calculated by knowing elevation values; therefore, it is required to know the elevation parameter in flood management and control owing to showing flood risky regions. Countries' sub-regions and cities can be ranked and warned early related with flood risks by Anil Flood Risk Factor (AFRF) and Eken Flood Ratio (EFR), which use elevation parameter in their equations.

$$\text{AFRF} = |(\text{Average Yearly Prec.}/1,000 - \text{Average Elev.})| \times (\text{Max. daily. Prec.}/ \text{Min. Elev}) \quad (4.29)$$

$$\text{EFR} = \frac{| \text{Average Yearly Prec.}/1,000 - \text{Average Elev.}| \times (\text{Max. Yearly Prec.}/ \text{Min. Elev.} \times 1,000)}{21.9} = \frac{\text{AFRF}}{21.9} \quad (4.30)$$

When average yearly precipitation is between 2,000 and 2,999, the result at eq.4.29 must be multiplied by five. When it is between 3,000 and 3,999, the result at eq.4.29 must be multiplied by twenty five (5^{n-1} , n is a first interval range coefficient of precipitation value, which is assumed as 1 for less than 1,999 mm average yearly rainfall roughly, as approximately 2 between 2,000-2,999 mm but exact number of interval coefficient can be calculated and determined through different methods due to being a kind of assumption).

4.3.3. Distance

The distance between main river stream and the border line of settlements must be minimum 10 km while the distance between tributaries or distributaries of main river stream and the border line of settlements must be minimum 5 km. The zones that remain among those minimum distances must be used as riparian area, agricultural area and partial forestry area to absorb river floods and control water pollution without allowing any residents or industrial facilities in the zones. Authorities should never allow any settlements in the intersection zone between main stream and tributaries or distributaries of rivers until the distance between two become minimum 30 km. Shortly, intersection or confluence zone of rivers should not be allowed for settlements by authorities. The distance between lakes and settlement must be minimum 10 km. For sea and ocean, the distance must be minimum 15 km and 20 km respectively from shore to prevent possible tsunami events in the highly earthquake risk zones or highly volcanic eruption risky zones, especially if there are no coastal management measurements. All coastal management measurements together with the measurements of earthquake and volcanic eruptions must be taken against possible tsunami in such as areas.

If there is a dam in the region, settlements should never be allowed from dam point for the length of minimum 10 km (5 km for upstream and 5 km for downstream of dam) toward the inland direction for the length of 20 km. Such as zones which remain between dam failure effect zone and settlements must be used as riparian areas to absorb possible flood waters, especially under the condition of dam failures. Settlements in the distance rules must remain in high elevation little bit compared to dam region and riverside, be protected well from the river directions and all erosion measurements in those settlements must be taken against landslide and mudflow risks. If there is a hill or mountain in the region, the distance between the settlement and hill or mountain must be minimum 2 x height of the hill or the mountain and the settlement must be protected well from mountainside or hillside against landslide, mudflow, snowmelt flood and avalanche. The distance of industrial facilities to the main river system and the tributary of river must be minimum 50 km and 40 km respectively and any kind of industrial water should never discharge into fresh waters. Such as distance rule concept will prevent

not only flood events and but also water pollution. For each 15 km in the river, measurement stations must be created for all flood parameters. On the other hand, hydrological measurement stations must be found per 3 km in main river stream or in tributaries of river. No doubt that all those distance minimum parameter rules will minimize flood risks or damages substantially in the flood risky regions.

4.3.4. Erosion Rate

The factors that affect erosion are climate or precipitation, soil type, topography, land use and vegetation. Soil erosion equation can be used to calculate average annual soil erosion rate. When erosion rate is high in the region, crop losses, mudflow and landslide risks in the flood events will be high too; therefore, flood damages or losses will be great as directly proportional in the such as places or regions. Erosions control measurement are required to minimize crop losses, landslide and mudflow risks in such as regions due to flood events.

Universal Soil Erosion Equation (Global Institute of Sustainability-Arizona State University)

$$A = R.K. (LS). C. P \quad (4.31)$$

A: Estimate of soil loss rate in tons/ hectare/ year

R: Rainfall factor

K: Soil erodibility factor

(LS): Slope factor

C: Crop Management Factor

P: Conservation practice factor

Rainfall factor (R) in a region for the equation may be calculated from eq.4.32.

$$R = \frac{(\sum_{i=1}^{12} \% \text{ Portions of Rainfalls of Months in a year}) \times \text{Annual Rainfall}}{12} \quad (4.32)$$

K factor in the equation is dependent on soil types. Soil can be composed of different types of sediments such as sand, silt and clay and all this different soil types erode at different rates. Table 4.11 shows that K factors values dependent on soil texture and organic matter contents.

Table 4.11. K Factors for Soil Textures and Organic Matter Contents (Global Institute of Sustainability, Arizona State University).

Soil Texture	Organic Content 0.5 %	Organic Content 2 %	Organic Content 4 %
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Very Fine Sand Loam	0.47	0.41	0.33
Silty Loam	0.48	0.42	0.33
Clay Loam	0.28	0.25	0.21
Silt Clay Loam	0.37	0.32	0.26
Silt Clay	0.25	0.23	0.19

LS in eq.4.31 can be calculated from eq.4.33 as well.

$$LS = \left(\frac{L}{22.13} \right)^m [65.41 \sin^2 \theta + 4.58 \sin \theta + 0.065] \quad (4.33)$$

L: Slope Length (m)

θ : Angle of slope

m: 0.5 for slope 5 % or more, 0.4 for slope range 3.5-4.5 %, 0.3 for 1-3 % and 0.2 for less than 1 % slope (Singh, 2018).

Water and gravity force the soil down faster when the hillside or slope is steep and long. Table 4.12 shows LS-slope factors for eq.4.31 as well, which can be obtained from the webpage of Global Institute of Sustainability, Arizona State University too.

Table 4.12. Slope or Soil Loss Factors (Global Institute of Sustainability, Arizona State University).

Slope Length (m)	Degree of Slop	LS Factor
250	1.8	0.2
200	3.6	0.4
150	5.4	1.5

125	7.2	2
110	9.0	2.5
100	3.6	1.2
90	12.6	4
60	14.4	4
50	16.2	4.5
45	18.0	5

Crop management factors of some crops and lands for eq.4.31 can be observed at Table 4.13, which will be helpful to calculate annual erosion rate.

Table 4.13. Crop Management Factor Values (Panagos, 2015).

Crop or Land Type	C Factor Values
Rice	0.15
Wheat	0.20
Rye	0.20
Barley	0.21
Soya	0.28
Sunflower seed	0.32
Potatoes	0.34
Sugar beet	0.34
Vineyards	0.15-0.45
Fruit trees	0.1-0.3
Olive Groves	0.1-0.3
Pastures	0.05-0.15
Agricultural area	0.07-0.35
Agro-Forestry Areas	0.03-0.13
Coniferous Forests	0.0001-0.003
Natural Grasslands	0.01-0.08
Transitional Woodland Shrub	0.003-0.05
Sparsely Vegetated Areas	0.1-0.45
Burnt Areas	0.1-0.55

If there is no conservation practice in the area, P value can be taken as 1 to calculate annual soil lose rate. Rajendra Singh, who is professor in the Department of Agricultural and Food Engineering at Indian Institute of Technology, gives “Conservation Practice Factor (P)” values for contouring, contour strip cropping plus terracing and contour in his YouTube lecture video, which can be observed at Table 4.14.

Table 4.14. Conservation Practice Factor Values (Singh, 2018).

Slope %	Contouring	Contour Strip Cropping	Terracing and Contour
1.1-2.0	0.6	0.3	
2.1-7.0	0.5	0.25	0.1
7-12	0.6	0.3	0.12
12-18	0.8	0.4	0.16
18-24	0.9	0.45	

When the average annual soil lose rate is high in the region, the region will exposed to great erosion; therefore, the risk of landslide, mudflow events and crop losses will be very high, which is a kind of early warning for landslide, mudflow and crop losses under the condition of precipitation and flood events Erosion measurements are required in such as regions to minimize the risks. Table 4.15 shows the erosion classes for calculated annual erosion rate from eq.4.31.

Table 4.15. Erosion Classes for Calculated Annual Erosion Rate (Singh, 2018).

Erosion Class	Erosion Rate (ton/ha/year)
Slight	0-5
Moderate	5-10
High	10-20
Very High	20-40
Severe	40-80
Very Severe	>80

Fournier Index (F) and Fournier Modified Index can be used to calculate rainfall erosivity in the region as well. Fournier Index (Fournier, 1960);

$$F = \frac{\rho_{max}^2}{\rho} \quad (4.34)$$

ρ_{max} : The monthly average amount of precipitation of the most rain month (mm),

ρ : The average annual quantity of precipitation (mm).

Table 4.16. The Erosivity Classes by Fournier.

Erosivity Class	F
Very low	0-20
Low	20-40
Moderate	40-60
Severe	60-80
Very Severe	80-100
Extremely Severe	>100

Fournier Modified Index (Arnoldus, 1980) (4.35)

$$F_M = \sum_{i=1}^{12} \frac{P_i^2}{P} \quad \begin{array}{l} P_i: \text{ the monthly average amount of precipitation for month } i \text{ (mm)} \\ P: \text{ the average annual quantity of precipitation (mm).} \end{array}$$

Table 4.17. The Erosivity Classes by Modified Fournier Index (Arnoldus, 1980).

Erosivity Class	F _M
Very low	0-60
Low	60-90
Moderate	90-120
High	120-160
Very High	>160

4.3.5. Infiltration

Infiltration rate must be measured in region and observed continuously because it is possible to give flood or run-off early warning from infiltration rate. The infiltration rate can be measured by infiltrometers. Infiltration rate must be perceived as topographical parameter in the region instead of hydrological. The unit of the infiltration rate is mm like precipitation and the rate decreases as the

soil becomes saturated. When the precipitation rate exceeds maximum infiltration rate, run-off occurs; therefore, infiltration rate of lands or soil must be known and be observed continuously to give run-off or flood warning. When soil is close to saturation, run-off or flood can be inevitable result even by light rains. Great flood events can occur by heavy rains, especially as flash flood type as well. Knowing infiltration rate before precipitation can prevent possible flash floods damages via activating officials or residents because infiltration rate is an early warning for flood and run-off.

4.3.6. Permeability

Hazen equation can be used to calculate permeability or hydraulic conductivity. Loss of permeability in the soil is major cause of flooding in the region; therefore, this parameter must be followed in the regions as an early flood warning.

$$\text{Hazen Equation} \quad K = C \cdot D_{10}^2 \quad (4.36)$$

K: cm/sec, permeability or hydraulic conductivity value.

C: Hazen's empirical coefficient, 0.8-1.2, typical is 1.

D₁₀: The diameter of 10 percentile grain size of material.

Table.4.18. Soil Permeability Classes.

Class	Permeability mm/hour
Very slow	Less than 1.30
Slow	1.31-5.00
Moderately Slow	5.01-20.00
Moderate	20.01-50.00
Moderately Rapid	50.01-130.00
Rapid	130.01-250.00
Very rapid	>250

4.3.7. Vegetation

Vegetation of the region must be controlled, which is required for erosion and flood control. For example, precipitation intercepted by the leaves and the branches of plants will increase flood protection in the region because of preventing the reach of water to the soil via evaporation. Conifers can increase flood protection better than hardwood or deciduous trees because of having higher

interception capacity. Plant types that will have high interception percentages must be preferred in the afforestation works for the erosion and flood control. For example, pine trees can be preferred as flood preventive plant due to being high interception values.

Except for interception, transpiration of plants is significant factor to minimize flood risks because transpiration reduces the moisture of soil and increases the water holding and infiltration capacity of the soil. The types of plants or trees which include great transpiration rates must be preferred to control flood events and erosion, especially in the regions that are exposed to great precipitations constantly. Acacia and eucalyptus trees as great transpiration plant types can be used to prevent flood damages in the regions, which include high moisture rates in soil or high flood risks. If forest floor or death cover layer that include all of dead matter is thick, this thickness can prevent or delay the possible flood events too.

4.3.8. Moisture

Following or observing moisture content of soil or floor can be helpful to warn the floods early so it can be accepted as a flood parameter. Warning levels as moisture percentage can be determined by continuous observation in the region. If the moisture content in the soil is higher than average before mostly rainy or snowy months of the year, officials or personals must especially be very active to take measurements against expected great floods events continuously until the flood threats finish because great flood events are almost inevitable result for such moisture content conditions.

4.4. Environmental Parameters

When environmental quality of the water resources or regions is bad, polluted waters in the floods will spread around, damage environments, cause water-borne diseases in humans and lead to loses of crops. Environment quality must be increased in the region continuously and managers must fight against all kinds of pollution; therefore, environment parameters and the standard values determined in legislations or EU environment directives must be obeyed to increase environment quality, minimize pollution and prevent the water borne diseases caused by flood events.

4.5. Sociological Parameters

Sociological parameters are significant as early warnings for flood damages. Population, Population Density, Disadvantaged Groups, Human Development Index and Imperial Natural

Disaster Risk Index in the countries or regions or cities or settlements can be categorized as sociological parameters.

4.5.1. Population

This parameter is significant to determine population that exposed to flood damages. Population knowledge shows how much people will be affected roughly in the flood risky regions. The needs of the people under the condition of disaster must be met in the region dependent on minimum this population number; otherwise, chaos, looting, quarrel-murder events and cannibalism can be observed in there, especially if there are no enough products during flood events or after flood event; therefore, the population is a kind of an early warning as a sociological parameter. For example, sufficient flood management equipment and relief materials before disasters must be planned well and provided to the flood risky regions dependent on population as precaution. This plan designed before disaster must be implemented truly and properly during flood disaster events and after the events. Some countries do not provide missing and death numbers truly after disaster due to lack of healthy population and identity knowledge in the region; therefore, population or identities must be checked well, which will contribute security. Shortly, population parameter must be followed well in the region to determine disaster needs and supply those needs to the region. If there are lacks in the needs of population and in the equipment provided by state organizations, losses or damages and looting events are inevitable results.

4.5.2. Population Density

Population density can show complexity, management difficulties and chaos in the cities or countries. When population density is high than average values, flood risks increase in the region because of management difficulties, crowds, chaos and urban sprawling. Of course, some exceptions might be available for this condition; for example, some countries or cities can have great population density while population of them is very low. The rule might not be valid for such as countries or regions or cities. More than 5,000 people per km² will generally be a sign of chaos, complexity and urban sprawling in a city or place. Infrastructure system in such as places will be insufficient, complex and uncontrollable. Major people in such as cities will not meet their basic needs as well. High education level will be required to manage systems because of being complex. If education standards are inadequate to raise people in cities, city management organizations or system will be more complex, unmanageable and unsustainable by new generations; hence disasters or ruins will be inevitable results. Cities or regions need controllable, sustainable, livable, simple and long-term

systems than complex, uncontrollable, chaotic and unsustainable systems; for this reason, population density should not be so high. Observations show that population density in a place together with precipitation and elevation is directly proportional to flood effects. The study explained how to calculate AFRF and EFR at eq.4.29 and eq.4.30 respectively. Flood Rainy Effect Risk Ratio (FRERR) which shows the probable effect of actual rain precipitation can be calculated from eq.4.37. The unit of population density at the equation is people per km².

$$\text{FRERR} = \frac{\text{AFRF} \times \text{Population density} \times \text{actual hourly prec.} \times 8760}{\text{EFR} \times 10^6 \times \text{Average yearl prec.}} \times a \times b \quad (4.37)$$

4.5.3. Disadvantaged Groups

Disadvantaged groups and the numbers of those groups must be identified. Babies, disabled and elderly people in the flood risky regions are major disadvantaged groups related with flood losses. Flood measurements, especially in a highly flood risky regions must take the disadvantaged groups and their needs into considerations to minimize the losses because babies, disabled and elderly people are extremely risky groups in flood risky regions.

4.5.4. Human Development Index

If human development index is low in a country or region, it means that life expectancy, education level and per capita income are low in there, which can be used as a sociological early disaster or flood damages warning in this society; therefore, this parameter must be followed continuously. When life expectancy is low in a place, it is a sign of environmental, health and disaster problems in the region as an indicator component of Human Development Index. It is not possible to create disaster management organizations and manage flood events if education index is low in a country. It is inevitable that deaths, looting or chaos events in a flood or disaster events will be so much in such as places or countries due to low educational levels. On the other hands, people or organization or states will not meet their needs when per capita is low, so they will need assistance from neighbor states or regions under the condition of disasters or floods because of not meeting the basic needs of people and not having enough organized disaster plans. In shortly, human development index is an early disaster warning for societies. Eq.4.43 calculates human development index simply from eq.4.38, eq.4.39, eq.4.42 and eq.4.43. The sources of equations are UNDP's Human Development Report 2010 and UNDP's 2013 Technical Notes.

$$\text{Life Expectancy Index (LEI)} = \frac{\text{Life expectancy at birth}-20}{85-20} \quad (4.38)$$

$$\text{Education Index (EI)} = \frac{\text{Mean Years of Schooling Index} + \text{Expected Years of Schooling Index}}{2} \quad (4.39)$$

$$\text{Mean Years Schooling Index} = \frac{\text{Years that a person aged 25 or older has spent in formal education}}{15} \quad (4.40)$$

(Barro J.R., 2010).

$$\text{Expected Years Schooling Index} = \frac{\text{Total expected years of schooling for children under 18 years of age}}{18} \quad (4.41)$$

(UNESCO Institute for Statistics, 2010).

$$\text{Income Index (II)} = \frac{\ln(\text{Gross National Income at Purchasing Power Parity Per Capita}) - \ln(100)}{\ln(75,000) - \ln(100)} \quad (4.42)$$

$$\text{Human Development Index (HDI)} = \sqrt[3]{LEI \cdot EI \cdot II} \quad (4.43)$$

Table. 4.19. Categories of Human Development Index (Source: UNDP-Human Development Index Trends, 1990-2017).

0.800-1.000	Very High
0.700-0.799	High
0.555-0.699	Medium
0.350-0.554	Low

4.5.5. Imperial Natural Risk Index

Natural disaster types together with hours of the regions must be followed continuously and be identified to show risks and plan proper managements because floods can occur through synergic effects of other disasters. The number of disasters in a month and the hours of the events must be recorded. The risks of major dominant disaster types must be determined for the months. Natural disaster types can be observed in the Table.4.20.

Table 4.20. Natural Disaster Types.

Meteorological Disasters	Hydrological Disasters	Geophysical Disasters	Biological/Man-made/ Environmental Disasters
Asteroids	Floods	Earthquakes	Diseases/Epidemics
Blizzards	Tsunamis	Landslides	Insect/Animal Plagues
Cyclonic storms/	Limnic Eruptions	Avalanches	Famine/poverty
Hail Storms	S. Surge/ Tidal Waves	Volcanic Eruptions	Pollution/Industrial accidents
Ice Storms		Sinkholes	Climate Change
Cold Waves			
Heat Waves			
Droughts			
Thunderstorms			
Tornadoes			
Wildfires			

There are 25 types of natural disasters in the table. The numbers of disasters for each type in a month must be divided by 100 to calculate the monthly risk values. For example, when the value is 0.03 or greater for same type disaster in a month, the next 3 years disaster warning for this disaster type must be given to officials and organizations to take measures about that month. The sum of the risk values of each month in a year will give Imperial Natural Disaster Risk Index for that region, which can be calculated both as for each disaster type risks separately and as total risks of all types.

$$\text{Imperial Natural Disaster Risk Index (INDRI)} = \sum_{i=1}^{12} \frac{ND}{100} \quad (4.44)$$

ND: Number of disasters in a month

Table.4.21. Disaster Type Warning for the Months in a year.

Monthly Risk Values for the disaster type	Chronic Warning Duration for the disaster type	Alert Color
0.03 $\geq$	Minimum 3 years Warning for this month of the year	RED ALERT

0.02	2 Years Warning	ORANGE ALERT
0.01	1 Years Warning	YELLOW ALERT
0.00	No warning	GREEN ALERT

Table.4.22. Imperial Natural Disaster Risk Index.

Natural Disaster Risk Index Values	Risk	Alert Color
$INDRI \geq 0.12$	Extremely Risky	RED ALERT
$0.06 \leq INDRI < 0.12$	Very Risky	ORANGE ALERT
$0.04 \leq INDRI < 0.06$	Average Risk	YELLOW ALERT
$0.02 \leq INDRI < 0.04$	Low Risk	GREEN ALERT
$0.01 \leq INDRI < 0.02$	Very Low Risk	BLUE ALERT
$0.00 \leq INDRI < 0.01$	No Risk	VIOLET ALERT

Disasters hours of the months must be checked and if the disaster index value for the hours between 10.30 pm and 10.30 am is 0.03 or bigger, night disaster employees, managers and officials are actively required for this risky month for minimum three years to plan the measures and minimize losses during sleep, which is called Z-Disaster or Flood warning. Z comes from the Slavic-Hebrew name of Zorana, which means dawn.

5. CONTINUOUS PREDICTION PREVENTION PROTECTION STUDIES

Flood managers need the researches continuously to obtain data and create quality flood or disaster prediction, prevention and protection systems. All kind of studies that carried out continuously by flood managers to create quality prediction, prevention and protection systems in the region is called three PPPs. All three PPPs must be fulfilled dependent on four significant elements;

- 1-Determinations of problems, the hazards or risks, the needs and requirements related with the flood disasters,
- 2-Creating plans and programs to meet those needs and requirements to reach the aims,
- 3-Designing systems and implementations of those systems for solutions,
- 4-Continuous inspections and revisions of all those elements and their compounds

5.1. Continuous Prediction Studies

In previous section, flood parameters and early warning systems discussed and emerged. This discussion to create flood parameter and early warning system was a kind of prediction studies of three PPPs. Such as studies to create quality prediction systems must be carried out by managers continuously until reaching to precise prediction systems and accurate results. For better prediction, flood managers need data and observations. To obtain the data and observation, measurement systems of those parameters in the region must be designed and planned. Measurement results must be transferred into website automatically and quickly. Warning or predictions must be done from this website to the officials or people. Radio station, SMS or E-mails, mobile phone applications, Facebook, Twitter, YouTube and WhatsApp can be integrated into this website to spread the warnings or predictions. No doubt that such as prediction implementations in flood management will be helpful to save the lives from disasters. Only meteorological warnings are not enough in flood management; therefore, this website must warn and predict about all types of parameters discussed in previous section dependent on geography or regions. All this warnings and data related with regions must be recorded and archived to check, help and shape the probable future studies, implementations and managements. When prediction gives wrong alarm or it is not true and no effective, flood managers must control, repair and change this prediction system or method until obtaining stable and true predictions or warnings. All prediction studies must be fulfilled dependent on four significant elements as well; for example, previous parameter and early warning system section the study

discussed is a production of those elements to make better predictions. Determination and listing of the risk or hazards in the region dependent on prevention studies are very significant because it is a kind of hazard identification which will help to the prevention studies in three PPPs and contribute to the mitigation or the preventions and preparedness activities in the flood risk assessment cycle.

5.1.1. Satellites

Satellite data, images and earth observation outputs from space can be used to make better predictions by flood or disaster managers as well. Some of significant satellites can be observed at bottom.

5.1.1.1. Copernicus sentinel mission. For example, sentinel missions of EU Copernicus Program developed by European Space Agency (ESA) observes the earth to obtain data, which carry a range of technologies such as radar and multi-spectral imaging instruments for land, ocean and atmosphere monitoring. According to EU Copernicus website, Sentinel 1 is a polar orbiting, all weather, day and night radar imaging mission for land and ocean services. There are two twin types, which are Sentinel 1A and Sentinel 1B. Both carry a C-Band Synthetic Aperture Radar that provides all light and weather conditions. Sentinel 1 satellites can track many environment aspects on earth. For example, they can detect and map the movements in lands surfaces, oil spills, sea ice, floods and the changes in surfaces. They can estimate wind speeds over oceans. Furthermore, it is possible to map flooded areas through the backscattered microwave energy from ground. The repeat cycle of the satellites is 12 days, supplying imagery at about 20m resolution every 6 days over the same area through both sensors. Detailed information related with satellites can be followed from the webpages of ESA and Copernicus Program.



Figure 5.1. Sentinel-1 Satellite (ESA).

Goodegong-Jemalong - AUSTRALIA
Flood - Situation as of 3009/2014
Delineation Map - MonIS2

Geographic Information
 Date: 2014-09-10 10:14:14 (UTC) Data: 2014-09-10 10:14:14 (UTC) Data: 2014-09-10 10:14:14 (UTC)
 Scale: 1:1000000
 Projection: UTM
 Datum: WGS 1984
 Units: Meter

Legend

Class Information
 Name: Goodegong-Jemalong
 Description: Goodegong-Jemalong
 Date: 2014-09-10 10:14:14 (UTC)
 Author: [Name]
 Version: 1.0
 Status: Final
 Project: [Project Name]

Hydrology
 Name: [Name]
 Description: [Description]
 Date: 2014-09-10 10:14:14 (UTC)
 Author: [Name]
 Version: 1.0
 Status: Final
 Project: [Project Name]

Transportation
 Name: [Name]
 Description: [Description]
 Date: 2014-09-10 10:14:14 (UTC)
 Author: [Name]
 Version: 1.0
 Status: Final
 Project: [Project Name]

Map Information
 This map was created using the MonIS2 software. It is a digital map of the Goodegong-Jemalong area. The map shows the flood delineation for the 3009/2014 event. The map is a grayscale aerial photograph with flood areas highlighted in blue. The map includes a legend, scale bar, and various information panels on the right side.

Data Summary
 Name: Goodegong-Jemalong
 Description: Goodegong-Jemalong
 Date: 2014-09-10 10:14:14 (UTC)
 Author: [Name]
 Version: 1.0
 Status: Final
 Project: [Project Name]

Disclaimer
 This map is a digital map of the Goodegong-Jemalong area. It is a grayscale aerial photograph with flood areas highlighted in blue. The map includes a legend, scale bar, and various information panels on the right side.

Copyright
 Copyright 2014 by [Name]. All rights reserved.

Figure 5.3. Flood delineation map generated with Sentinel-1B data (ESA/European Commission).

Sentinel-2 is a wide-swath, high resolution, multispectral imaging mission which aims to monitor earth's surface changes or the variabilities in land surfaces. Revisit time is 10 days at equator with one satellite, 5 days with two satellites and 2-3 days at middle latitudes under the cloud-free conditions. Sentinel-2 is responsible for the Multispectral Instrument works passively and collects the sunlight reflected from earth and it is a multispectral imaging mission, supporting land monitoring studies, including the maintaining of vegetation, soil and water cover, as well as observation of inland waterways and coastal areas according to ESA. Sentinel-2 can produce geo- information at international, national, regional and local scales. ESA website express that Sentiel-2 provides data to the managers or users interested in thematic areas such as; Spatial planning, Agro-Environmental monitoring, water monitoring, forest and vegetation monitoring, land, carbon, natural resource monitoring, global crop monitoring. Planners or managers or users can determine the risks and take measures against those risks via the data or maps provided by Sentinel-2. Detailed information about Sentinel-2 can be learned from the webpages of ESA and Copernicus.



Figure 5.4. Sentinel-2 Satellite (ESA).



Figure 5.5. Floodwaters filled by sediment in the 2017 Queensland Flood after heavy rains and Tropical Cyclone Debbie, the image captured by Sentinel-2 (ESA).

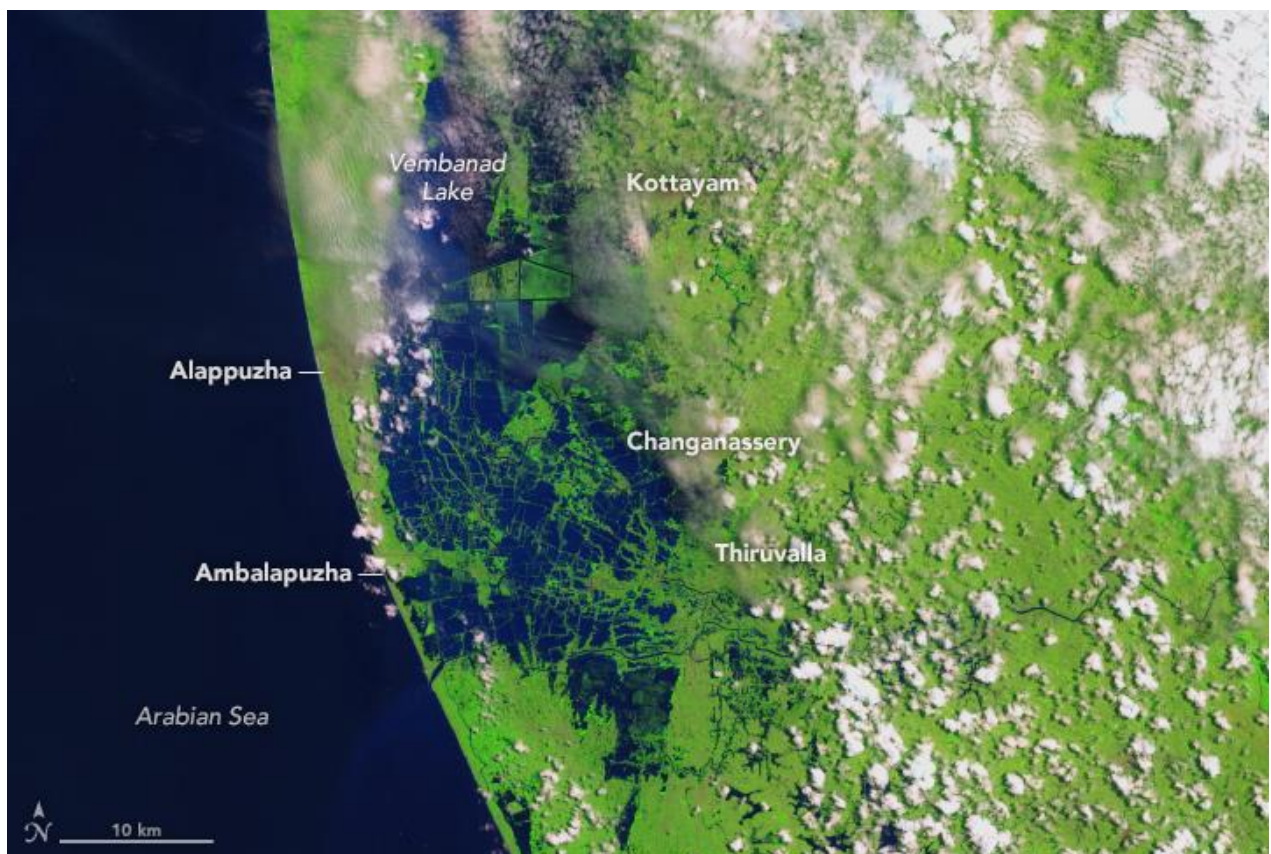


Figure 5.6. Kerala Flood 2018 in dark blue and vegetation in green color captured by Sentinel 2 (NASA Earth Observatory, 2018).

The aims of Sentinel-3 are to measure sea surface topography, sea and land surface temperature, and ocean and land surface color with high accuracy and reliability. Sentinel-3, which is jointly operated by ESA and EUMETSAT, supports ocean forecasting systems, environmental and climate monitoring. Algal blooms and vegetation can be observed in those satellites. Spacecraft carries Ocean and Land Color Instrument (OLCI), Sea and Land Surface Temperature Instrument (SLSTR), SAR Radar altimeter (SRAL) and Microwave Radiometer (MWR). Sentinel-3 has three versatile satellites: Sentinel-3A, Sentinel-3B and Sentinel-3C. Detailed information about Sentinel-3 can be obtained from the web page of ESA.



Figure 5.7. Sentinel-3 Satellite and payloads (ESA).

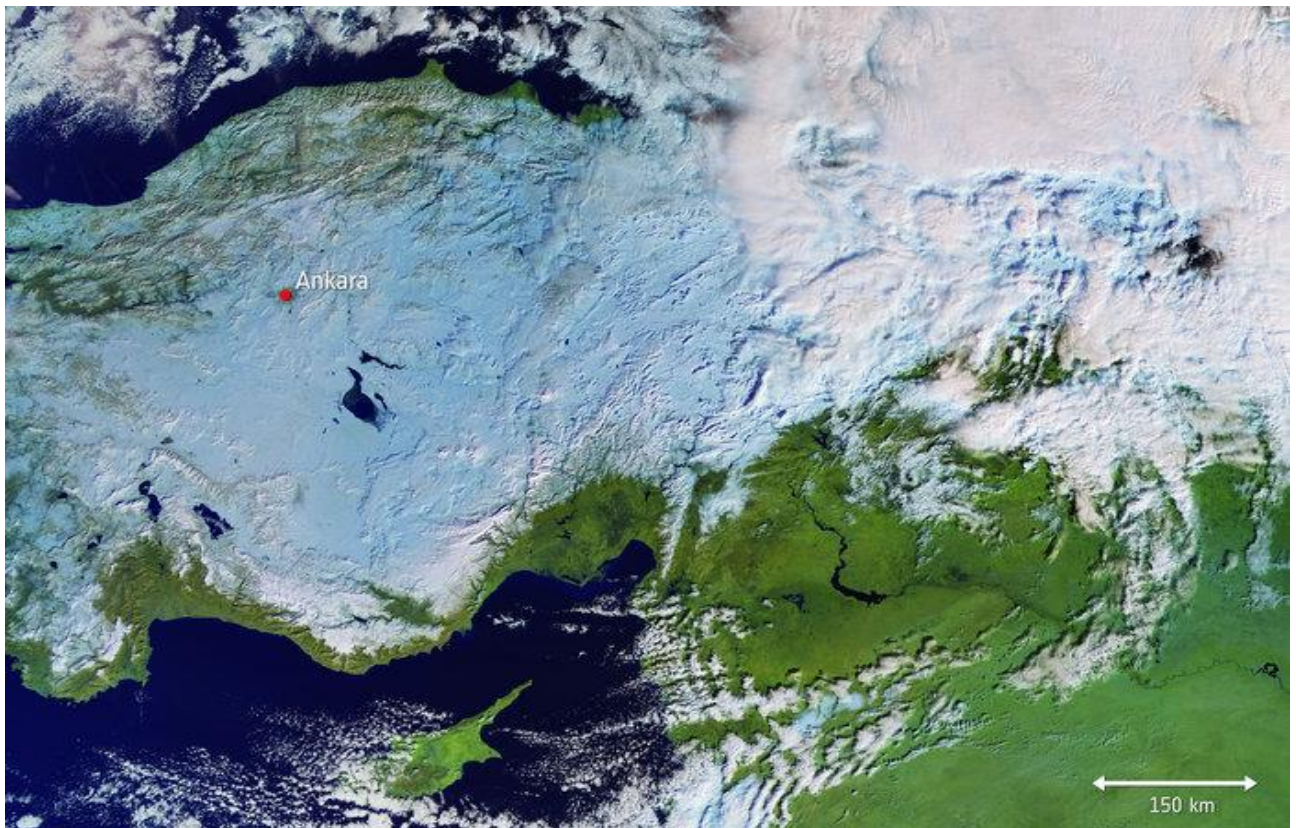


Figure 5.8. Cold Turkey on January 10, 2019 captured by Sentinel 3 (ESA).

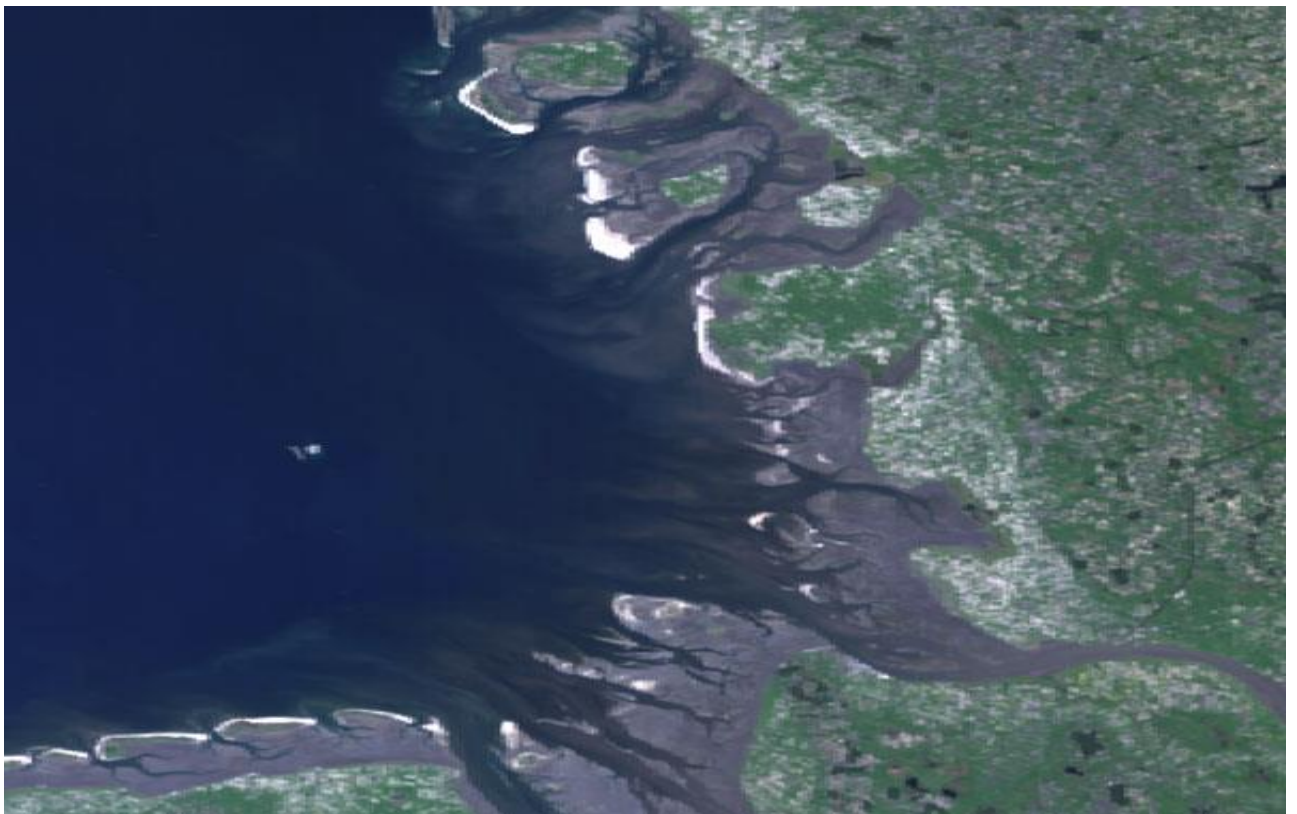


Figure 5.9. The flows of the rivers into the sea and transport of sediments in the brown colored waters near the coast of Germany in North Sea captured by Sentinel 3 (EUMETSAT).

According to ESA, Sentinel-4 provides routine data or observations related with air quality, stratospheric ozone, surface UV radiation and climate. Sentinel-4 can be used to monitor trace gas concentrations, aerosols, volcanic activities and atmospheric composition or chemistry to forecast. Detail information can be followed from ESA and Copernicus webpages. It is possible that the satellite might predict or determine the directions of condensation nuclei and the regions accumulated by condensation nuclei, which can herald heavy rainfalls regions in general; therefore, flood events will be expected in such as regions or zones.

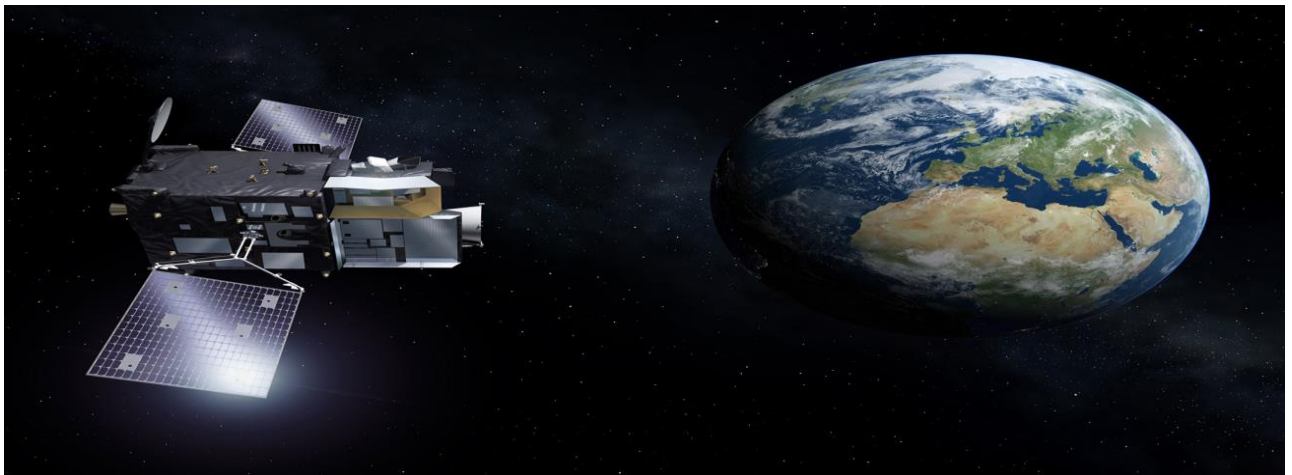


Figure 5.10. Sentinel-4 Satellite (ESA).

According to ESA, sentinel-5 mission aims to perform atmospheric measurements such as air quality, climate forcing, ozone, and UV radiation as daily coverage. Sentinel-5 consists in a single instrument which is a UV-VIS-NIR-SWIR (UV-visible-near-short wave). It is embarked as a Customer Furnished item (CFI) on the MetOp-SG-A satellite (illustrated in the figure 5.11.) which is operated by EUMETSAT as part of the EUMETSAT polar system second generation (Source: ESA).

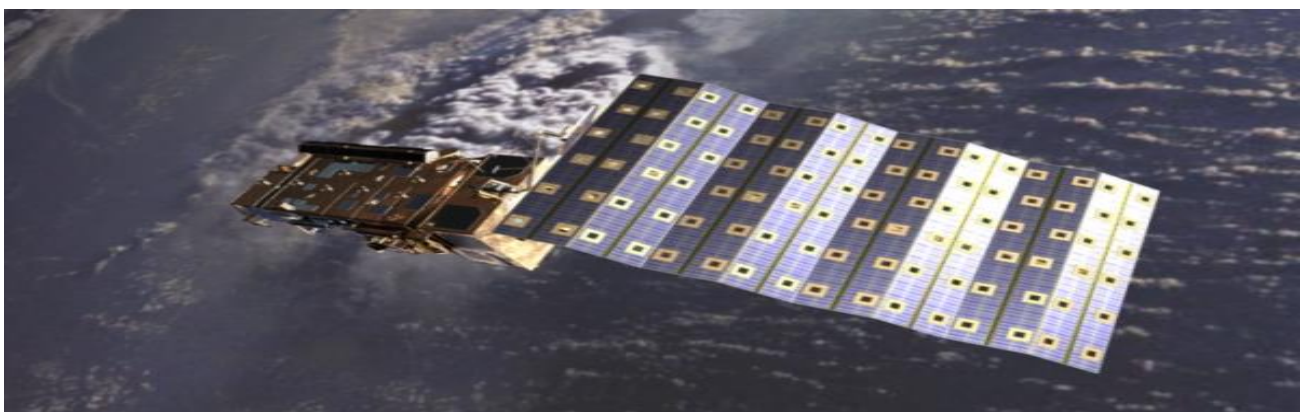


Figure 5.11. Illustration of the MetOp-SG-A spacecraft carrying the Sentinel-5/UVNS instrument (ESA).

ESA webpage expresses that the Sentinel-5 Precursor mission is a joint initiative between ESA and the kingdom of Netherland, represented by the Netherland Space Office (NSO). The mission consists of one satellite carrying the Tropospheric Monitoring Instrument (TROPOMI) UV-VIS-NIR-SWIR instrument. The main objective of the Sentinel-5P mission is to perform atmospheric measurements, with high spatio-temporal resolution, relating to air quality, climate forcing, ozone and UV radiation. It is possible that the satellite might predict aerosols or condensation nuclei, determine the directions of condensation nuclei and the regions accumulated by condensation nuclei, which can herald heavy rainfalls regions in general; therefore, flood events will be expected in such as regions or zones.



Figure 5.12. Sentinel-5P Satellite (Airbus).

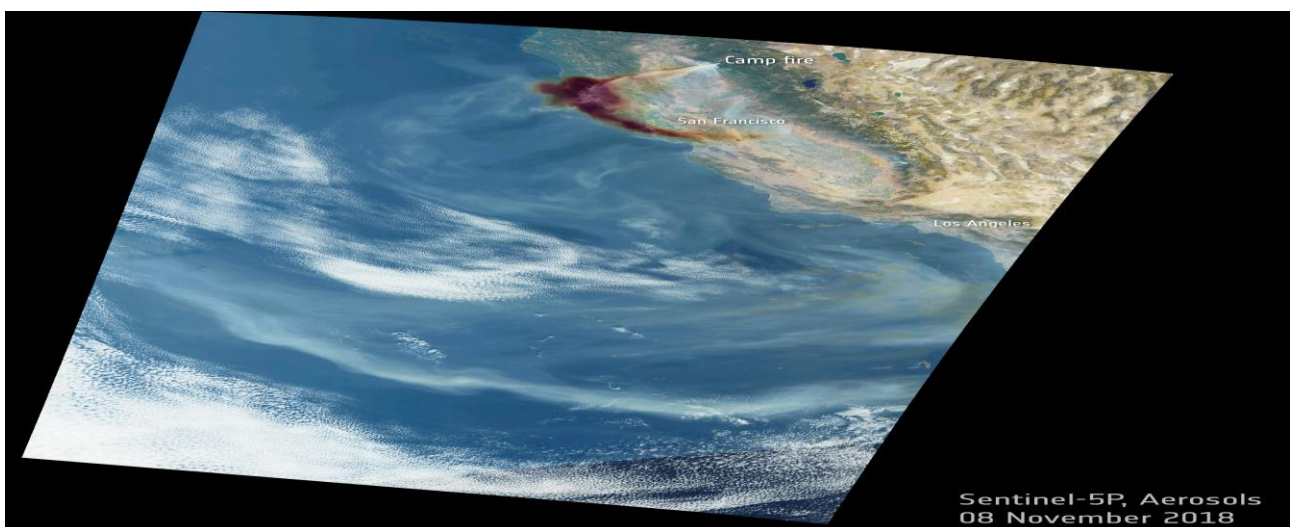


Figure 5.13. Sentinel-5P Aerosols Image (ESA).

5.1.1.2. Aqua satellite. Aqua satellite can be used in flood prediction because Aqua is a NASA scientific satellite in orbit around the earth that research the precipitation, evaporation and cycling of water.

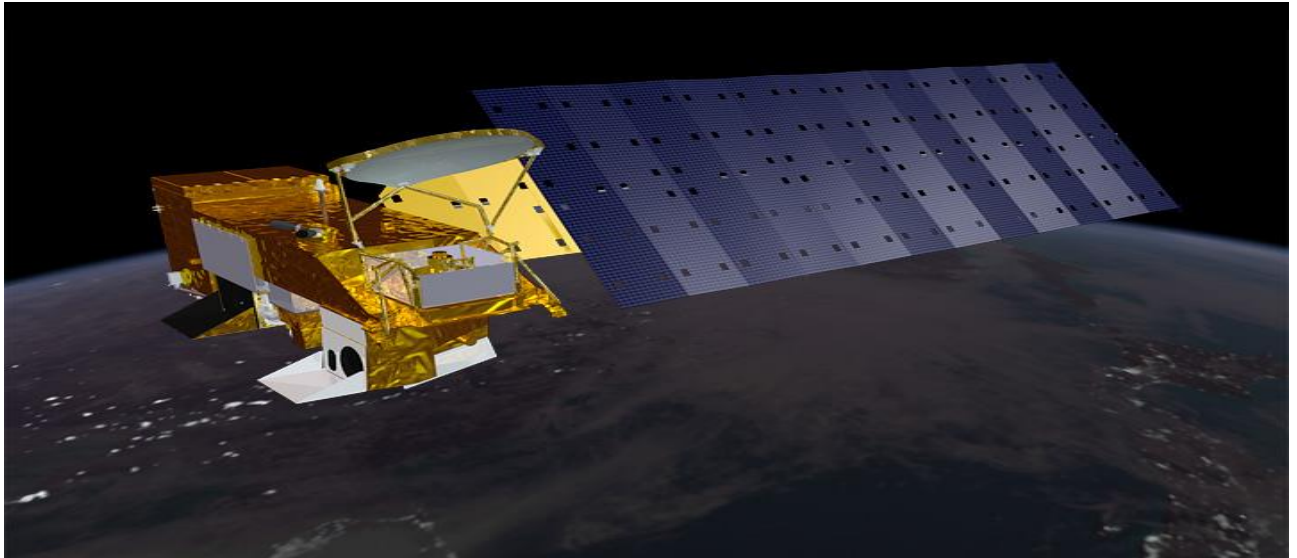


Figure 5.14. NASA's Aqua satellite orbits 705 kilometers (440 miles) above the Earth, carrying six instruments that monitor Earth's atmosphere and water systems (NASA earth observatory).

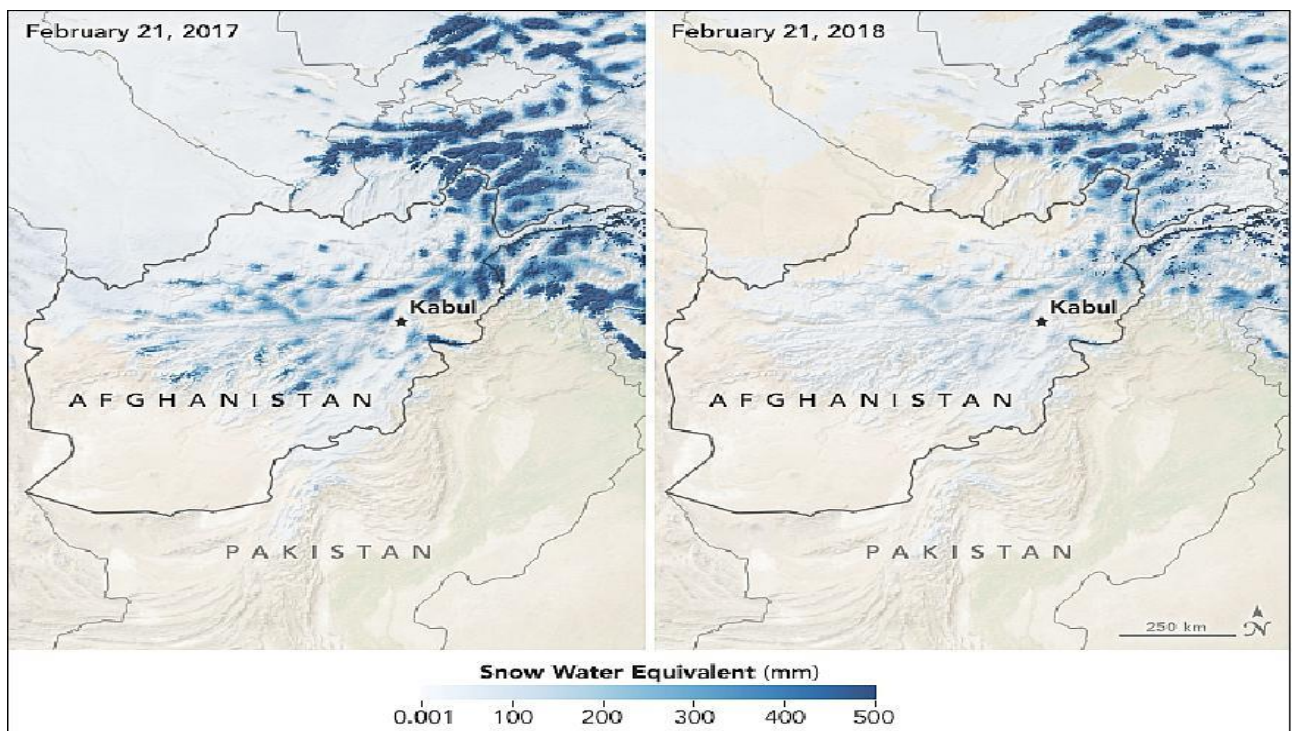


Figure 5.15. The Aqua satellite image on the right shows the conditions on February 21, 2018, amid a low snowpack; the left map shows conditions on February 21, 2017 (NASA Visible Earth, NASA Earth Observatory).

5.1.1.3. Aura satellite. Aura is a multi-national NASA scientific satellite in orbit around the earth which research ozone layer, air quality and climate. Condensation nuclei such as aerosols can be detected and followed by Aura satellite too.

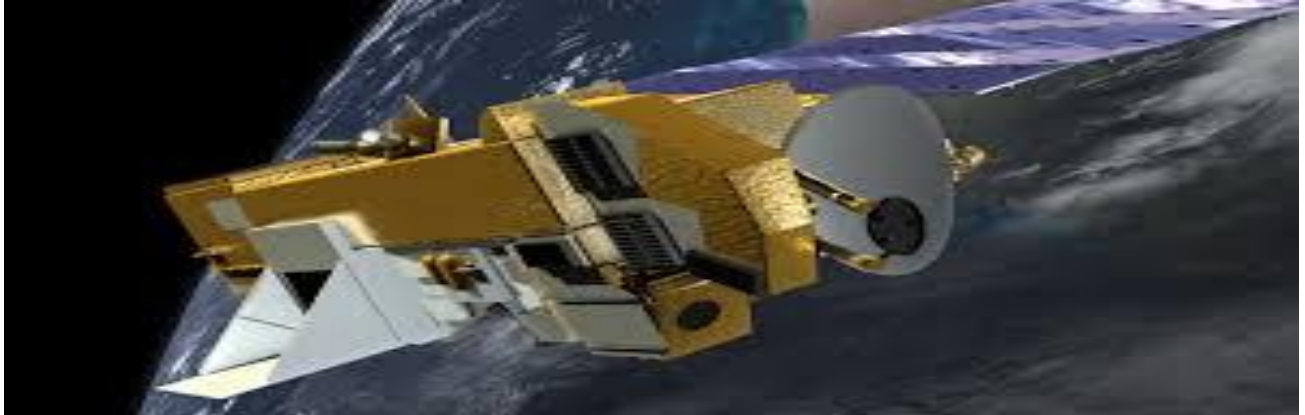


Figure 5.16. Aura Satellite Image (NASA Aura).

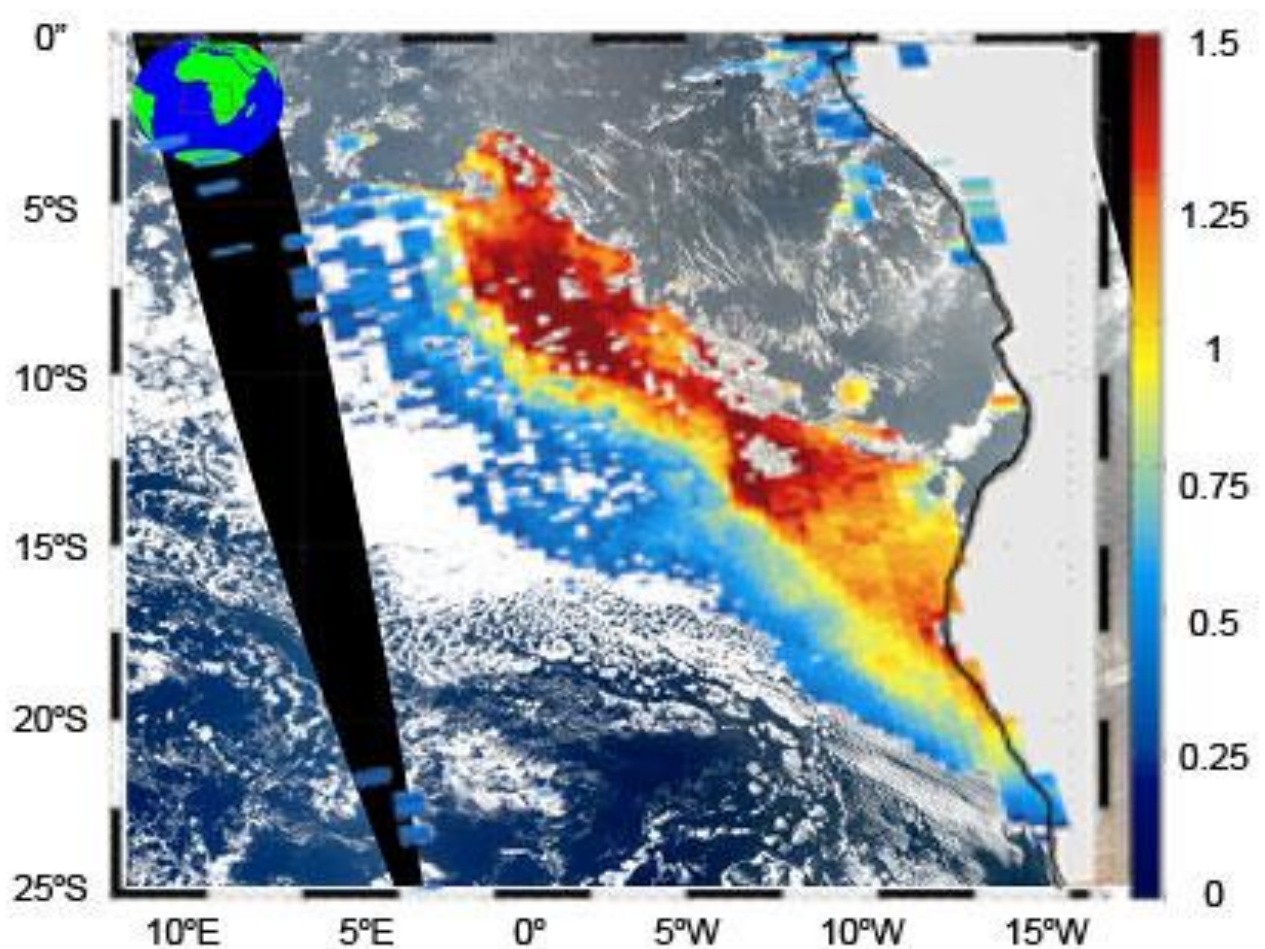


Figure 5.17. Derived aerosol optical depth field (388 nm) corresponding to the aerosol layer captured by Aura Satellite (NASA Aura).

5.1.1.4. CALIPSO. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) are a joint NASA and CNES (National Centre for Space Studies of France) Environment Satellite. CALIPSO monitors aerosols and clouds 24 hours a day; therefore, it is possible to make flood or heavy rain precipitation and hurricane predictions via this satellite.



Figure 5.18. CALIPSO spacecraft (CNES).

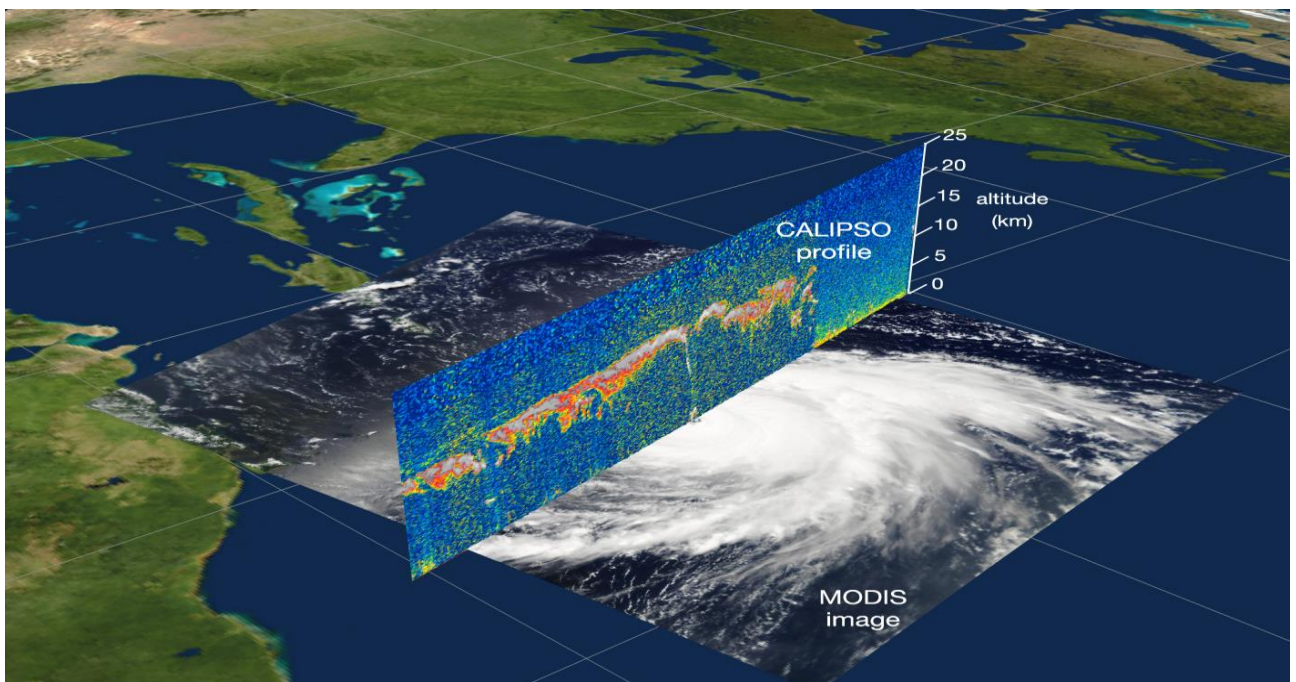


Figure 5.19. Hurricane Bill nears Cuba in 2009. A vertical profile from the Cloud-Aerosol Lidar and Infrared Pathfinder satellite (CALIPSO) is overlaid on an image from the Moderate-resolution Imaging Spectroradiometer (MODIS) (NASA).

5.1.1.5. CryoSat. Cryosat is an ESA program to monitor thickness of polar ice and variations in the extent. This satellite can warn the sea level rise due to the ice melt so it can be used to predict coastal floods, especially in the coastal regions or countries that are close to the poles or coastal glaciers.



Figure 5.20. Cryosat-2 Image (ESA).

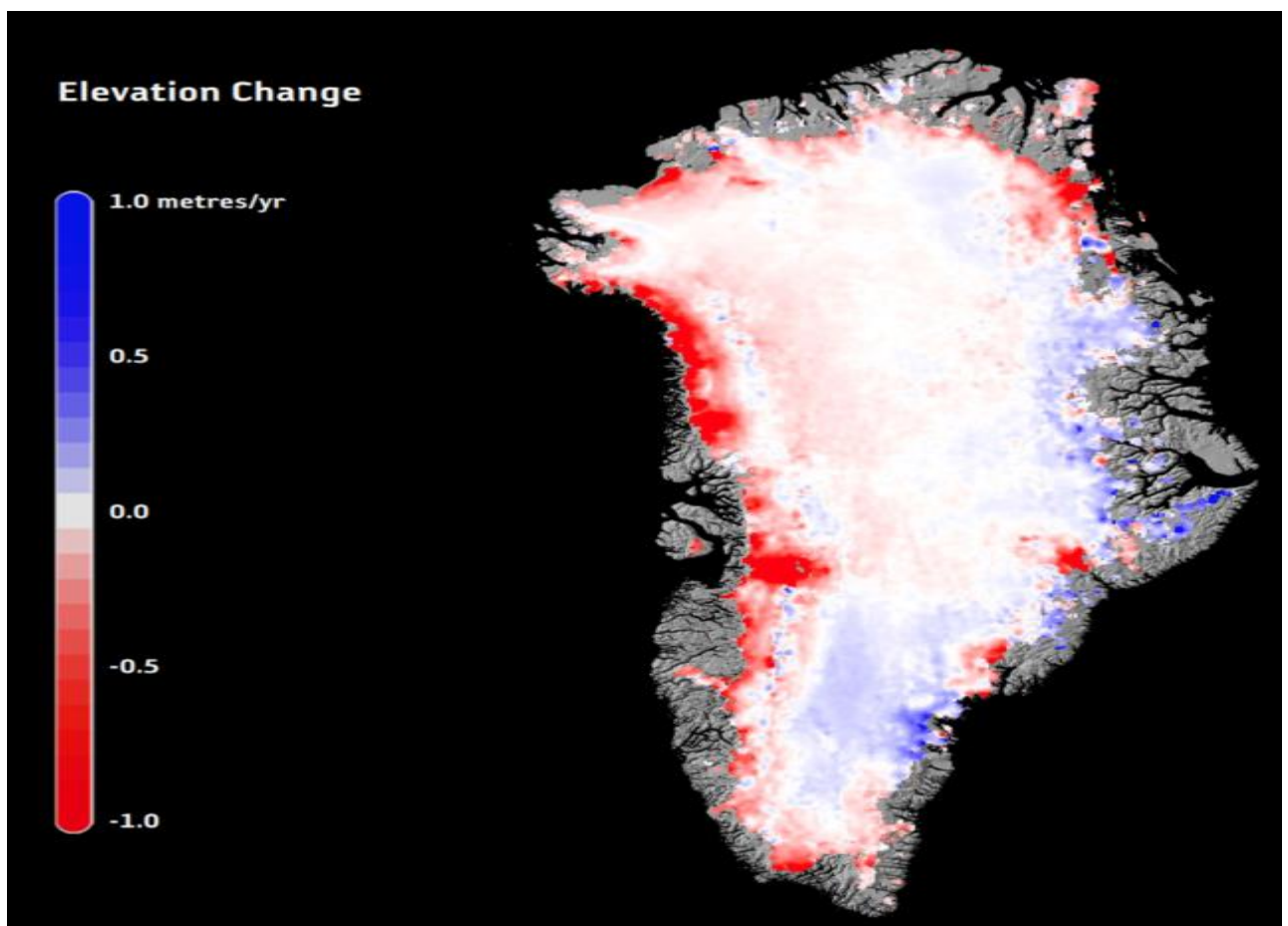


Figure 5.21. Greenland Ice Change, 2015 (ESA).

5.1.1.6. CloudSat. Cloudsat is a NASA earth observation satellite which uses radar, determine storms, hurricanes or typhoons and measure the altitude and properties of clouds so it can be used as a warning satellite to predict flood events or damages too in the regions.

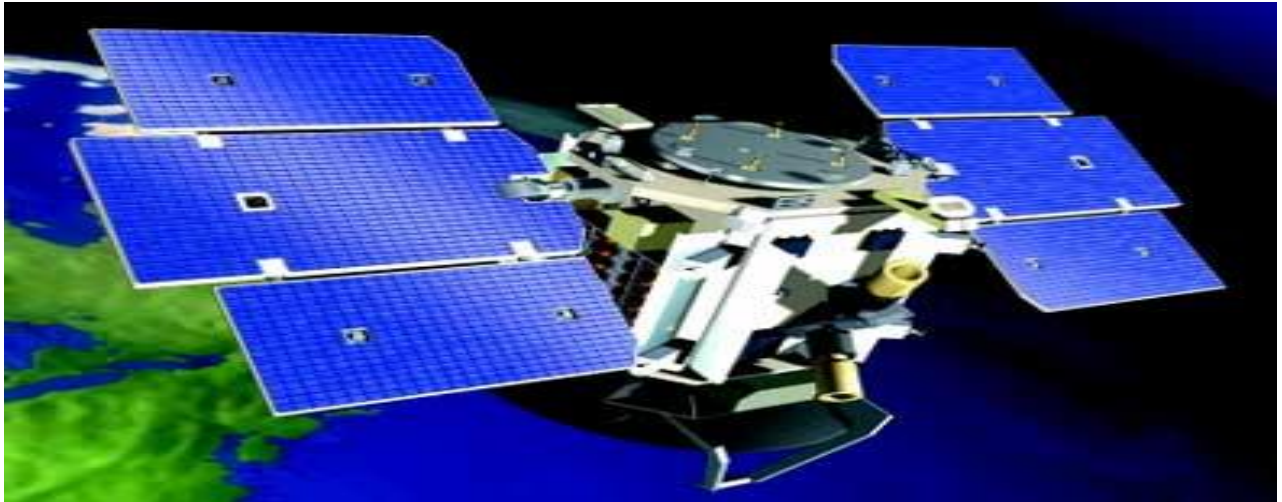


Figure 5.22. CloudSat Image (Gunter's Space Page or NASA).

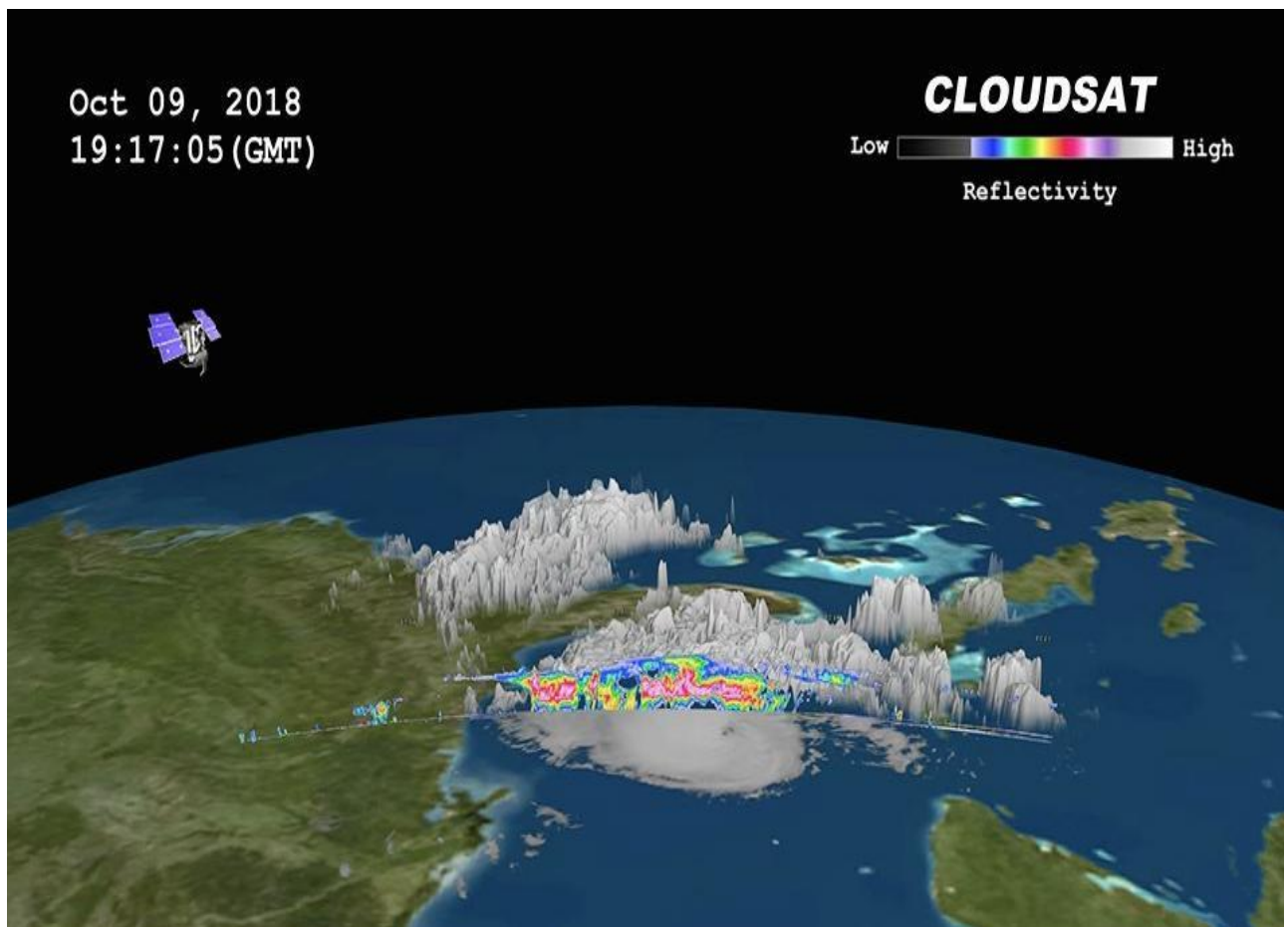


Figure 5.23. NASA's CloudSat passes over Hurricane Michael (NASA Jet Propulsion Laboratory)

5.1.1.7. Deep Space Climate Observatory (DSCOVR). Deep Space Climate Observatory (DSCOVR) is a NOAA space weather, space climate and earth observatory satellite, formerly known as GoreSat and Triana. Variations in condensation nuclei such as aerosols, particles and volcanic ashes on earth can be observed, which may herald heavy precipitations. NOAA expresses, “*Space weather events like geomagnetic storms caused by changes in solar wind have the potential to disrupt nearly every major public infrastructure system, including power grids, telecommunications, aviation and GPS.*” about the satellite. Such as potential disrupted regions can be determined and predicted by DSCOVR. When heavy precipitation and geomagnetic storm occur together, they can undermine the power system, telecommunication, infrastructure, flood search and rescue operations in the region because of damaging GPS system and causes extra losses or damages; therefore, predictions of such as locations is significant and helpful in flood management and in all kind of disaster management studies or operations.



Figure 5.24. Deep Space Climate Observatory (DSCOVR) Image (NASA/NOAA or Spaceflight101.com).

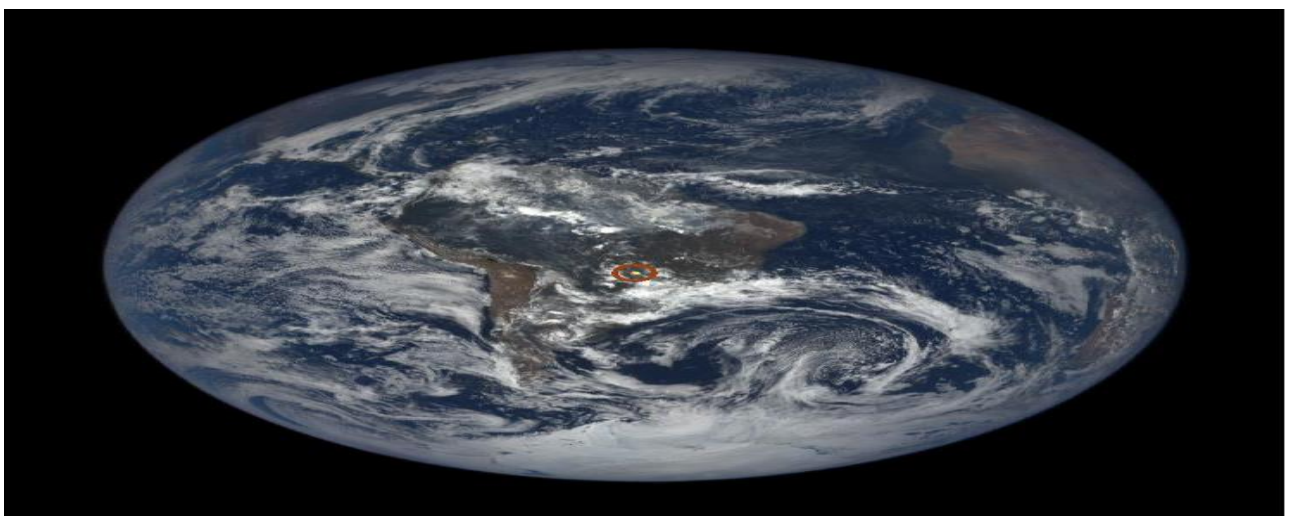


Figure 5.25. Sun glints off atmospheric ice crystals (circled in red) in this view captured by NASA's EPIC instrument on NOAA's DSCOVR satellite (NASA or directory.eoportal.org).

5.1.1.8. Global Precipitation Measurements (GPM). GPM is a joint mission JAXA and NASA as well as other international space agencies to observe Earth precipitation, extreme events and provide global precipitation maps to assist flood and climate managers or researchers. GPM provides data or maps and observes the earth frequently almost every 2-3 hours to predict precipitations. Flood managers, disaster management services, disaster emergency management services must apply to GPM's data or maps so much to created plans and implement the plans such as evacuation plans, search and rescue plans or operations, and pre-during-post-flood plans or activities. It can be expressed that this satellite is a real treasure or pathfinder for city planners, disaster managers, disaster emergency services and flood managers.



Figure 5.26. Global Precipitation Measurement/Dual-frequency Precipitation Radar (GPM/DPR) (JAXA).

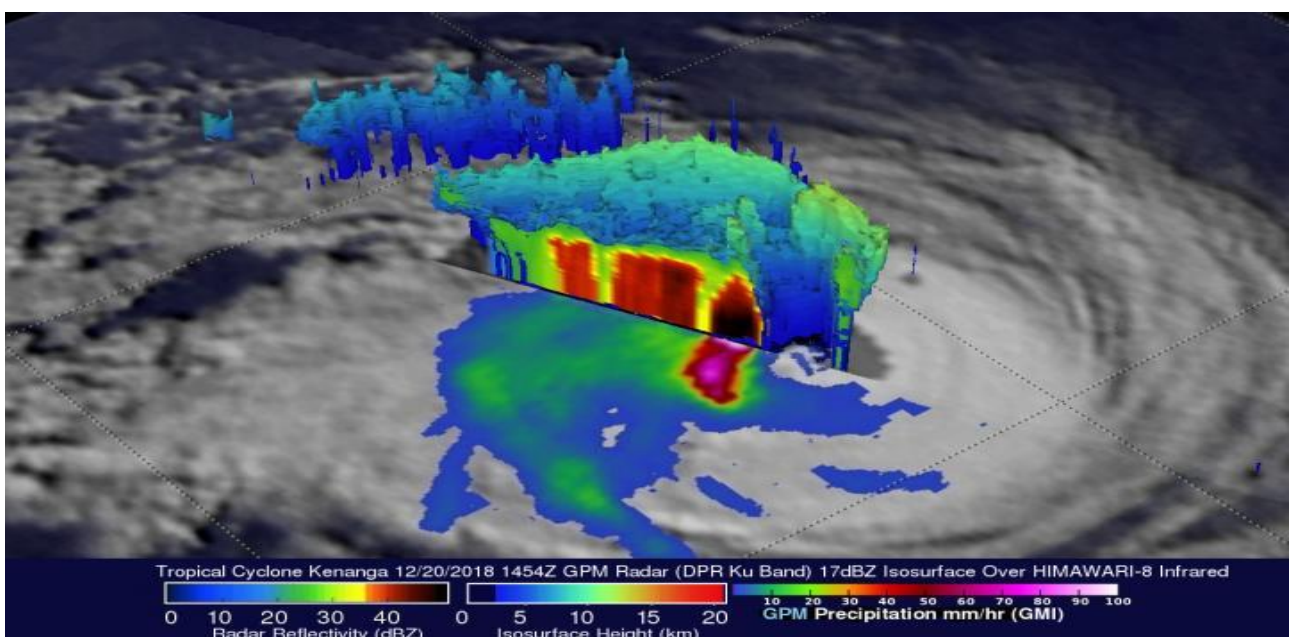


Figure 5.27. Weakening Tropical Cyclone Kenanga captured by GPM (Source: Scienmag.com).

5.1.1.9. Grace follow-on (GRACE FO). It tracks water movements on earth. For example, it can monitor the amount of water in rivers and large lakes, underground water storages, changes in sea levels and changes in ice sheets and glaciers. Data or maps provided by this satellite can be used in flood management and control. Some of maps provided by GRACE-FO can be observed at bottom figures.

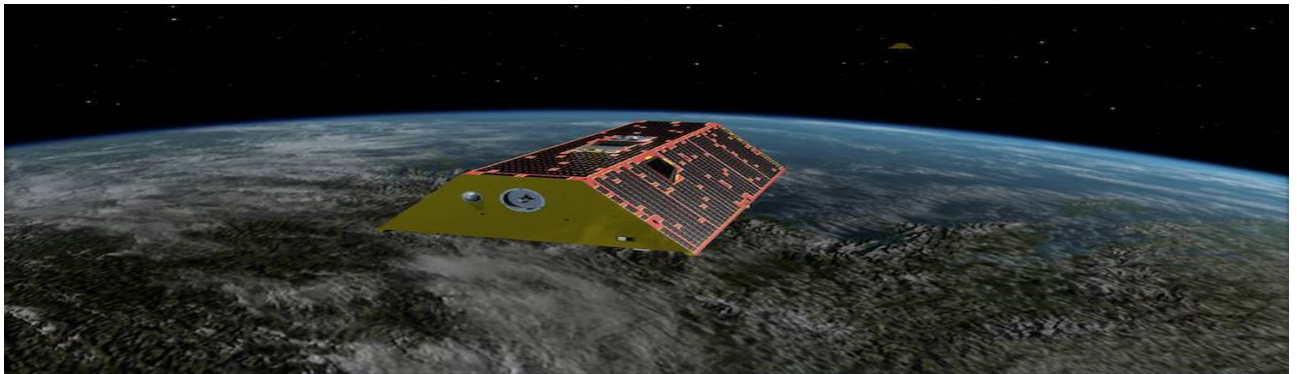


Figure 5.28. GRACE-FO tracks the evolution of Earth's water cycle by monitoring changes in the distribution of mass on Earth (NASA/JPL-Caltech).

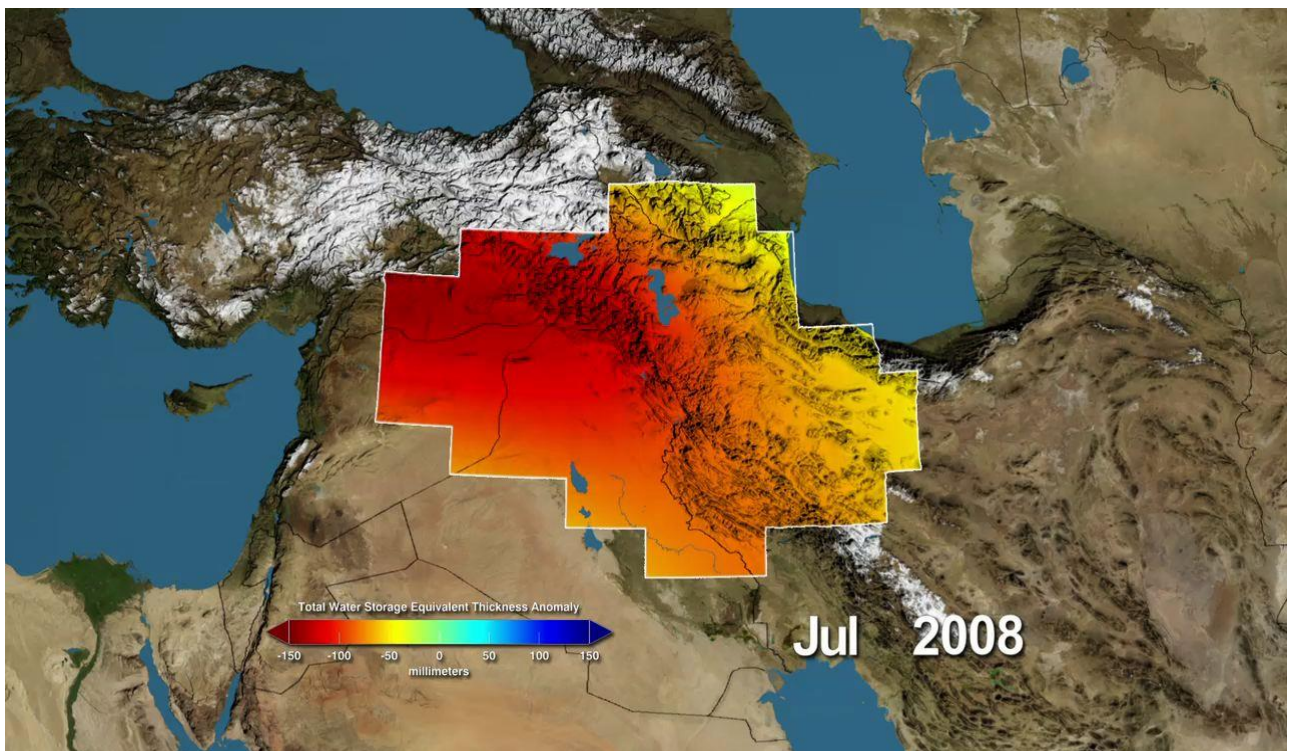


Figure 5.29. Variations in water storage in the Tigris and Euphrates river basins from 2003 to 2009, measured by GRACE-FO satellite: Reds represent drier conditions, while blues represent wetter conditions. The majority of the water lost was due to reductions in groundwater caused by human activities (JPL).

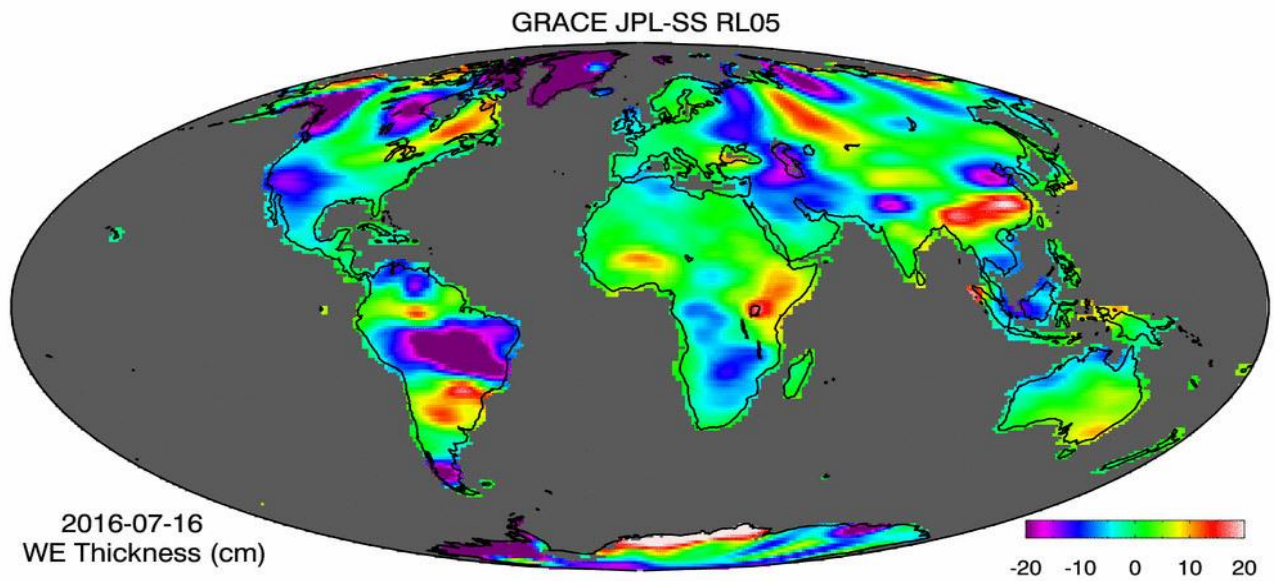


Figure 5 30. This image shows the land water storage anomalies in July 2017, as observed with the GRACE satellites. Blue colors indicate below-average terrestrial water amounts, while red colors show above-average water amounts (JPL).

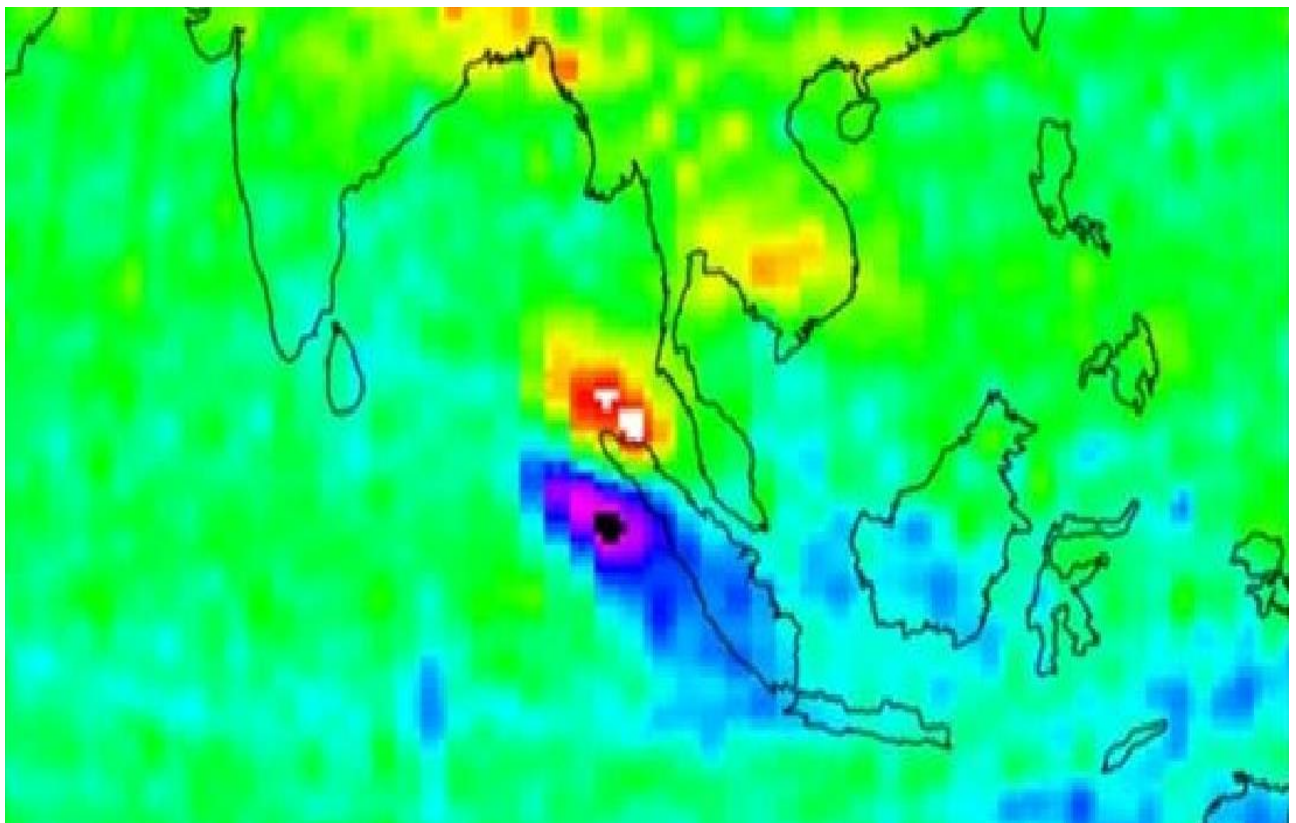


Figure 5.31. The signal of the December 2004 Earthquake or Tsunami in the Indian Ocean in Grace-FO observation of Earth's gravity field (JPL).

5.1.1.10. Jason-3. Jason-3 is a satellite created by EUMETSAT, NASA and an international cooperative mission that NOAA and CNES became partners. Jason-3 measures sea level variations over global oceans so it is helpful in the prediction of coastal floods due to sea level rise. Jason-3 observes sea surface temperature, ocean temperatures, climate change and ocean topography measurements such as the hills and valleys of ocean.

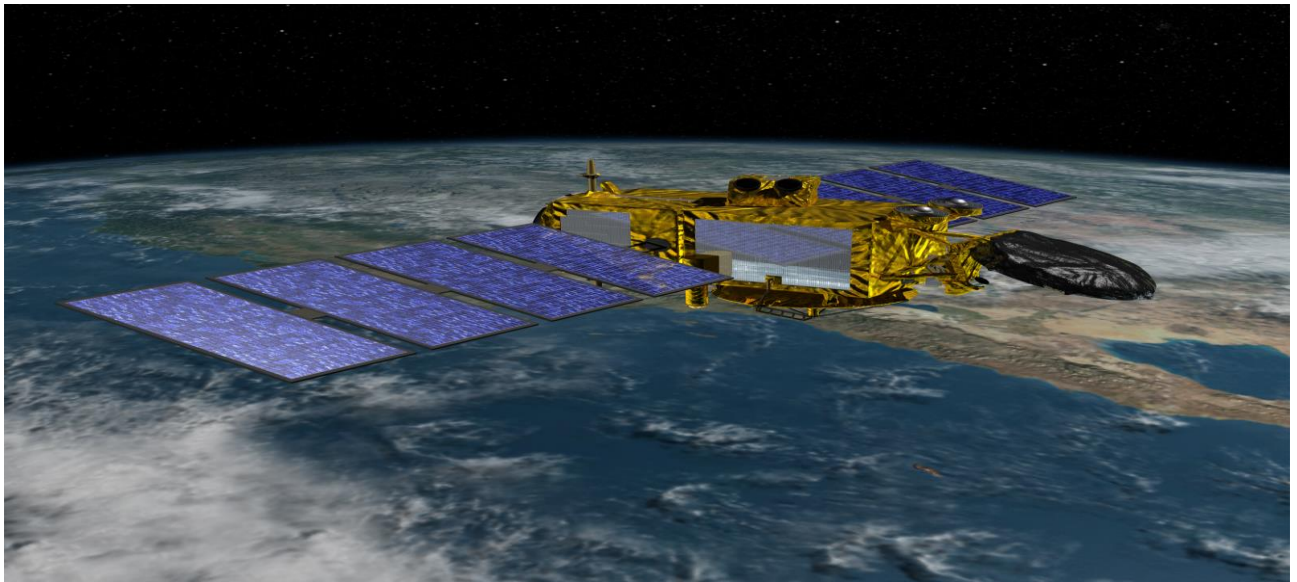


Figure 5.32. Jason-3 Satellite Image (JPL).

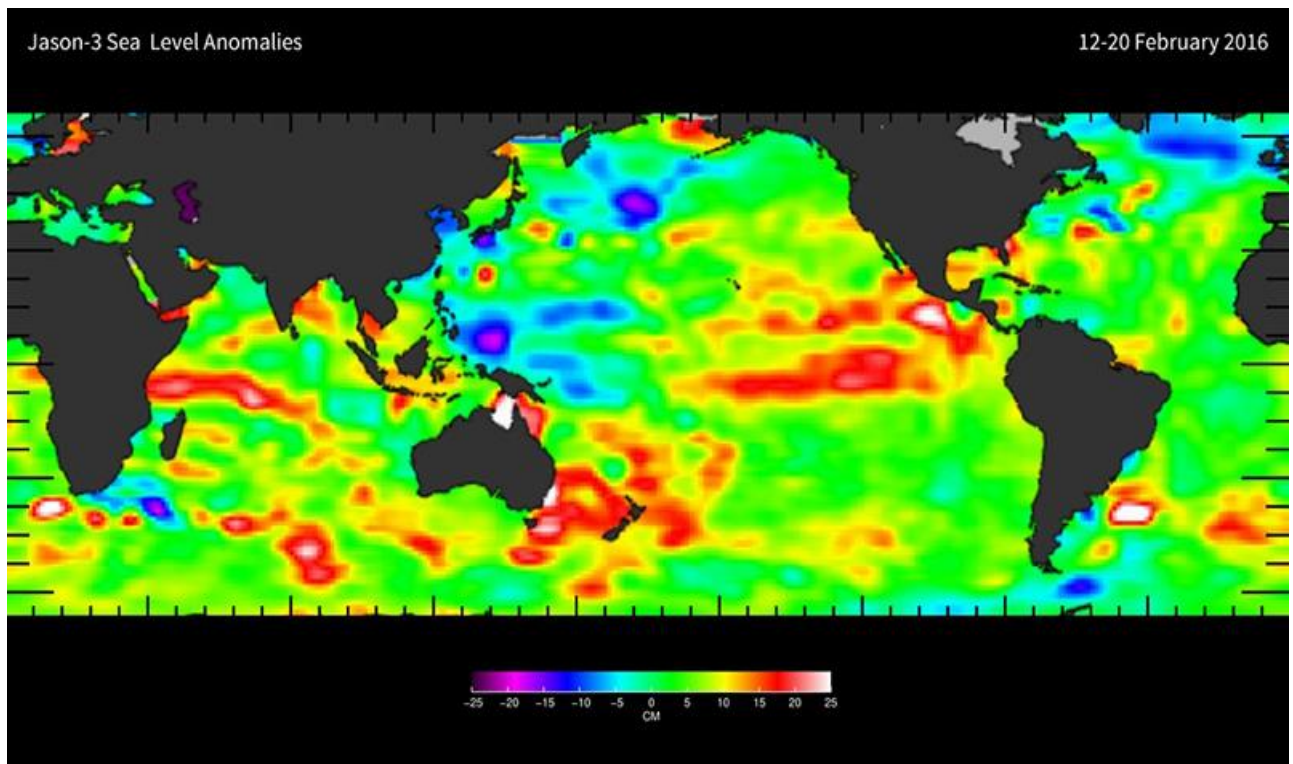


Figure 5.33. Jason-3 maps the ocean (NASA or sealevel.nasa.gov).

5.1.1.11. SWOT. Surface Water Ocean Topography is a mission of NASA, CNES, in partnership with Canadian Space Agency (CSA) and UK Space Agency (UKSA). SWOT will monitor ocean circulation and offer the first truly global observation of changing water levels in rivers, lakes and floodplains or zones and be launched on 16-17 April, 2021.

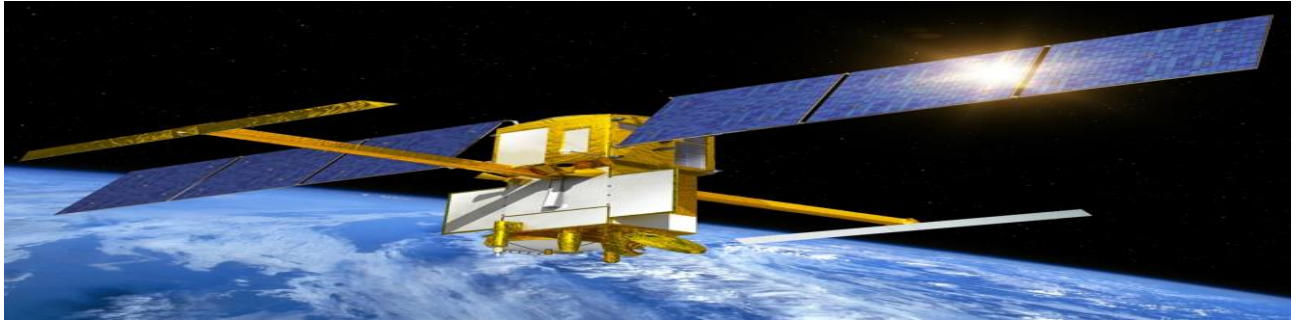


Figure 5.34. SWOT Satellite (CNES).

5.1.1.12. TRMM. Tropical Rainfall Measuring Mission (TRMM) collected global tropical rainfall and lightning data during 17 years. The TRMM satellite ended collecting data on April 15, 2015 according to Goddard Space Flight Center. The center's webpage expresses, "*TRMM delivered a unique 17-year dataset of global tropical rainfall and lightning. The TRMM dataset became the space standard for measuring precipitation, and led to research that improved our understanding of tropical cyclone structure and evolution, convective system properties, lightning-storm relationships, climate and weather modeling, and human impacts on rainfall. The data also supported operational applications such as flood and drought monitoring and weather forecasting.*" TRMM data in this study was used in the previous sections as well. Those data from archives as past records can be used always to support future climate and flood prediction studies.



Figure 5.35. Visualization of the TRMM satellite in space over a tropical cyclone (NASA).

5.2. Continuous Prevention Studies

Continuous Prevention Studies must be implemented by flood managers dependent on identified hazards or risks. A list of identified hazards or risks is needed to fulfill prevention studies. Flood managers must try to create plans to eliminate each determined hazards or risks in this list. After forming a solution plan, the plan must be tested and if it eliminates the identified hazard, the prevention study must be completed for this identified hazard or risk through adding those solutions to the flood management cycle.

Table 5.1. Some hazards or risk identifications in settlements.

1-The fragility or color of the settlement against flash flood is unknown. There is no early warning meteorological, environmental, geographical, topographical, infrastructure and flood history data.
2- People do not know what will do under the condition of flash flood. There is no disaster or flood education plans or program for residents, no measurement for disadvantages groups.
3-The settlement has no Local Environment and Disaster Council (LEDC) to take local or settlement measures.
4- The settlement has no Natural and Man-made Disaster Emergency Plans.
5-No smart city planner staffs, no enough disaster and environmental engineer staffs, no meteorology and civil engineer staffs, and no qualified personals for the settlement management.
6- Proximity to the rivers, lakes, dams, and coastal areas such as sea, ocean.
7-Lack of erosion, landslide and afforestation measures
8- No separate rain collection system.
9-No clean sewer system, no periodic maintenance or no quality sewer system.
10-No irrigating gardens and urban farms.
11- No permeable pavement, sidewalks and gardens.
12-No bridge warning, no periodic maintenance about roads and bridges, no road or bridge closure plans under the flood disasters.
13-No underground tanks for the locations where the traffic heavy is load
14-No green roofs or rooftop gardens.
15-No waterproofing in the buildings.
16-No flood control measures for ground floors and basements in the buildings.
17-Electrical installations or electrical outlets or sockets are not high in building walls.
18-No flood insurance in the buildings.

Some hazards or risks that identified at above list can be solved like that as a part of preventive approaches or studies.

Solution 1: Anil Imperial color system must be used to determine the color of settlement place, which is a chronic warning for the settlement. When a flood damages the settlement below 60 mm rainfall, this settlement is a chronic red color alert risky place, which needs pre-flood activities or plans so much. Structural and non-structural measurement must be implemented together to mitigate the hazards or risks for such as places. Each settlement must have a meteorological measurement system; therefore, rainfall meteorological data that represents the settlement must be collected to manage the flood events. Geographical data, environmental data, topographical data, infrastructure and flood history data are required too. Those official data must be archived for the settlement. Prevention measures must be taken dependent on this recorded data always; therefore, flood managers or engineers must research this data always to plan or organize the prevention measures.

Solution 2: People do not know what will do under the condition of flood; therefore, death number or losses become so high. It is inevitable result that education as pre-flood activities, conscious or logical behaviors of individuals during flood events will save the lives or damages. Flood education in red color alert settlements must be compulsory for the residents by law or regulations. Preventive approaches at bottom are the part of solution 2.

Before floods

1-People must know the emergency telephone numbers such as emergency service office, police, ambulance, hospital, fire-fighter, search and rescue organizations or teams, disaster and emergency management authorities and essential services like gas and electricity services. A list of this emergency numbers must be kept the near phone and be recorded in mobile phones for the security.

2-People must know the evacuation routes, the emergency routes, the locations of local and regional relief centers and where higher or secure grounds can be found.

3-People must know to have an emergency kit, which must be ready at all times. Flood Emergency kit must include insurance documents, the numbers such as insurance emergency helpline, local council and emergency service numbers, family and friend telephone numbers, emergency cash, disposable camera, local radio frequencies, water proof torch or flashlights, non-rechargeable batteries, portable radio, mobile phone, first aid kit with essential prescription medication, blankets, warm clothes, non-perishable food items and bottled water (check use-by date), wash kit such as soap, hyposol, toiletries, napkin, toothbrushes ,wet wipes etc. Relief centers may not have sufficient items

because of an influx of people; therefore, such as items will be helpful to the people to sustain the hygiene and the basic needs.

4-People must know to keep a lot of vegetation around their home or gardens and plant tree and shrubs for the protection, which will minimize the erosion and soften the speed of the flowing waters, especially in the low-lying areas.

5-People must know to place the live-stocks, machinery, pumps, irrigation equipment, chemicals or anything to the higher grounds or to the upper floors before.

During floods

1- When there is a bit of time, people must know to turn off electric fuse or electrical appliances at home or buildings.

2-When flash floods started, people must ensure that elderly or disable people or children are safe by the leaving the house to a higher ground.

3- People in the outside must try to be far away from power lines or broken transmission cables. Otherwise, electrocution can cause to deaths.

4- People must try to be far away from flood flow instead of watching. Otherwise, floods can drag them, and drowning can be an inevitable result. Flood waters can contain chemicals or hazardous materials as well; therefore, they must know to leave the area immediately. They must go to higher grounds.

Measurements in the vehicles or roads during floods;

1-The roads of such as red color settlements must have a flood warning sign. This flood signs must be observed in the google-earth maps or in the Yandex maps to inform drivers. The drivers under the condition of rainfall warning must be directed from this flood risk road or settlements to the alternative secure routes via the maps or mobile-phones.

2-Most deaths occur in the cars. If water rises around the vehicle, the drivers must leave the vehicle instead of trying to drive. The vehicles or cars will lose control and stall on road if water depth is 15 cm or more, and 30 cm will be enough to float most cars. When the car stalls, the driver must leave it immediately and seek higher ground (MacDonald, 2018).

3-In heavy rainy days or warnings, the drivers should not prefer to drive. If it is not possible to implement this advice, the car must have enough fuel and the drivers must be very careful on road. For example, the driver should never drive into water covering the road and be careful about flooding at bridges, highway dips or low areas, especially at night due to low visibility because road or bridges

might be washed away. If there is no alternative except for driving through body of the water, the driver must move slowly in first gear with both hands; otherwise, driving fast can lead to aquaplaning on road (Independent Online, 2018).

4-They must avoid disaster areas on roads instead of watching the flood area. If the avoiding or changing route is not possible, the driver should pull off the vehicle and leave enough space for emergency vehicles to make rescue or other emergency operations easy (Independent Online, 2018).

5-Do not prefer to park the cars or vehicles along streams or fresh waters or coastal region to prevent possible damage or losses.

After floods

1-If emergency officers do not permit to get back inside the house or buildings, people should never enter the inside without officer permission.

2-During cleaning operation at home, all powers or electric fuse or electrical appliance must be off until the end of proper cleaning operation. Without the confirmation of an electrical expert, they should never be turned on.

3-After floods, taking photos or recording the damages through video or camera might be helpful for insurance claims.

4- Before using items or objects at home, people must clean them very well because they might be contaminated. People must wear rubber boots, gloves and masks before cleaning operations.

Emergency or disaster council via flood managers must prepare booklet about what to do before, during and after flood and distribute it as compulsory for the residents in red color regions. Education duty to raise awareness of people or residents can be fulfilled with this booklet way shortly. For example, Emergency Management Australia has a quality booklet related with this issue. If people have no emergency council to inform or educate them, people can learn from this booklet as a guide. People can access the booklet from this link of Australian Government Bureau of Meteorology: http://www.bom.gov.au/water/floods/document/What_todo_floods.pdf.

Solution 3: Local Environment and Disaster Council must be founded in the settlements, especially in the red color settlements. Council's personals or management organization must include meteorological, environmental, electrical, agricultural, civil engineers, geology engineers, city planner and landscape architects together with experts in the fields of man-made and natural disasters. Sustainable cities or settlements and disaster preventions can be formed only by those local teams or staffs. Conventional cities or urban sprawls cities can only be transformed into sustainable cities via

the coordination of those staffs and residents by state laws or regulation support. Some of prevention works were listed at the bottom, which must be prepared and planned by Local Environment and Disaster Council;

1-MIS, EIS, GIS, infrastructure and flood data about settlements must be collected and researched to create prevention plans continuously by council.

2-Council must list the determined risks or hazards.

3-Official Natural Disaster Emergency Action Plan (NDEAP) and man-made disaster emergency action plan for settlement must prepared by the council. Those plans must be checked by state inspectors and be revised each year.

4-NDEAP must be prepared dependent on four flood management risk cycle: 1-risk assessment, 2-mitigation, 3-preparedness and 4- response and recovery. Cycles must be reviewed and monitored. When insufficiencies are determined via inspections, all solutions that implemented to mitigate the identified hazards or risks or insufficiencies must be recorded to a database system, which is called Natural Disaster Risk Reduction System (NDRRS). NDRRS can be used as consultation and communication materials to help to solve the flood prevention problems in other settlements or in the future as well.

5-The plans must show the duties of people, organizations and authorities together with the coordination ways among them.

6-The plans must show the infrastructure needs or requirements, the locations together with the using procedure of any kind of tool, equipment, technology, and systems that will be used during or after flood and the procedure of periodic maintenance of those items or systems.

7-The plans must include maps related with risky places. For example, the map of low-lying areas, the map of bridges, risky buildings, schools, roads, railways, airports, higher grounds, the maps of emergency routes to go hospitals, police and fire-fighter stations, evacuation routes, local and regional relief centers, the location map of stored disaster management equipment, the map of flood risky settlements or roads, the map of the locations of dams, rivers, lakes, sea, ponds, wetlands, the diversion channels, wastewater treatment facilities, the maps of sewage system, rainwater system, groundwater system, the maps of garden or parks, the maps of crops or agricultural areas, industrial area, mountain and coastal areas, vegetation maps, landslide risks maps, erosion risk maps, prediction or satellite maps, meteorological maps, seismic hazard maps, volcano hazard maps and so on.

8-The limit values of parameters followed and early warning values of those parameters must be listed in the plans.

9- Significant regulations or laws or directives that the settlement or regions subject to must be listed.

10-Councils must try to standardize the actions or the measures taken before, during and after the floods.

11-Council must prepare search and rescue operation plans. They must provide relief materials dependent on population to meet the basic needs of people with state coordination. They must create a distribution plan to prevent looting events. Special laws or rules by state can be made to deter the looting events as well.

12-Employee settlers, civil defense forces, logistic managers, hospital, fire-fighters, search and rescue personals must do practice each months of a year with coordination of council as if there is a disaster event. This concept will prepare the personals to the disasters, offer an opportunity to test the quality of the plans and be helpful to improve those plans.

13-Independent observer experts for the settlement in council must join the monthly practice and prepare an audit report for each month in a year to check the implementations, the quality of emergency action plans and the other available risks against possible floods or natural disasters. The determinations or observations of other experts and engineers in the council must enter this report as well. Those reports or insufficiencies the reports determined must be discussed to solve in the council after the publishing. Copies of this report must be offered to local, regional state authorities and metropolitan municipalities to inform about the insufficiencies or needs they observed to meet those needs.

14- After every flood or disaster events, this council must prepare a flood or disaster report with the evidences they collected. Flood report must include the information such as flood type, the river height, rainfall as mm from the settlement gauges or sensors designed by smart city planners, flood rise or high in settlement, how long flood lasted, a list of damages, losses or deaths, a list of deficiencies or failures and so on. All this information must be written in detail and supported by evidences such as photos, camera or video to identify the available problems and solve the problems in the future. Those reports must be accepted as official reports and recorded in archives to cope with future's flood problems.

Solution 4: When settlement has no natural disaster plan and no man-made emergency plan, it will be always in the disaster risks; therefore, losses and damages will be high. To create those plans, disaster characteristics of the region or settlement must be determined. Disaster type warnings of the months, natural disaster risk index and Z-Disaster or flood warnings must be used to characterize the disasters and plan the prevention measures, and make the recover or responses strong. If the disaster index value for the hours between 10.30 pm-10.30 am is 0.03 or bigger, night disaster employees, managers and officials are actively required for this risky month for minimum three years to plan the measures and minimize losses during the sleep. For such as months during three years in the scope

of Z-Disaster or Flood warning, those personals must prepare the warning sirens or warning lights for the night or dawn works, the night or dawn evacuation plans, the night or dawn disaster or flood parameter watching, the night or dawn search and rescue operation plans, the night or dawn relief plans, the night or dawn suitable disaster gathering places, planning the night or dawn the vehicles or items or objects such as dozers, lorries, boats, water discharge pumps or air pumps, night or dawn works or activities such as lighting plans, the audit methods and other night risks list because of invisibility during this risky periods. It is inevitable that such as proper night or dawn activities in the scope of Z-Disaster Flood warning will minimize the disaster losses or damages during the sleep period.

Solution 5: Each settlement must have a council or team which includes a smart city planner, a disaster management expert, an environmental engineer, a meteorological engineer, an agricultural engineer, a forestry engineer, a civil engineer, an electrical engineer, a renewable energy engineer and a landscaping engineer. Those staffs can prevent urban sprawling and floods or disasters with their works and create high quality sustainable, renewable, ecofriendly, green and blue settlements. State must appoint such as engineers or team to produce sustainable cities. This appointment concept is a kind of green job offering concept, which will help to prevent highly unemployment rates, disasters, losses or damages and climate change in the countries and increase the life quality in the settlements.

Solution 6: The distance rules in the topographical parameter section must be implemented for new settlement places. Old ones that do not meet the distance criteria related with rivers, lakes, dams and coastal areas such as sea and ocean must be moved to the suitable places that bring this distance criteria, this concept will save water resources and losses or damages from natural or human made disasters. Settlements must be protected well from hazard direction. Hazards to the settlements come from the rivers, the dams, the lakes, sea or ocean as flood disasters and especially as snowmelt floods or landslide or mudflow or avalanches from hillside or mountain regions triggered by rainfalls or temperature decreases. Settlements must be planned against water resources or its routes, mountain regions or hillsides and low-lying areas especially, to prevent floods but of course, forest areas, agricultural areas and industrial areas are significant in those plans to minimize disasters in the settlements. Distance or proximity rules as standard values will prevent flood or natural disasters' losses and damages; therefore, distance or proximity rule must be used as a preventive parameter.

Solution 7: Erosion risky locations must be determined and be showed in the maps. When erosion risky is high, erosion measurements are very required to prevent the floods, landslide, and

mudflows. There are many erosion control methods such as: buffer strips, windbreak for wind erosion, crop rotation, terracing, mulching, reforestation, seeding for the inaccessible steep slopes especially, grassed or vegetated waterways, impoundments such as detention and retention ponds to control storm-waters or water erosion, These methods can be used to prevent the floods, the sediment movement through water or wind erosion, landslides and mudflows to increase the quality of environments. Observed fallen rocks and collapsed pavements around settlements or road can be an early warning for the landslide. Construction locations and roads because of being highly risky must be checked and be protected against erosion or landslide without stops. On mountain or hill sides, terracing can be used to prevent landslide and erosion because it reduces the intensity of run-off. Terracing, which is positioned perpendicular to the flow of water, is a kind of flood prevention technique. Cultivation terraces increase the agricultural productivity and food security as well.



Figure 5.36. Terraced landscape in Vietnam (Source: Vietnamnews.vn or daidoanket.vn).

Land use or vegetation and planting tree are significant to control erosion in a region. Table 5.2 is a PhD study result carried out by Balcı in 1958, which can be accessible from the book of I. National Flood Symposium of General Directorate of State Hydraulic Works, shows the effect of erosion and infiltration dependent on land use or vegetation.

Table 5.2. Land use and soil transport time, erosion of vegetation, surface run-off and the effect of infiltration (I. National Flood Symposium, DSİ or Balcı, 1958).

Land Use	Rainfall	Infiltration		Surface runoff		Erosion	Soil Transport Time for 15 cm soil.
	mm	mm	%	mm	%	Ton/ha	Year
Fallow	1336.2	591.7	44	744.5	56	16.014	122
Grassland	1336.2	855.6	64	480.6	36	1.360	1434
Forest	1336.2	1094.8	82	241.4	18	-----	-----

To prevent erosion and floods with afforestation, plant types that include high interception and transpiration values must be preferred. The advices of forest engineers are significant in those options; however, those plants or trees such as pine, larch, cypress, spruce, maple, bamboo, oak, poplar, acacia and eucalyptus may be preferred to prevent the flood, erosion and landslide due to including potentially high transpiration and interception percentages.

Solution 8: Separate rain collection system or surface water system must be used to control the floods; in other words, sewage system must be separated from storm or surface water system. Roadside channel or ditches must be used to collect the runoff along road to prevent floods, which is required for road flood safety. Side inlets or grated inlets can be used on roads. Inlets include grids which prevents the falling of larger objects or debris or sediments into drain. Small objects accumulate at the bottom of catch basin and gully pots usage may block the exit of rodents, methane and bad smell gases such as hydrogen-sulfide. Catch basin must be cleaned to prevent the clogging and to function properly when sediments or particles reach to one-third of the catch basin. The rules of Average Rainy Days Flood Warning Capacity of Months for Channels must be used for the clean or the maintenance of catch basins or storm water filtration systems. Bioswales can be built in streets to prevent the floods due to storm water. Water collected on road channels can be diverted into bioswales before flowing into the storm sewers. Plants that need so much water must be preferred in the inside of bio-swales. To prevent overburdening into public storm system and sewage systems, detention tanks or ponds or a rain harvesting system near the buildings might be built to hold rainwaters temporarily during heavy precipitation. Retention ponds can be used to prevent the flood events. Well-designed retention ponds and well-periodic maintenance may provide good flood control, aesthetic or ecological benefits to the urban landscapes. Of course, the retention ponds must have an emergency spillway if storage capacity exceeds; otherwise, it can create flood risk during

heavy rains. Shortly, storm water system must be separate in settlements to prevent flood events. Central urban advanced treatment facilities must be set up in a suitable place for the settlement and after treatment, those waters can be used in the industry such as metal, the energy, the irrigation and in other water usage aims.



Figure 5.37. A bioswale in Binghamton, New York (Binghamton-ny.gov).



Figure 5.38. A retention pond image (nwrn.eu).

Solution 9: Sewage system must be separate system from storm water system and have a good maintenance plan to prevent floods. Main reasons that lead to the floods in sewer system are the clogging or stoppages, broken sewer lines or pipes, and leakages. To prevent those problems, sewage system must have a good routine and periodic maintenance plans. The rules of Average Rainy Days

Flood Warning Capacity of Months for Channels can be used for the inspection, the clean or the maintenance of sewer systems. Smart sensors can be preferred to observe the level and flow rate. Vacuum trucks and hydro-flushing can be used to suck the sludge or slurries and clean drain line to prevent floods or clogging. Pipe bursting method can be used to replace old buried or broken pipes as well. In shortly, sewage system must have a good routine and periodic maintenance plans to prevent the floods from sewage system.

Solution 10: Urban farming can be developed in the cities or settlements. Especially crops that need so much water can be preferred in the urban farms of the cities that have highly precipitation as mm. Urban farming reduces food or crop prices for city dwellers in the settlement, provides green jobs, cope with starvation problems and prevent possible flood events in cities. Urban farming must use the urban resources such as organic waste as compost, the urban residents as laborers and the rainwater or wastewaters after advance treatment as irrigation waters. Flood disasters can be prevented with this way. Alternatively, irrigation gardens can be preferred in cities to decrease extreme water levels or prevent the floods.

Solution 11: Pavements and sidewalks must be permeable. Plastic grid pavers, interlocking pavers, pervious concrete and pervious asphalt can be preferred to reduce the run-off from rainfall and filter out pollutants from rainwaters. Rain gardens, bioswales, planter boxes near the sidewalk or pavements must be preferred to prevent the floods. Especially in the parking a lot, permeable pavements or sidewalks, bioswales and planter boxes must be used to prevent the floods or the vehicle drags due to the floods.

Solution 12: Floods scour away the riverbed downstream of piers. Debris or materials hit the bridge and create immense force which can be described as dam effect. When flood water reaches the deck, pressure force increases and causes the collapses. All bridges upon rivers or lakes or water resources must have a routine and periodic maintenance plan. High speed water transports or erodes the materials that support bridge abutments and weak the standing of bridge on the floor with the time. Holes created in the floor by high speed or sediment transport flow water lead to collapsing too; therefore, water level or speed and sediment flow must be measured continuously to warn the officials or personal that interest in the management of those bridges. Smart sensors designed by smart city engineers can be used in the warning. Especially when water levels or speed reach the warning level around bridges, the bridges must be closed to the traffic and the pedestrian passages immediately. Passages can never be acceptable when water level reaches the deck of bridge so the warning levels or speeds must be determined or designed before to close the bridges for the passes. Except for

periodic maintenance, civil engineers must measure or control the resistance capacity of bridges dependent on the rules of Average Rainy Days Flood Warning Capacity of Months and take measurements to prevent possible collapses or losses. Cleaning operations of debris or material around the bridge must be carried out dependent on those monthly rules as well.

Solution 13: Underground tanks can be used for the locations in the highway dips or low-lying areas, the locations under the bridges on road and the locations where the road traffic is heavy in the settlements, especially if this settlement is exposed to heavy precipitation climatically. The number of inlets and grids must be increased under the bridges on roads to prevent floods or water accumulations, especially when the floor is low or dip. This concept will prevent water accumulation or floods on roads. Underground tanks must be checked dependent on the rules of Average Rainy Days Flood Warning Capacity of Months.

Solution 14: Green roofs and rooftop garden must be designed to absorb rainwater which will help to decrease the level of storm system. They can offer food, insulation, ecological benefits, a habitat for wildlife, recreational opportunities and help the human health by minimizing stress due to aesthetic appearances.

Solution 15: Waterproofing prevents the penetration of waters or the floods in the buildings, which forms impervious barrier in the structures. The waterproofing in the structures such as foundations, basements, bathrooms, kitchens, walls, balconies roofs or terraces, water tanks or pools and plumbing materials are required to protect the buildings from possible flood events.

Solution 16: By law or regulation, waterproofing and flood insurance must be compulsory in the buildings which have a basement. In red color settlements, flood insurance company and its engineer or expert must take measurements two times in a year related with possible flood events for such as buildings, especially for the basement and the ground cover. They must inform the residents or workers what they will do under the flood conditions. Hospitals and school buildings must be checked for each month against natural disaster or floods by experts or engineers as well.

Solution 17: Electrical installations or electrical outlets or sockets must be high in building walls; otherwise, electrocution, which is very risky thing for the buildings especially in the basements or the ground floors, can occur during the floods. People must know to turn off all electrical devices or fuse during the floods to minimize losses from electrocution.

Solution 18: Many residents did not have home contents insurance and now face large debts in Glasgow (BBC News, 1 August, 2002, Floods costs into “millions”). This flood news revives the importance of flood insurance. Governments or many municipality managements that gave permission to the home or buildings, or sectors in flood prone area inappropriately in the past must implement compulsory flood insurance system to the people, especially the ones that live in highly flood risk regions as compulsory until they rehabilitate those areas in a sustainable way. Buildings need solutions against flood events or risks. People must have flood disaster insurance automatically against a flood event. Governments must work together with insurance companies against all kind of natural disaster, not to witness such as events like in the Glasgow 2002 flood event. In the U.S.A, FEMA implements National Flood Insurance. This program might be a good example to the insurance collaboration. Detailed information can be obtained from the link of FEMA (<https://www.fema.gov/national-flood-insurance-program>). The Economist (Sep 9th, 2017) expressed that over \$30bn in property losses in Texas after 2017 Hurricane Harvey, only 40 % may be insured (Economist, Sep 9th 2017-Inadequacy of Flood Insurance). Countries need good planned flood insurance implementations that will cover 100 % of property and other losses related with flood risks determined.

Solution 16 must be implemented by law or regulation as well; *“By law or regulation, waterproofing and flood insurance must be compulsory in the buildings which have a basement. In red color settlements, flood insurance company and its engineer or expert must take measurements two times in a year related with possible flood events for such as buildings, especially for the basement and the ground cover. They must inform the residents or workers what they will do under the flood conditions. Hospitals and school buildings must be checked for each month against natural disaster or floods by experts or engineers as well”*.

Other risk or hazard identifications must be determined in river basins and solutions be produced by managers to prevent flood damages. Major hazards in river basins can be observed in Table 5.3.

Table 5.3. Some hazards or risk identifications in river basins.

19-No quality river basin management plan
20-No water and water quality management
21-No pollution prevention measures
22-No riparian areas
23-No quality agricultural management

24-No quality industrial area or water management
25- No erosion control measures in agricultural and hillside areas
26-No coordination among state or regional or local administrations or council,
27-No a dam control and measurement system
28-No quality emergency action plans and no audit
29- No discharge policy and its inspection
30-No settlement control

Solution 19: Without quality and sustainable river basin management plans, preventing flood damages and losses is impossible. Therefore, river basin management plans must be very quality, which is required to manage the waters in sustainable manner, protect the public health and environment, and prevent the flood damages against the agricultural areas, the industries, the settlements, the humans, the livestock and the economy. 2000 Mozambique flood might be a good example to addresses some problems. It indicates that what kind of flood damages might occur shortly and basically. *“About 700 people had died and another 100 were missing. Almost 2 million people (some of 12 percent of total population) were seriously affected, with half needing food aid. Almost 250,000 people lost their homes, and 140,000 hectares of cultivated and grazing land lost to floods Furthermore, some 20,000 head of cattle were missing and many more could die of disease. 90 percent of country’s functioning irrigation infrastructure was damaged. Industry too suffered as torrential rains caused severe damage, leading to shutdowns and sharply reduced production in some of Mozambique’s most successful factories. Almost all productions stopped due to the electricity installations are under water. Over a thousand shops and wholesalers in the river basin, and even low-lying areas were damaged. Many secondary and tertiary roads were washed away, as were many bridges. All the railways in southern Mozambique are badly affected. The flood also closed the schools, and many health units were destroyed by the disaster.”* the report explains (African recovery, United Nations, 2000). This flood event points out where the flood risks may occur roughly, and the places or boundaries that need precautions or measures against flood events in river basin mainly. The research will try to create solutions in those places or boundaries now.

A good river basin plan must include the features at bottom;

1-The main river, the tributaries and the distributaries together with their flow directions must be shown in a map. They must be named and listed. For each stream, hydrological, meteorological and environmental parameter measurement stations must be planned or designed dependent on distance parameter. The locations of those stations must be indicated in a map as well. Data collection,

distribution and early warning procedure for each must be explained and drawn in a diagram.

2-All water diversion points from main river or tributaries or distributaries, its channels or its routes to the temporarily storage location such as wetlands, ponds, tanks must be shown in a separate map. All those temporarily storage areas such as wetlands, ponds, dams and tanks must be identified dependent on water usage aims, named and listed. Distribution routes from this storage area and the locations of advanced water treatment facilities for the water distribution must be indicated in a map too. There must be enough experts together with hydraulic and environmental engineers to control the water quality, prevent the water losses and pollution, and distribute the water resources properly for its usage objectives from the origin of river diversion. Of course, except for those staffs, there must be enough hydraulic and environment engineers to control water flow and pollutions in all main streams or tributaries or distributaries. Pollution can only be prevented with the control, the measures and the work of those engineers. The objectives of water usage for a storage area can be drinking, irrigation, industrial usage and energy production shortly and basically.

3-Settlements which do not fulfil the minimum distance criteria for mains streams or tributary or distributaries must be shown in a map as red alert color settlements. Flood signs to the inside or the roads of such as settlements must be placed as compulsory to show flood hazards and warn the humans. Flood insurance in buildings must be compulsory in such as places by law or regulation. Furthermore, a council that emerges from engineers this study expressed before must be created for such as places. They must work to manage the possible disasters risks and determine the fate of such as settlements for future sustainable aims. Transformation and transport of those places in the future to the places that bring minimum distance criteria can only be with decisions or plans of this council's long-term work when the conditions or needs or decisions are supported by state or international organizations. The settlement councils' long-term research, plans, evidences and views must be decisive. Regional administrations, local administration, municipalities, disaster council, governors and state organizations should never allow new settlements in this distance zone to protect water resources and possible damages or losses from floods. Such as zones which remain river and settlement are not suitable for livestock as well. This zone which remains between river and settlement must be used as riparian area, water storage or distribution areas and agricultural areas. Continuous observation and control must be implemented against illegal buildings or settlements in this zone. Settlements which fulfill the distance criteria can plan livestock area in other side that is far away from riverside and mountain side. Special well-observed and controlled non risky small ponds and feeding troughs must be planned for live-stocks. Domestic wastewaters of settlements should never discharge into river or fresh waters. Those waters can be reused in washing or cleaning operations or in industrial aims (no food industry) depend on the preference of the settlement council if they can be treated well by advance treatment systems.

4-Industrial areas which are close to river basin must be shown in a map. The industrial areas that do not bring the distance criteria must be indicated as red alert. Such as red alert industrial facilities that use chemicals are great risks in river basins for the all water resources, fishes, public health, agricultural crops, livestock, other ecosystems and all environments as pollution resource. State or its policies must organize industry settlement plans to protect environment and move such as industrial facilities to the barren and secure places. State should never allow the industry production except for the designed barren regions. Agro-food industry can be close to agricultural areas but they must be designed well. All industrial facilities must have great water storage and advanced treatment facilities as compulsory. After treatment, those waters must be reused in the industry as washing, process or energy production aims without discharge into natural waters. This concept will prevent extreme water consumption, pollution, drinkable water scarcity, the cost of energy and the cost or the prices of environment problems in some extent.

5-If there are discharges into the rivers or fresh waters, those points and its location must be shown in a map as red alerts. Solutions must be produced for each one by regional authorities or staffs.

6-All dams upon natural waters must be shown in a map. Each one must be inspected by independent engineers periodically except for its own operators. All of them must have an early warning plans and an emergency action plans prepared by its own operators. Those plans must be checked by state organizations for minimum every year to prevent possible dam failures.

7-All bridges upon rivers must be shown in a map. All of them must have a warning procedure dependent on water level or speed and sediment transport. When those warning levels exceed, bridge must be closed to the traffic or passes by officials. All bridges must be controlled routinely and periodically well dependent on the rules of Average Rainy Days Flood Warning Capacity of Months for the possible collapse events.

8-All roads or its routes or bridges upon roads which close to river basin must be shown in a map. Highway dips or low-lying areas must be determined upon this route. Underground tanks must be used to collect floodwaters or rainwaters in such as highway dips or low-lying areas or tunnels or under the bridge. The numbers of grate upon road under the bridges or tunnels must be increased as well. Alternative emergency exit roads or routes must be built, especially when flood risk or landslide risks are high in the region.

9-River basins must have an emergency action plan against disasters or floods. Evacuation roads, emergency roads, hospitals, emergency gathering places, the location of relief centers and the route of disaster prevention equipment centers for risky regions must be shown in a map.

Solution 20: There must be enough experts together with hydraulic and environmental engineers to control the water quality, prevent the water losses and pollution, and distribute the water resources

properly for its usage objectives from the origin of river diversion. Of course, except for those staffs, there must be enough hydraulic and environment engineers to control water flow and pollutions in the all main streams or tributaries or distributaries. Pollution can only be prevented with the control, the measures and the work of those engineers. The objectives of water usage for a storage area can be drinking, irrigation, industrial usage, and energy production shortly and basically. Livestock waters into ponds or troughs must be provided from the drinking waters or its systems. Domestic wastewaters of settlements, livestock wastewaters, industrial and irrigation wastewaters should never discharge into river or fresh waters or ponds even if they treated well by advanced system. Those waters can be reused in washing or cleaning operations or in industrial aims again and again except for food industries depend on the preference of the engineers or experts; therefore, all kind of wastewaters must be reused after advance treatment instead of discharging into rivers or natural waters. Such as water reuse systems must be planned by staffs or engineers or regional administrations to protect water resources.

Solution 21: Pollution prevention measurements in river basin management must be planned by environmental engineers, which will help to increase water and environment quality in the basin. Domestic wastewaters of settlements, industrial and irrigation wastewaters should never discharge into river or fresh waters or ponds even if they treated well by advanced system. Those waters can be reused in washing or cleaning operations or in industrial aims again and again except for food industries depend on the preference of the settlement council. Therefore, all kind of wastewaters must be preferred to reuse instead of discharging into rivers or natural waters to prevent pollution or water borne disease due to floods. For example, floods can increase the transmission of water borne diseases such as cholera, hepatitis-A, leptospirosis, and typhoid fever according to WHO. The transmission of vector-borne disease such as dengue, malaria and West Nile fever can increase by floods as well. Polluted waters by industrial discharges can spread to the environment in floods and lead to different disaster outbreaks caused by chemicals. Pollution prevention measures must be taken by environmental engineers.

Solution 22: Riparian zone prevents floods, offers habitat for wildlife, filters the pollutants, the excessive nutrients and sediments, reduces streambank erosion and provides shades to decrease the temperature and support high dissolved oxygen. Minimum 2 km from riverside must be used as riparian areas. Many different trees and aquatic plants must be used in this riparian zone. Any kind of grazing, timber harvesting, settlement or urban development and agriculture must be prohibited in this zone by law. Managers or staffs and regional administration must control this zone very well. After the riparian zone, controllable wetlands zones for agriculture aims and drinking water usages

must be built within 1 km for water storage. This riparian concept will prevent the agricultural crop damages due to floods from rivers. When water level is higher than average volume or level or speed in river dependent on the months, water diversion must be made into those wetlands dependent on the parameter rules of Average Rainy Days Flood Warning Capacity of Months for Dams or Reservoirs. Those waters in wetlands must be used in agriculture and drinking aims. When water levels or volume are high in wetlands before highly rainy months, excessive waters must be released into waterways and used immediately for agriculture, drinking or other purposes to prevent possible future floods and crop damages in the fields.

Solution 23: After 1 km wetlands zone, agricultural zone must be built for agricultural productions. Of course, flood walls or buffer strips or filter must be used to protect agriculture areas from wetlands and vice versa. Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. After agricultural zones, green areas or buffer strips or flood walls must be built to protect settlements from the agriculture areas and river floods. Landslide or erosion measurements must be taken in settlements and the settlements should not relatively be in the low-lying area. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain between river and settlement. This riparian and agricultural management concept prevent flood damages or losses, prevent pollutions, erosion and disasters, increase the water quality, the biodiversity, the fertility and the quality of life, and support sustainable economy, sustainable settlements and public health in the river basins.

Solution 24: The industrial areas that do not bring the distance criteria must be indicated as red alert. Such as red alert industrial facilities that use chemicals are great risks in river basins for the all water resources, fishes, public health, agricultural crops, livestock, other ecosystems and all environments as pollution resource. State or its policies must organize industry settlement plans to

protect environment and move such as industrial facilities to the barren and secure places. State should never allow the industry production except for the designed barren regions. Agro-food industry can be close to agricultural areas but they must be designed well. All industrial facilities must have great water storage and advanced treatment facilities as compulsory. After treatment, those waters must be reused in the industry as washing, process or energy production aims without discharge into natural waters. This concept will prevent extreme water consumption, pollution, drinkable water scarcity, the cost of energy and the cost or the prices of environment problems in some extent.

Solution 25: Erosion measurements must be taken in environmental area to prevent flood, mudflow and landslide, especially when calculated erosion rate is high.

1-When slope is between 3 % and 9 %, contouring can be implemented to reduce soil losses or erosion. The contour ridges will help to slow or stop the downhill flow and reduce soil erosion. Waters will be held in between these contours and create a good soil moisture environment for the crops except for preventing soil erosion.



Figure 5.39. Contour Farming (NRCS New Jersey or USDA).

2-When a slope is too steep and long, contour strip cropping which is alternated in a crop rotation system that practices the growing of a series of different crops in sequenced seasons can be used to prevent soil erosion. Contour strip cropping holds water in the strips or slows the downhill water; therefore, it helps to control run-offs or the floods.



Figure 5.40. Strip cropping along contour lines (UK) (nwrn.eu).

3-Terrace farming can be used in hillsides or mountain terrains.

4-Buffer strips must be used as permanent vegetation which includes grass, trees and shrubs to trap sediments and minimize soil losses, water and wind erosion.

5-Windbreaks can be implemented in edges of fields by planting one or more rows of shrubs or tree to prevent wind erosion and floods.

6-Mulching enriches soils and prevent erosion too. Straws, wood chips or saw dust can be used in the mulching, which helps to minimize evaporation and control weeds.

7-Grassed or vegetated waterways, retention and detention ponds help to prevent erosions.

8-Seeding can be implemented especially in hillsides to prevent erosion.

Solution 26: State must create regional basin management administrations for each region. Settlement council, local administrations, municipalities and regional administration must meet one time in a year and take decisions related with the coordination rules. Everyone must know their duties and responsibilities obviously. Those organizations must be under the communication and contact continuously, especially for abnormalities. Those organizations must meet urgently for emergency events or disasters if there is a need. Law or regulations must determine those procedures; otherwise, coordination problem or response problems against disaster events will appear and increase the losses or damages in regional basins.

Solution 27: Regional authorities must create a regional inspection system and regional emergency action plans or system for all dams in rivers except for the dam's own emergency action

plans against dam failures. Each dam plans must be inspected by independent engineers periodically except for its own operators. All of them must have an early warning plans and an emergency action plans prepared by its own operators. Those plans must be checked by state organizations for minimum every year to prevent possible dam failures.

Solution 28: Evacuation roads, emergency roads, hospitals, emergency gathering places, the location of relief centers, basic needs, emergency needs, the methods of relief material supply, search and rescue teams and equipment needs of those personals, the organization of technical teams or personals except for search and rescue teams, and the emergency route of disaster prevention equipment centers for risky regions must be planned in the scope of emergency action plans before. Periodic exercise or practice upon this emergency is required. Minimum each month must be practiced to improve and mature the response skills against floods or other disasters. Alternative emergency exit roads or routes must be built, especially when flood risk or landslide risks are high. All roads or its routes or bridges upon roads which close to river basin must be shown in a map. Highway dips or low-lying areas must be determined upon this route. Underground tanks must be used to collect floodwaters or rainwaters in such as highway dips or low-lying areas or tunnels or under the bridge. The numbers of grate upon road under the bridges or tunnels must be increased as well. Hospitals or doctors or needs must be prepared both for emergency actions to protect hospitals from disasters and for the possible flood diseases; for example, against the transmission of water borne diseases such as cholera, hepatitis-A, leptospirosis, and typhoid fever, the transmission of vector-borne disease such as dengue, malaria and West Nile fever and the different disaster outbreaks caused by chemicals due to the contaminated or polluted waters that spread to the environment in floods.

Solution 29: Discharge points must be controlled periodically. New discharge points into rivers or fresh waters should never be allowed. Old-ones should be finished with time for the zero discharge into rivers or natural waters. Environment friendly water storage and reused systems with advanced water treatments must be invested, developed and used instead of discharging into rivers or fresh waters as a policy.

Solution 30: Authorities or state organizations with coordination should never allow new settlements or buildings, especially in riparian zone when they do not fulfill the distance parameter. Old ones must be researched continuously by the settlement councils as red alert risks.

Table 5.4. Some hazards or risk identification in coastal settlements.

31-No coastal management council
32-No measurement system
33-No beach nourishment for flood or erosion control and recreational aims
34-No hydro-seeding aesthetic walls and castles
35-No emergency exit routes and signs
36- No lifeguards and their coordination with costal management council or no evacuation staffs
37- No castles behind the hydro seeding walls or green space designed after hydro seeding wall
38-Settlements or buildings or traffic roads between castles and sea.
39- No coastal emergency action plans

Solution 31: When a settlement is a coastal settlement near the sea or ocean, it must create a coastal management council to protect the settlement against tsunami, high tide or coastal floods except for its own settlement council. The staffs must be composed of environmental engineers, oceanographers, aquaculture engineers, meteorological engineers, construction engineers, tidal or wave renewable energy engineers, astronomer, geology engineer, disaster management experts and tsunami protection engineers.

Solution 32: Coastal councils must prepare a measurement or parameter system for the sea or ocean environmental quality, storm surges, tsunami or coastal floods, which must include the measurement of water level rise, high tide for tidal tables, the astronomical observations or changes, the measurements of wave speed, frequencies and amplitude, flow directions and speeds, water temperature, wind speeds and directions, atmospheric pressures changes, rainfall contributions or evaporation losses in the the sea or ocean levels, the measure or observation of geological activities and volcanic activities, to protect coastal areas, create an early warning system and prevent the possible flood or tsunami damages. Tsunami occurs after earthquake, volcanic eruptions and asteroid strike in general. When water level is high due to wind or pressure or astronomical tide, it is a kind of an early warning for coastal flood. Staffs must be ready for a possible coastal flood disaster. When earthquake or volcanic eruption occurs during this high tide or high-water level period, it is inevitable that damages or losses or risks due to tsunami or coastal flood or earthquake will be greater. Earthquake, volcanic eruption and asteroid strikes should be perceived as an early warning system for the close regions; therefore, wavelength values, periods, frequencies, wave speeds, angular frequencies and amplitudes of waves must be recorded continuously and regularly in the fault lines, in waters that include volcanic eruption risks due to the proximity, in the coastal areas or cities, and

a siren early warning system must be developed in coastal areas dependent on those values measured. Observation or values measured must be far away sufficiently from the coastal settlement or locations and be close to the dangerous zone such as fault line or active volcanic mountain in safety position. A network of sensors must be used and values measured in dangerous zone must warn and activate sirens immediately in the shores via remote sensing before hazard reaches to the coastal settlements or shores or beaches. Evacuation plan designed before must be implemented immediately until waves strike to the shores. There is no doubt that such as concepts, implementation or activities planned before the disasters and the hazard will save lives and minimize the losses or damages under the condition of a possible disaster such as earthquake, volcanic eruption, asteroid strike, storm surge, coastal floods and tsunami events.

Solution 33: Beach nourishment must be created from the sea or ocean. 10-15 m beach or sands or sediments can help to combat erosion, offer suitable environment for loggerhead sea turtles and provide swimming areas for people.

Solution 34: Behind the 10 m beach, there must be 3 m hydro-seeding walls and some emergency exit routes such as upstairs among those walls must be built or designed for the evacuation of people to the high grounds in the warning. In high grounds, green spaces, green parks, flowers and tide gates can be designed to divert and collect the excessive salt-flood waters under the coastal flood conditions. Under the tsunami, those hydro seeding walls will not be enough.

Solution 35: Those 3 m high grounds designed behind the beaches must have an emergency tsunami or flood signs or evacuation routes together with siren system as well to direct the people toward higher or protected inland and secure places. Staffs with coordination of councils and its warnings must work in there to evacuate the people. Sea walls or castles in the 5-10 m height dependent on sea or ocean location or risks must be built behind the 3 m walls. Those castles must have an emergency exit routes too.

Solution 36: Life guards must be employed to evacuate the people from shores during tsunami or flood alarm. There must be a planned coordination and communication between warning centers and life guards that are responsible from the evacuation.

Solution 37: For example, tsunami in India Ocean earthquake 2004 reached to mean 9.71 m height in Indonesia; therefore, sea walls or castles in the 5-10 m height dependent on sea or ocean location or risks must be built behind the 3 m walls. İstanbul's castle or walls near sea can be good

example for such as walls. Emergency exits routes must be designed among those walls for the people. Authorities should never allow the roads or highways or the any kind of settlements or building between castles and sea as well. Roads and settlements must be designed the behind of walls or castles. Castles must be restored and be audited continuously. Tidal gates and coastal floodways among the castles can be designed with good protections, which can offer the recreational, the aquaculture and the tidal or wave renewable energy opportunities. Those waters can be used after the advance treatment systems for the settlements in the inside of walls or castle as well. Istanbul's walls or castles are very suitable for such as aquaculture, renewable energy, salt water usages or its implementations.

Solution 38: Authorities should never allow the roads or highways or the any kind of settlements or building between castles and sea as well. Roads and settlements must be designed the behind of walls or castles. Castles must be restored and be audited continuously.

Solution 39: Coastal regions must have a disaster emergency action plan against tsunami, high tides, volcanic eruption, tropical cyclones or cyclone and storms. Coastal cities must have two independent emergency action plans. The first is the emergency action plan prepared by settlement council and the second is the emergency action plan prepared by coastal management council. The location of relief centers and its capacities or the needs such as relief materials and its supply routes must be planned dependent on the settlement population and the tourist potential of settlement. Each coastal city must have an early siren warning system with a remote sensing technology against tsunami or earthquake or volcanic eruptions. People in settlements must be educated about the meaning of the voices of those sirens, which will help to save the lives in coastal settlements. After storm made landfall the threat finishes at coastal region but the risk of flood remains for the inland, and the threat continues as a great flood potential for up to several days later. Inland floods might be described like that. Therefore, coastal management council must warn the central management authorities and possible inland settlement councils about heavy rainfall, strong storms and strong winds and tropical cyclones or hurricanes in coastal areas when managers observe such as abnormal or extreme events. All staffs in inland settlements must be ready to act for this flood warning that comes from coastal regions or coastal management councils. Inland settlements can expose to the areal floods up to several days. Such inland flood risky regions must prepare their agricultural areas so well against floods except for other measures. Subways or rail ways must be protected well against floods or disaster by railway companies as well. Station entrances must be raised, designed and protected well against rain water entrances. Enough pumps, valves, backup power for pumps, flood gates near the risk regions and subway plug must be installed to prevent the floods and interruptions

in the railways or subways. For airports, similar measures can be taken such as adding new pumps, expanding the catchment, raising the lounge entrances, water proofing measures and so on.

Solution 40: Some settlement risks in mountain regions can be volcanic activity, avalanche, snowmelt flood, forest fires and debris flood. Any kind of settlements can never be acceptable in the volcanic active mountains or its regions or zones. Settlements near mountain or hillsides which are exposed to snow so much in the winter times are under the risk of avalanches and snowmelt flow. Settlement must be far away from the hillside or mountain as two times of the heights of mountain minimum to protect the settlement against avalanche, snowmelt flood and debris flood. Sediment traps and green protection walls must be designed toward mountain direction to slow down the speed of avalanche or debris as compulsorily to protect settlements from mountain sides; on the other hand, hillside or mountains must be protected against erosion. All other measurements in settlement against avalanche, snowmelt and debris flood must be taken as well by settlement council. In snow accumulated hillsides or mountains, snows generally accumulate in winter and melt in spring. Those waters can be collected via tanks or channels or flood gates and directed to the special snowmelt collection wetlands or ponds or tanks designed and be used as drinking aims or other usage aims. When mountains or hillside are exposed to fires, settlements which close to those areas must be warned against possible debris floods or mudflow or landslide except for the fire warning immediately. Such as debris warning is a chronic warning in fact so much than acute. Erosion control, seeding and reforestation works must start immediately in burned areas to prevent future debris flood events. When construction works such as building tunnel, mining or dynamite usage occur in such as hillsides or mountains, risks will be so higher for debris flood or landslide or mudflow or avalanche; therefore, distance rule must be increased to the minimum 5 times the height of hillside for settlements from hillside or mountains when a future construction plan is available. Sediment traps and green protection walls toward mountain or hillside must be built as compulsorily to protect the settlements from hillside or mountainside as well by the coordination and the advices of settlement councils.

5.3. Continuous Protection Studies

Continuous protection studies must be carried out by local councils to prevent abnormal events such as violence or looting or discrimination during floods or disaster. Local relief centers and evacuation centers must be designed and planned well for settlements and the numbers of people. Those places must be enough materials to meet the needs of people at same time. Distribution of those materials to the people, especially for the disadvantage groups must be designed well. All protective measures must be taken and implemented not to allow the any kind of violence, the lootings

and the discrimination. Disadvantages groups must be determined and registered well. All measurements must be taken to meet the needs of this people such as toilet needs or healthcare services. Water and food supply or its coordination must be planned well. Enough police and security personals must available to service. All needs, its supply, its foundations, and its distributions to the humans must be coordinated; otherwise, unwanted events are an inevitable result. For example, unequal access to assistance, discrimination in aids, loss of personal documentation, land disputes, enforced relocation, the losses of contacts among family members, no enough water, food, shelter, medical care, toilets, hygiene and the lack of other needs are some of chaos or violence reasons. The governments must create systems continuously to produce life-saving assists and provide it to the humans or victims. All possible obstacles or social, physical and economical barriers to produce those needs must be removed continuously or without stop by state or its organizations. All production system, supply to the centers, distribution to the people, and consumption of people properly must be coordinated well by central, local governmental organizations and settlement councils; otherwise, services will be disrupted for the people, which means chaos or losses or damages in disasters. In 2018 Kerala flood in idduki, India, relief camps looked for such as needs at the bottom according to the webpage of the NEWS Minute. All continuous measures or plans and coordination will protect the lives and health of people in floods or disasters and meet the basic needs of people. When those protection measures are coordinated or implemented well, the probability of chaos or damages or losses or violence or discrimination or loots will be minimum risk.

Search and rescue centers must be built for each settlements and disaster risky regions. Search and rescue teams must be educated and ready always for response against disasters or floods in risky regions. Inflatable boats, rescue ropes, life jackets, life buoys, diving equipment, submersible search lights, medical first response kits, portable engine pumps, water discharge hoses, chainsaws, fuel or gas cans, sandbags, flood barriers, hand tools, lighting or power equipment, mountaineering equipment, rescue helicopters, firefighting equipment, hip boats or waders or water rescue boots, rain suits, whistles, mega phone, other communication equipment, traffic cones and other required materials must be available always in the search and rescue centers to use by search and rescue teams. All of those personals must be trained and educated continuously dependent on search and rescue operation standards to improve their response skills against floods or disasters because personals will protect the lives during floods. All systems created in PPPs need a continuous control to work properly. The controls, inspections, insufficiencies and solutions in those designed system are a continuous protection studies.

Sl No	Essential Materials	Sl No	Essential Food Items
1.	Bed Sheet	1.	Rice (5 kg / 10 kg / 50 kg Pkt)
2.	Blanket	2.	Drinking Water
3.	Towel	3.	Green gram (500gm / 1000gm Pkt)
4.	Lunki / Dothy	4.	Ground Nut (500gm / 1000gm Pkt)
5.	Shirt / T-Shirt	5.	Dhal (500gm / 1000gm Pkt)
6.	Saree	6.	Salt (500gm / 1000gm Pkt)
7.	Nighty	7.	Coconut Oil
8.	Undergarments	8.	Sambar Powder
	Small		
	Medium		
	Large		
9.	Tooth Brush	9.	Turmeric Power
	Small		
	Large		
10.	Tooth Paste	10.	Chilli Powder
11.	Toilet Soap	11.	Coriander Powder
12.	Bucket	12.	Sugar
13.	Mug	13.	Tea Powder
14.	Washing Soap	14.	Biscuit
15.	Washing Powder	15.	Rusk
16.	Dettol / Antiseptic Lotion	16.	Coconut
17.	Torch	17.	Tinned Foods
18.	LED Bulb		
19.	Slippers/Foot wears		
	Children		
	Adults		
20.	Floor Cleaning Lotion		
21.	Sanitary Napkin		
22.	Vicks/Amruthanjan		
23.	Lighter/Matches		
24.	Candles		
25.	Gloves		
26.	Face Mask		
27.	Umbrella/Rain Coat		
28.	Aluminium Pots		
29.	Spoon		
30.	Steel Plates		
31.	Sleeping Mat		

Figure 5.41. List of foods and essentials in 2018 Kerala flood idduki relief camps.

All three PPPs studies must be considered in flood cycles as well.

5.4. Flood Cycle

Three PPPs' findings, listing or characterizations by regional and settlement councils form the flood cycles. Settlement councils must declare an official flood cycle decree for each year and send those decrees to the regional council. Regional council must prepare and declare an official regional flood cycle decree each year too. All decrees are composed of identified risk assessment lists, identified mitigation lists, identified preparedness list and identified response and recovery implementations. Settlement councils must implement its own official decree to the own settlement. Regional councils in the states must implement own decrees to the region. Supplies such as flood equipment, foods, relief materials, search and rescue services, the coordination of health and security services, and early warning announcements and evacuation decisions must be executed or coordinated by the regional councils. The four phases of the flood cycle created by the activities of continuous three PPPs must be implemented in this way;

The components of risk assessment in flood management are hazard identification, risk analysis and risk evaluation shortly. A list of hazard identification, the results of risk analysis and the risk evaluation outputs as components of risk assessment must be added as first phase to the flood cycle decrees, which form the official identified risk assessment list. Authorities identify the risks or hazards in this way and should never allow inappropriate developments in the settlements and regions with continuous controls, re-evaluations and compliance decisions, which is a first flood cycle.

A list of identified mitigation activities that will be implemented against each risks or hazards by councils or authorities must be added as components of mitigation phase to the decrees, which is second phase of flood cycle to eliminate the risks, hazards and the probability of flood or disaster occurrences and reduce the flood or disaster effects. Of course, each mitigation activities must have a clear implementation procedure and obvious fulcrums. All mitigation implements must be recorded regularly and archived well, which will be helpful to illuminate the future management implementations.

A list of identified preparedness programs or plans and their clear procedures that will be implemented by officials must be added to the decrees, which is third phase of flood cycle that helps to save lives, minimize flood damages and improve response systems. Such as plans must be available in this cycle; the plans of emergency exercises or trainings, planning and programming the things such as the leaders, the duties of officials, the emergency personals, their locations, the communication and the contact lists, the plans of warning systems, the plans of transport and logistic supports, the planning and programming of relief centers, in addition the search and rescue centers or their needs or supply systems, the plans of communication system, the plans of educations, public information and guidelines, the clear plans of the implementations of structural or non-structural implementations, the plan of resource inventories and the other identified plans determined by continuous three PPPs.

A list of identified response and recovery activities must be added to the decrees, which is four and last phase of cycle. Immediate assistances and implementations form this phase until all system return to normal. During disaster, system created by managers must assist the people to meet the needs such as transport, initial repair of structures, temporarily emergency or health service, food, temporarily shelters, restoring the life, supporting infrastructures to return to normal, reconstruction and rebuilding activities, temporarily houses. Search and rescue operations, emergency announcements, health and safety education, economic and disaster impact studies, collection of evidences about disaster events, objective flood event reports prepared by settlement council, regional

council and independent flood or disaster managers for the flood event to inform the public, the authorities, the national and international organizations are required as well. If such as things planned well in the preparedness phase, response and recovery will be very successful. B plans for immediate assistance and implantation to response should be prepared for during and after flood activities always to respond and recover well. Different B plans for during flood and post flood can be very helpful to prevent the possible insufficiencies and unexpected events that will hinder the official flood plans designed. Flood management is a long-term effort which requires continuous activities and studies to solve available problems and improve the flood or disaster management. Lessons learned from events and evidences must be recorded and archived continuously and properly as well.

6. FLOOD RISK PREDICTIONS IN THE REGIONS OF TURKEY

AFRF as milimeter can be calculated from the comparison of precipitation and elevation. When elevation is low and precipitation is high, flood risks are high in the region. Eq.4.29 shows how this risk factor can be calculated. If there is no information of minimum elevation and maximum precipitation in the region, average precipitation and elevation values can be used in eq.4.29. When AFRF is divided by 21.9, EFR as daily base is obtained as unitless which show the ranking of flood risks in the regions or in a country. EFR and AFRF do not take consideration the availability of flood prevention infrastructures and water resources such as lake, rivers and seas in the region; however, no doubt that flood infrastructure in the region minimizes flood risks while water resources increases the flood risks; therefore, both balances each other and supports the factor and the ratio. If EFR is high in the regions or cities of the country, flood risks are high as directly proportional in there and the protective priorities must be given to such as places. Countries' sub-regions and cities in the regions can be ranked and warned early related with flood risks by those equations at bottom. To calculate the risk values in the cities of regions, eq.4.29 and eq.4.30 were used through precipitation and elevation values of the cities in the regions.

$$AFRF = |(Average\ Yearly\ Prec/1,000 - Average\ Elev.)| \times (Max.\ daily.\ Prec./\ Min.\ Elev) \quad (4.29)$$

When average yearly precipitation is between 2,000 and 2,999, the result at eq.4.29 will be multiplied by five. When it is between 3,000 and 3,999, the result at eq.4.29 will be multiplied by twenty-five. Multiply value is an assumption that comes from 5^{n-1} roughly. The value of n is a first interval range coefficient of precipitation value, which is assumed as 1 for less than 500- 1,999 mm average yearly rainfall roughly, as approximately 2 between 2,000-2,999 mm yearly rainfall but exact number of interval coefficient can be calculated and determined through different methods due to being a kind of assumption).

$$EFR = \left| \frac{Average\ Yearly\ Prec/1000 - Average\ Elev. \times (Max.Daily\ Prec./\ Min.Elev.x1000)}{21.9} \right| = \frac{AFRF}{21.9} \quad (4.30)$$

Observations show that population density in a place together with precipitation and elevation is directly proportional to flood effects per person. The study explained how to calculate AFRF and EFR at eq.4.29 and eq.4.30 respectively. Flood Rainy Effect Risk Ratio (FRERR) which shows the probable effect of actual rain precipitation can be calculated from eq.4.37. The unit of population

density at the equation is people per km².

$$\text{FRERR} = \left[\frac{\text{AFRF} \times \text{Population density} \times \text{actual hourly prec.} \times 8760}{\text{EFR} \times 10^6 \times \text{Average yearly prec.}} \right] \times a \times b \quad (4.37)$$

Table 6.1. FRERR Rainfall Coefficients.

Average Yearly Precipitation, mm	FRERR and RFEP Rainfall Coefficients; a value at eq.4.37 and at eq.6.1
0-999	1
1000-1250	2
1250-1500	3
1500-1750	4
1750-2000	5
2000-2250	6
2250-2500	7
2500-2750	8
2750-3000	9
3000-3250	10

Table 6.2. FRERR Maximum Snow Height Coefficients.

Observed Maximum Snow Height, cm	FRERR and RFEP Maximum Snow Height Coefficients; b values at eq.4.37 and at eq.6.1
0-99	1
100-149	2
150-199	3
200-249	4
250-299	5
300-349	6
350-399	7
400-449	8
450-499	9
500-549	10

After the calculation of each sub-region's FRERR values, the total value must be calculated to find the flood effect percentages (FEP), which shows the rank percentage flood effects of sub-regions or cities related with FRERR. Probable effect regions can be shown with this way dependent on eq.4.37. Relative Flood Percent (RFEP) for the sub regions or locations must be calculated from eq.6.1, which ranks the sub-regions related with flood effects. The factor includes the contributions of AFRF, EFR, actual precipitation, FRERR, and population.

$$RFEP = \left[\frac{AFRF \times EFR \times population}{(actual\ precip.)^2 \times FRERR \times 10^4} \right] \times a \times b \quad (6.1)$$

$$\text{Average Ranking Percentage Points} = \frac{RFEP + FEP}{2} \quad (6.2)$$

6.1. Marmara Region Flood Risk Rankings

When the data such as precipitation, maximum daily precipitations, elevations, population and population densities are used in eq.4.29, eq.4.30, eq.4.37 and eq.6.1 in the Table 6.3 and Table 6.4, the flood risks rankings of cities in Marmara region can be determined.

Table 6.3. Flash Flood City Risk Rankings in Marmara dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Maximum Daily Prec. mm	Average Elevation m	AFRF mm	EFR	Population	Pop. Dens. per km ²	FRERR for 60 mm rain/hour Person
1.	Bursa	706.9	200.9	155	199.98	9.13	2,994,521	275	4.48
2.	Yalova	741.0	181.9	3	136.97	6.26	262,234	309	4.80
3.	Tekirdağ	581.8	140.1	10	131.96	6.03	1,029,927	162	2.51
4.	Balıkesir	583.0	130.0	120	129.37	5.91	1,226,275	86	1.70
5.	İstanbul	817.4	128.9	120	128.02	5.85	15,067,724	2836	39.91
6.	Kırklareli	573.6	128.3	209	127.95	5.84	360,860	57	1.14
7.	Sakarya	838.3	127.7	31	124.25	5.68	1,010,700	207	2.84
8.	Kocaeli	813.0	169.4	3	123.50	5.64	1,906,000	526	7.45
9.	Çanakkale	616.3	137.8	5	120.81	5.52	540,662	54	1.00
10.	Edirne	605.0	110.0	42	108.42	4.95	411,528	67	1.27
11.	Bilecik	452.3	92.0	620	91.93	4.20	223,448	52	1.32
Avr.	Marmara	666.2	140.6	119.8	129.37	5.91	25,033,879	421	6.22

*EFR values in the table must be multiplied by 10⁻³ to find exact EFR value.

The results of AFRF and EFR determined the rankings in Table 6.3 without population or population density parameters. FRERR values were calculated in table as well via AFRF, EFR, population density and an assumption of 60 mm/h rainfall to rank the cities in Table 6.4 related with the flood effects rely on the population, population density factor.

Table 6.4 shows the flood effect percent of cities in Marmara region dependent on population, population density and 60 mm/h rainfall. When AFRF value is equal or greater than 110 in a city or sub regions, the city is a flood prone city climatically. When this value is high, it shows unstable climate for flood events. The cities that AFRF is equal or greater than 110 in Table 6.3 are Bursa, Yalova, Tekirdağ, Balıkesir, İstanbul, Kırklareli, Sakarya, Kocaeli, and Çanakkale. They will be under the flood risk so much from unpredicted or sudden developed flash floods mostly due to geographical characteristics and precipitation values in Marmara Region. The EFR values that are equal or greater than 5.00 in Table 6.1 are same cities too, no new city will be added to the list.

Table 6.4. Flash Flood City Disaster Effect Rankings in Marmara Region.

Rank	City	FRERR for 60 mm rain /hour Person	FEP %	RFEP %	Average Ranking Percentage Points
1.	İstanbul	39.91	58.3	7.85	33.08
2.	Kocaeli	7.45	10.9	4.95	7.93
3.	Yalova	4.80	7.0	1.30	4.15
4.	Bursa	4.48	6.5	33.9	20.2
5.	Sakarya	2.84	4.2	6.98	5.59
6.	Tekirdağ	2.51	3.7	7.00	5.35
7.	Balıkesir	1.70	2.45	15.32	8.89
8.	Bilecik	1.32	1.9	8.63	5.27
9.	Edirne	1.27	1.85	4.83	3.34
10.	Kırklareli	1.14	1.7	6.57	4.14
11.	Çanakkale	1.00	1.5	10.00	5.75
Total	Marmara	68.42	100		

The cities that FRERR value are greater than 2.00 in Table 6.4 are İstanbul, Kocaeli, Yalova, Bursa, Sakarya and Tekirdağ, which are mostly risky cities in Marmara region related with deaths. The cities such as Bursa, İstanbul Balıkesir and Çanakkale which FEP or RFEP or Average

percentage value are equal or greater than 10 enter to the list of the mostly affected cities as well. Bilecik will be added to the highly flash flood risky cities because average ranking points of Bilecik is higher than the average ranking points of Kırklareli. There are 10 highly flash flood risky cities in Marmara Region. Those cities can be ranked like that respectively;

1-İstanbul	33.08	6-Sakarya	5.59
2-Bursa	20.02	7-Tekirdağ	5.35
3-Balıkesir	8.89	8-Bilecik	5.27
4-Kocaeli	7.93	9-Yalova	4.15
5-Çanakkale	5.75	10-Kırklareli	4.14

According to the findings, all cities in Marmara region are high risk flash flood prone cities except for Edirne. This finding list does not come to meanings that Edirne except for high risky cities in Marmara is not under the flood disaster threats. Such as places can be threatened via riverine and snowmelt flood owing to remaining around the confluence of natural waters and mountains. Such as cities must give importance to the riverine flood protections or consideration in river basin management plans except for flash flood measures even if they are in the low ranks; however, the cities in high ranks must give importance to sustainable city plans and its implementations immediately to minimize the high disaster risks or effects determined. Some flood news from Turkish press services and advices related with the cities in Marmara region are like that;

İstanbul

- İstanbul's flood Disaster in 2009: 31 Deaths, 9 losses,
<http://www.hurriyet.com.tr/gundem/istanbulda-sel-felaketi-31-olu-12441217>
- 'Infrastructure' disaster, not flood in İstanbul,
http://www.cumhuriyet.com.tr/haber/turkiye/96421/istanbul_da_sel_degil_altyapi_felaketi.html
- Unbelievable images in İstanbul 2017 Flood,
<http://www.milliyet.com.tr/son-dakika-istanbul-da-saganak-gundem-2492144/>
- İstanbul 2018 Flood,
<https://www.sozcu.com.tr/2018/gundem/istanbulu-sel-aldi-2-2620807/>
- Metro trips stopped between Yenikapı and Bayrampaşa stations,
<https://www.haberturk.com/son-dakika-istanbul-da-metro-seferlerine-yagis-engeli-2074927>

Advice 1: Road maintenances seem inadequate in İstanbul. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Flood insurance and periodic waterproofing in basement or ground floors must be compulsory in the districts affected by floods such as Halkalı, İkitelli, Güneşli, Silivri, Çatalca, Sultangazi, Arnavutköy, Bağcılar, Esenler, Eyüp, Bahçelievler, Küçükçekmece, Büyükçekmece, Ümraniye, Ataşehir, Başakşehir, Beylikdüzü, Hadımköy, Gaziosmanpaşa, Aksaray, Bakırköy, Ataköy, Şişli and Üsküdar. Green solutions such as swales, green roofs, green walls, retention ponds and detention ponds must be implemented especially in such as districts and in the parking lots or truck parking areas. Creeks and settlements near the flows such as creeks or rivers or lakes must be checked, rehabilitated and protected well as red alerts. Settlement councils must be created for each district. Relief and evacuation centers are required. Industrial facilities must be moved to planned remote areas which are far to rivers or fresh waters and settlements. The waters of industry must be reused in industry after advance treatments instead of discharging into fresh waters or environment.

Advice 3: Subways or rail ways must be protected well against floods or disaster by railway companies. Station entrances must be raised, designed and protected well against rain water entrances. Enough pumps, valves, backup power for pumps, flood gates near the risky places and subway plug must be installed to prevent the floods or the interruptions in the railways or subways.

Advice 4: İstanbul is an earthquake prone city. All measurements must be taken against earthquake continuously. Earthquake can create tsunami in İstanbul's shores or coastal areas. Early warning and siren system must be built by coastal councils against earthquake and Tsunami. When it occurs, roads near shores will be affected mostly. İstanbul's historical walls are a kind of water diversion systems and protection walls against Tsunami. They must be protected, restored and maintained well. According to Turkish State Meteorological Service, Maximum wind speed observed in İstanbul is 113.4 km/h in 1970, which shows wave height can reach the 11.5 m height in sea as violent storm in Beaufort scale.

Kocaeli

- İzmit Flood 2013,

<http://www.kocaelihaberci.com/izmit-sele-teslim-h4026.html>

- Flood paralyzed the life in Kocaeli 2014,

<https://www.haberturk.com/video/haber/izle/kocaelinde-sel-hayati-felc-etti/127900>

- Flood Victim Kocaeli 2017,

<http://www.sozkocaeli.com/gundem/kocaeli-sel-magduru-h14523.html>

- Kocaeli's Flood Disaster- Many people stranded 2018,

<http://www.hurriyet.com.tr/gundem/kocaelide-8-kisi-selde-kayboldu-40910836>

- Landslide in Gölcük 2018,

<https://www.haberturk.com/kocaeli-haberleri/65552104-golcukte-heyelan-yol-kapandi-elektrik-telleri-koptu>

Advice 1: After extreme hot weathers, heavy rains must be expected; therefore, channels must be controlled, cleaned and water volume decreased in the sewage and rainwater systems before rain season start. 2013 floods show that Kocaeli is a red alert city dependent on Anil imperial color system because 41.4 mm which is less than 60 mm damaged the city. Sewage and rainwater collection system must be designed or ready to collect the rainfall amount of 200 mm/h minimum.

Advice 2: Flood insurance and periodic waterproofing must be compulsory for basements or ground floors in Kocaeli. Municipalities must apply the green solutions. Industry waters must be managed well because it is great possibility to mix with flood waters. The road maintenances seem inadequate in Kocaeli. Bridges must be controlled periodically against the collapsing. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 3: All measurements against landslides must be taken in İzmit and Gölcük because the city is prone to landslide. Tunnel constructions sites or dynamite usage during construction, and mining areas must be determined in the city. Erosion measurements, settlement protection and sediment traps must be implemented in such as locations to prevent possible landslides. Relief and evacuation centers are required.

Advice 4: Snow accumulation must be controlled in Samanlı Mountain because snowmelt floods can be occurred. Snow height in Kocaeli was 90 cm in 1929 according to Turkish State Meteorological Service. Settlements must be protected against mountains or the snowmelt waters which will accelerate and affect districts such as Kartepe in Kocaeli. Such as snowmelt flood contributions can be observed in spring and summer months during rains in districts that close to

Samanlı Mountain.

Advice 5: 1999 Earthquake is a proof that Kocaeli is an earthquake prone city. All measurements must be taken against earthquake continuously. Earthquake can create landslides and tsunami in Kocaeli's shores or coastal areas. Coastal parameters must be measured. Early warning and siren system must be built by coastal councils against earthquake and Tsunami. When it occurs, roads and industrial facilities near shores will be affected negatively. Except for this, maximum wind speed observed in Kocaeli is 126 km/h in 1973 according to Turkish State Meteorological Service, which shows the wave heights can reach the 14.5 m height in sea as hurricane in Beaufort scale. This wind speed is category 1 in Saffir Simpson scale and storm surges can affect the city negatively in this wind speed. City or structures or buildings in city must be prepared against category 2 hurricane to protect city against high wind damages and storm surges.

Yalova

- 4 children lost their lives, 2009 Yalova Flood,
https://www.takvim.com.tr/yasam/2009/11/02/4_cocugu_sel_alDI
- One hour rain paralyzed Yalova, 2012
<https://www.haberturk.com/gundem/haber/757365-1-saatlik-yagmur-yalovayi-felc-etti>
- Gale and Heavy precipitation in Yalova, 2015,
<https://www.sabah.com.tr/yalova/2015/05/07/yalovada-firtina-ve-saganak-yagIs>
- Yalova Flood 2017,
<https://www.cnnturk.com/video/turkiye/yalovayi-sel-alDI>
- Yalova flooded within 30 minutes, 2018,
<https://www.cnnturk.com/video/turkiye/yalova-30-dakikada-sele-teslim-oldu>

Advice 1: Bridges must be controlled periodically against the collapsing; otherwise, death events can occur. Yalova is prone to flash flooding. Within one-hour, everywhere can be flooded due to low elevation. Sewage and rainwater system must be designed or ready to collect the rainfall amount of 200 mm/h minimum. Channels must be controlled, cleaned and water volume decreased in the sewage and rainwater systems periodically dependent on Table 4.10 to prevent the clogs and floods before rain season started.

Advice 2: Flood insurance and periodically water proofing must be compulsory, especially for the basements or ground floors in Yalova.

Advice 3: It can be stated that city resistance against high winds such as violent storms or hurricane is extremely weak. Maximum wind speed observed in Yalova is 82.1 km/h in 1989 according to Turkish State Meteorological Service, which is gale level in Beaufort scale but even lower wind speeds than this gale level in 2015 became enough to uproot dozens of trees in Yalova. Elevation is very low in this city and an earthquake prone city. Storm surges and coastal floods will be observed when this wind speed record is broken; therefore, the city must be prepared to the violent storm level as minimum and category 1 maximum. Earthquake can create tsunami and lead to coastal floods in Yalova as well. Coastal parameters must be measured continuously. Early warning and siren system must be built by coastal councils against earthquake and Tsunami. When it occurs, roads and buildings near shores will be dragged and destroyed. Relief and evacuation centers are required.

Advice 4: Samanlı Mountain can affect Yalova city as well by snowmelt floods because of remaining in low elevation. The roofs of buildings in Yalova must be green roofs. Municipality must encourage the construction sectors to the green roofs and green-walls.

Bursa

- Flood caused to a death, school cancelled, 2010,
https://www.sabah.com.tr/yasam/2010/10/14/bursada_okullar_tatil?paging=false
- Bursa flooded in summer month due to water release from dam, 2013
<https://www.turkiyegazetesi.com.tr/yasam/42019.aspx>
- Flood demolished the bridge in Bursaa, 2014,
http://www.cumhuriyet.com.tr/haber/turkiye/124489/Bursa_da_sel_kopruyu_yikti.html
- Bursa remained under water, flood dragged the paving Stones,
<http://www.bursadabugun.com/haber/bursa-sular-altinda-sel-kaldirim-taslarini-surukledi-455350.html>
- Heavy rain captured the Bursa, 2018.
<https://www.sozcu.com.tr/2018/gundem/bursayi-su-basti-sel-kamyonu-surukledi-2429929/>

Advice 1: Sewage and rainwater system must be designed or ready to collect the rainfall amount of 250 mm/h minimum. Channels must be controlled, cleaned and water volume decreased in the sewage and rainwater systems periodically dependent on Table 4.10 to prevent the clogs and floods before water release from dam and rain season start.

Advice 2: Public must be informed related with water release from dams. Roads that close to dams must be closed before the releases. All measurements must be taken in channels and waterways against possible clogging. All measurements must be taken in agricultural areas against floods before release. Agricultural area or livestock owners must be informed with possible water release from dam. Agricultural areas and livestock region designed must be protected by sandbags or inflatable flood defense barriers and sediment traps. Schools and hospitals must be protected well and ready during releases. Sediment traps must be used to protect settlements from dam failure or water releases. Settlements and agricultural areas that close to dam must be always ready against failure or water releases from dams. A siren system must be designed to warn the flood release for people around. Officials must evacuate the people from possible affected regions. Settlement councils that determined the disadvantages groups must implement all special measurements they designed for those risky groups. Regional authorities must create a regional inspection system and regional emergency action plans or system for all dams in rivers except for the dam's own emergency action plans against dam failures. Each one must be inspected by independent engineers periodically except for its own operators. All of them must have an early warning plans and an emergency action plans prepared by its own operators. Those plans must be checked by state organizations for minimum every year to prevent possible dam failures. Relief and evacuation centers are required.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again

Advice 4: Bridges must be controlled periodically against the collapsing; otherwise, death events can occur. Bursa is a red alert city dependent on Anil imperial color system because even 24 mm rain lead to damages or floods in the city. Measurements must be taken in railways or metro.

Advice 5: Snow height in Bursa was 80 cm in 1942 according to Turkish State Meteorological Service. Samanlı Mountain and Uludağ can cause to snowmelt floods in Bursa. Snow accumulation must be observed, especially in winter-times and measurements be taken for the close settlements or roads against floods or landslides. Bursa is a landslide prone city in Marmara as well.

Advice 6: Bursa is an earthquake prone city at same time because the city is in the confluence zone of North Anatolian Fault lines, which can create tsunami and coastal floods in city after an earthquake; therefore, coastal council must prepare the city to the such as disasters. Maximum wind speed observed in Bursa is 126.7 km/h according to Turkish State Meteorological Service, which shows category 1 hurricane occurred in the city in 1963 so the city must be ready for category 2 level always, which can increase the sea level to more than 11.5 m height and create storm surges in shores of Bursa.

Sakarya

- 14.000 decares of cultivated fields damaged, 2012,
<https://www.haberler.com/sakarya-da-sel-ve-dolunun-bilancosu-14-bin-dekar-3642059-haberi/>
- One person is missing in Sakarya flood, 2014,
<https://www.sabah.com.tr/yasam/2014/06/06/sakaryada-sel-1-kisi-kayip?paging=false>
- Flood in Sakarya caused to deaths, 2015
<http://www.milliyet.com.tr/sakarya-da-sel-can-aldi-gundem-2078322/>
- Sakarya flood disaster-Agricultural areas remained under water, 2017.
<https://www.aksam.com.tr/yasam/sakaryada-sel-felaketi-tarim-arazileri-sular-altinda-kaldi/haber-635529>
- Flood struck the Sakarya, Kaynarca Mayor: The situation is desperate, 2018.
<https://www.haberturk.com/son-dakika-sakarya-yi-sel-vurdu-2162572>

Advice 1: Bridges must be controlled periodically against disasters. Landslide potential is high in Sakarya like Kocaeli and Bursa. Sakarya river basin must be managed well by regional authorities because the numbers of floods are very high maybe number one as river basin in Turkey. For example, according to General Directorate of State Hydraulic works (DSİ) 's I. National Flood Symposium book, the number of floods between 1970 and 2005 in Sakarya river basin was 114, which was highest in Turkey. Death numbers were 19 during this period, which means Sakarya river basin needs to be planned well.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantaged groups for possible disasters. Relief and evacuation centers are required. Industrial facilities must be organized in remote area which is far from natural water resources as well, not near the highways.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again.

Advice 4: Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors in Sakarya.

Advice 5: Sakarya is in the earthquake zone but no tsunami risk from Marmara Sea. Storm surges can be in the Black sea shores as well. Maximum wind speed is 97.6 km/h, which means that water height can reach 9.0 m

Advice 6: Road maintenances seem inadequate. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Tekirdağ

- Flood Disaster Images in Tekirdağ, 2009,
https://www.sabah.com.tr/yasam/2009/09/08/tekirdagdan_sel_felaketi_goruntuleri
- Flood in Tekirdağ 2011,

<http://www.milliyet.com.tr/tekirdag-i-sel-aldi--gundem-1441812/>

- Unbeliveable images in Tekirdağ, 2012

<https://www.haberturk.com/gundem/haber/787640-tekirdagda-akilalmaz-goruntuler>

- A soldier martyred in Tekirdağ Flood 2017,

<https://www.haberler.com/flas-10172681-haberi/>

- Citizens' camera recorded the flood disaster in Tekirdağ, 2018.

<https://www.haberler.com/tekirdag-daki-sel-felaketi-vatandas-kamerasinda-10994782-haberi/>

Advice 1: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups against possible disasters. Relief and evacuation centers are required. Saray is red alert district in the city, which needs riparian areas in Ergene River via quality river basin management plans and green solutions in the buildings.

Advice 2: Road maintenances seem inadequate in city. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 3: Tekirdağ can be affected from tsunami after a high magnitude earthquake as well. Maximum wind speed observed in the city was 150.1 km/h in 2012 which is category 1 level that is very close to category 2 and water height in sea can exceed the 14.5 m in this category. Therefore, coastal council and disaster managers must prepare the city against category 2 to prevent the storm surges in city. Tekirdağ needs green areas and forests so much because forest density seems very low as well.

Balıkesir:

- One death-Flood in Burhaniye, 2012,

<https://www.turkiyegazetesi.com.tr/marmara/28752.aspx>

- Flood Disaster in Balıkkeseir, 2013,

<https://www.takvim.com.tr/guncel/2013/03/10/balikesirde-sel-felaketi>

- Floods in Ayvalık, 2016,

<http://www.hurriyet.com.tr/ayvalik-sel-sularina-teslim-oldu-4-40291986>

- Flood dragged vehicles in Burhaniye,2017,
<http://www.hurriyet.com.tr/burhaniyede-sel-araclari-surukledi-40524007>
- Flood in Bandırma,2018,
http://www.cumhuriyet.com.tr/video/video/1082318/Bandirma_da_sel.html

Advice 1: Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Susurluk river basin must be planned and managed well by regional authorities. Close settlements to the rivers in Susurluk basin must be protected well. Relief and evacuation centers are required.

Advice 3: Balıkesir can be affected from tsunami after a high magnitude earthquake as well. Maximum wind speed observed in the city was 103 km/h in 1966 which is violent storm level and water height in sea can reach the 11.5 m in the Beaufort scale. Therefore, coastal council and disaster managers must prepare the city against violent storm level and maybe category 1 to prevent the storm surges in the city.

Bilecik:

- Flood paralyzed the life in Bilecik, 2018.
<https://www.sozcu.com.tr/2018/gundem/bilecikte-sel-hayati-felc-etti-2629072/>

Advice 1: Bilecik is a mountainous city so elevation is high. Snowmelt flood can occur; therefore, snow accumulation must be followed well. Maximum snow height was 80 cm in 2015.

Advice 2: The length of Sakarya River in Bilecik is approximately 75 km. River and close cities must be protected well against possible riverine floods. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum.

Edirne:

- Century's disaster in Edirne, 2015.

<http://www.hurriyet.com.tr/gundem/edirnede-yuz-yilin-felaketi-28104747>

- Flood in Edirne: one missing, 2018.

<https://www.haberturk.com/edirne-haberleri/65008711-edirnede-sel-1-kisi-kayip>

Advice 1: Meriç-Ergene river basin area must be controlled and managed well; otherwise, crops and live-stocks can be exposed to damage. Agricultural protection measurements against flood disasters are required in the city so much. Riparian areas must be created between river and agricultural areas. Industrial facilities must be organized in remote area that is far from natural water resources, which will prevent water pollution and floods.

Advice 2: Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups for possible disasters.

Advice 3: High magnitude earthquake from Saros Bay can affect the Aegean shores of Edirne. Coastal council must protect the Aegean shores of the city against earthquake and tsunami. Maximum wind speed observed in the city is 104 km/h in 1970, which is violent storm level and water height can reach 11.5 m in Beaufort scale. Edirne needs green areas and forests because forest density seems low, which might cause to debris flood.

Kırklareli

- Flood in Vize, 2006,

<http://www.gazetevatan.com/vize-de-de-sel-baskini-81229-gundem/>

- 3 deaths in Lüleburgaz, 2012,

<https://www.haberturk.com/gundem/haber/787767-luleburgazda-sel-3-can-aldi>

- Flood in Dereköy, 2013,

<http://www.marmarahaber.com.tr/haber/18709/kirklarelinde-sel-baskini.html>

Advice 1: Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups for possible disasters. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be

built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Meriç-Ergene river basin area must be controlled and managed well; otherwise, crops and live-stocks can be exposed to damage. Agricultural protection measurements against flood disasters are required in the city so much. Riparian areas must be created between river and agricultural areas. Industrial facilities must be organized in remote area that is far from natural water resources, which will prevent water pollution and floods. Yıldız Mountains might create snowmelt flood. Maximum wind speed observed in the city is 123.8 km/h in 1972, which is category 1 level in Saffir-Simpson scale and water height can exceed 14.5 m in Beaufort scale; therefore, black sea shores of Kırklareli can be affected from storm surges. Coastal council must prepare the city against category 2 level. Relief and evacuation centers are required.

Çanakkale

- Flood in Gökçeada, 2014,
http://www.cumhuriyet.com.tr/haber/turkiye/67259/Gokceada_da_sel_felaketi.html
- Midnight flood disaster in Çanakkale, 2017,
<https://www.sabah.com.tr/fotohaber/yasam/canakkalede-gece-yarisi-sel-felaketi/10>
- Flood swallowed the vehicles, 2018.
<https://www.haberturk.com/canakkale-de-sel-araclari-yuttu-2025766>

Advice 1: Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups for possible disasters. Relief and evacuation centers are required. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Maximum wind speed observed in the city is 139.3 km/h in 1991, which is category 1 level in Saffir Simpson and water level can exceed 14.5 m in Beaufort scale; therefore, Marmara Sea and Aegean shores of Çanakkale can be affected from storm surges. Coastal council must prepare the city against category 2 level. Çanakkale is an earthquake prone city as well, which can be exposed to tsunami, especially in Gelibolu from Marmara Sea and Aegean Sea parts together. Early warning system against storm surges and tsunami must be created in the city. Shores of city must be protected

well by coastal councils. Erosion control measurements such as seeding and afforestation, especially in mountain region are required. Çanakkale will be prone to debris flood when measurements are not taken. Forest fires in Çanakkale are a threat for future debris flood disaster as well.

6.2. Aegean Region Flood Risk Rankings

Table 6.5. Flash Flood City Risk Rankings in Aegean dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Maximum Daily Prec. mm	Average Elevation m	AFRF mm	EFR	Population	Pop. Dens. per km ²	FRERR for 60 mm rain/hour Person
1.	Muğla	1194.1	183.0	646	182.66	8.34	983,219	75	1.45
2.	Manisa	727.8	163.5	42	160.67	7.34	1,429,643	108	1.71
3.	İzmir	697.0	145.3	25	141.25	6.45	4,320,519	360	5.95
4.	Denizli	563.7	105.6	450	105.47	4.82	1,027,782	87	1.78
5.	Aydın	646.0	93.8	597	93.70	4.28	1,097,746	138	2.46
6.	Kütahya	558.0	92.2	969	92.15	4.21	577,941	48	0.99
7.	Afyon	438.4	79.2	1013	79.17	3.61	725,568	49	1.29
8.	Uşak	547.3	64.3	921	64.26	2.93	367,514	68	1.43
Avr.	Aegean	671.2	115.9	582.9	114.92	5.25	10,529,932	116.6	2.13

*EFR values in the table must be multiplied by 10^{-3} to find exact EFR value.

Table 6.5 shows that the cities that AFRF value is equal or greater than 110 are Muğla, Manisa and İzmir. They will be under the unpredicted or sudden developed flash floods mostly in Aegean region. The EFR values that are equal or greater than 5.00 in Table 6.5 are same cities too, no new city will be added to the list.

Table 6.6. Flash Flood City Disaster Effect Rankings in Aegean Region.

Rank	City	FRERR for 60 mm rain/hour Person/mm	FEP %	RFEP %	Average Ranking Percentage Points
1.	İzmir	5.95	34.88	18.40	26.64
2.	Aydın	2.46	14.42	4.97	9.70
3.	Denizli	1.78	10.43	8.15	9.29

4.	Manisa	1.71	10.02	27.39	18.71
5.	Muğla	1.45	8.50	57.39	32.94
6.	Uşak	1.43	8.38	1.34	4.86
7.	Afyon	1.29	7.56	4.47	6.02
8.	Kütahya	0.99	5.81	6.29	6.05
Total	Aegean	17.06	100		

The cities that FRER value are greater than 2.00 in Table 6.6 are İzmir and Aydın which are mostly affected cities in Aegean region; therefore, Aydın enters to this list due to FRER is 2.46, which is greater than 2. İzmir, Manisa and Muğla was already in the list due to AFRF values. The cities that FEP is equal or greater than 10 are İzmir, Aydın, Denizli and Manisa. Denizli will be added to the highly flash flood risky list because FEP value is 10.00. There are 5 highly flash flood risky cities in Aegean Region which can be ranked like that;

1-Muğla	32.94
2-İzmir	26.64
3-Manisa	18.71
4-Aydın	9.70
5-Denizli	9.29

Some flood news from Turkish press services and advices related with the cities are like that;

Muğla

- Flood in Bodrum,2012,
<https://www.ntv.com.tr/turkiye/bodrumu-sel-aldi,1aP4YyYPvEuu0q1NbxFQJA>
- Flood struck the Bodrum, 2015,
<http://www.hurriyet.com.tr/gundem/bodrumu-sel-vurdu-30142019>
- Flood in Bodrum,2017,
<https://www.sabah.com.tr/yasam/2017/03/09/bodrumu-sel-vurdu>
- Flood caused death and missing in Muğla, 2018,
<https://www.cnnturk.com/video/turkiye/muglada-sel-can-aldi>
- Heavy rain caused flood in Bodrum,2018,
<https://www.cnnturk.com/video/turkiye/bodrumda-kuvvetli-saganak-sele-neden-oldu>

Advice 1: Road maintenances seem inadequate in Muğla. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall

amount of 200 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Electric poles must be maintained and be resistance against floods and minimum 119.2 km/h wind speed.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors in Muğla. Muğla is an earthquake prone city which means the city can exposed to tsunami. Category 1 hurricane in Saffir Simpson scale can be observed in the city, which means sea level can exceed 14.5 m when the wind speed reaches this category 1 level. Therefore, coastal council must prepare the city against storm surges and tsunamis

Advice 3: Menteşe Mountain and other mountains in Muğla can create snow-melt floods because the city is mountainous area. Many spring floods in Muğla may be about snowmelt flood or its contributions from the mountains. For example, Menteşe Mountain which is located in the south of Büyük Menderes basin and Akdağlar can lead to snowmelt floods and increase water level or speed in streams. Dalaman stream, Eşen, Namman, the tributaries of Büyük Menderes such as Sarıçay, varvil çayı, Çine Suyu and Akçay in Muğla must be observed continuously and planned well in Muğla, which has yearly 1194.1 mm precipitation as number one in Aeagean region.

Manisa:

- Flood in Manisa,2005,
<https://www.tgrthaber.com.tr/haber/273834.html>
- Flood in Manisa: one child death and two children missing, 2006,
<https://www.haberler.com/manisa-manisa-da-sel-felaketi-1-cocuk-oldu-2-haberi/>
- A child drowned in Manisa flood 2014,
<https://www.cnnturk.com/haber/turkiye/denizli-aydin-yolu-sele-teslim>
- Flood in Manisa,2018,
<http://www.manisahaberleri.com/manisa/son-yillarin-en-buyuk-sel-felaketi-h85538.html>
- Flood in Manisa,2019,
<https://www.haberturk.com/manisa-haberleri/66041602-manisada-metrekareye-203-kilogram-yagis-dustusel-felaketi-nedeniyle-yaklasik-180-kisi>

Advice 1: Road maintenances seem inadequate in Manisa. Landslide events can occur; therefore, roads must be maintained well and periodically. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 200 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups for possible disasters. Relief and evacuation centers are required. Erosion measurements must be taken. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors in Manisa.

Advice 3: Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Manisa has no coast but inland floods can occur from Izmir direction. Maximum wind speed observed in Manisa is 137.9 km/h, which is category 1 level. Manisa has Manisa Mountains, Demirci, Yunt Mountains, Çal Mountain and Bozdağlar; therefore, they must be observed against snowmelt floods or its contributions to rivers. Kula volcanic mountains must be observed. To control food events, Gediz River and its basin, Bakır stream, Derbent stream, Kum stream and Nif stream must be observed and managed well in Manisa, which has yearly 727.8 mm precipitation.

İzmir

- One death and five missing, 2001,
<http://www.hurriyet.com.tr/gundem/sel-1-can-aldi-5-kisi-kayip-43240>
- Flood in İzmir, 2014,
<https://www.ensonhaber.com/izmirde-sel-felaketi-1-olu-2014-08-07.html>
- Flood in İzmir, 2015,
<https://www.ensonhaber.com/izmirde-sel-felaketi-1-olu-2014-08-07.html>
- The city remained under the floodwaters. Even vehicles dragged in İzmir, 2017,
<http://www.milliyet.com.tr/izmir-de-sokaklar-dereye-dondu-gundem-2459099/>
- Flood in İzmir, 2019

<https://www.sozcu.com.tr/2019/gundem/izmirde-sel-karayolu-kapandi-mahsur-kalanlar-var-3079892/>

Advice 1: In 1995 İzmir flood disaster, death number was 65, which shows the city is prone to flood disaster. FRERR value in İzmir is 5.95 for 60 mm rainfall/h in 2019, which predicts that average 5-6 people can die from flood disaster for 60 mm rainfall/h. Death numbers below 5-6 people in the city for 60 mm/h are a sign of chance factor, developing response skills against flood disaster and planned disaster mitigation activities. Above this number, the city needs sharp reforms, new city management plans, continuous coordination among organizations, urgent structural and non-structural measure implementations.

Advice 2: Road maintenances seem inadequate in İzmir. Landslide events can occur; therefore, roads must be maintained well and periodically. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 3: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors in İzmir.

Advice 4: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Erosion

control measurements such as seeding and afforestation, especially in mountain region are required. İzmir will be prone to debris flood when measurements are not taken. Forest fires in İzmir are a threat for future debris flood disaster as well. İzmir is an earthquake prone city which means the city can be exposed to tsunami. Maximum wind speed observed in the city is 127.1 km/h in 1970 according to Turkish State Meteorological Services. Category 1 hurricane in Saffir-Simpson scale can be observed in the city, which means sea level can exceed 14.5 m when the wind speed reaches this category 1 level. Therefore, coastal council must prepare the city against storm surges and tsunamis.

Advice 5: İzmir is a city which remains among Bakırçay (North Aegean), Gediz and Küçük Menderes river basins; therefore, river basin management plans of three basins must be very quality. Those rivers must be controlled and planned well to protect İzmir from flood disasters. For example, according to General Directorate of State Hydraulic works (DSİ)'s I. National Flood Symposium book, the number of floods between 1970 and 2005 in North Aegean, Küçük Menderes and Gediz were 51, 17 and 13. Death numbers during this period in the basins were 3, 76 and 0 respectively. Bridges and dams must be maintained periodically and controlled well in those basins. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Aydın:

- Two deaths in Aydın flood 2010,
http://www.cumhuriyet.com.tr/haber/diger/203436/Aydin_da_sel_2_olu.html
- Flood in Aydın, 2015,
<http://www.hurriyet.com.tr/venedik-e-donen-aydin-da-yagmur-manzaralari-37184871>
- Flood in Nazilli, 2016,
<http://www.milliyet.com.tr/aydin-da-sel-hayati-felc-etti-gundem-2292965/>
- Summer rain caused to flood in Aydın, 2017
<https://www.haberler.com/aydin-da-yaz-yagmuru-sele-dondu-9726795-haberi/>
- Flood and hail struck Aydın two times in five days, 2018,
<http://www.hurriyet.com.tr/gundem/aydinda-sel-can-aldi-1-olu-16501145>

Advice 1: Road maintenances seem inadequate. Landslide events can occur; therefore, roads must be maintained well and periodically. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h

minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 3: Aydın is an earthquake prone city which means the city can be exposed to tsunamis. Maximum wind speed observed in the city is 106.2 km/h in 1969 according to Turkish State Meteorological Services; therefore, violent storm level can be observed in the city, which means sea level can reach 11.5 m in this wind. Therefore, coastal council must prepare the city against storm surges and tsunamis.

Advice 4: Mountains in Aydın must be observed well against sudden waters releases or snowmelts. Büyük Menderes basin must be planned and managed well by regional authorities. Bridges and dams must be maintained periodically and controlled well in those basins. According to General Directorate of State Hydraulic works (DSİ)'s I. National Flood Symposium book, the number of floods between 1970 and 2005 in Büyük Menderes was 21 and death numbers during this period in the basin were 18.

Denizli:

- Flood disaster in Denizli, 2016,
<http://www.gazetevatan.com/denizli-de-sel-felaketi-985768-yasam/>
- Flood in Serinhisar, 2017,
<https://www.cnnturk.com/video/turkiye/denizliyi-sel-vurdu>
- Flood in Denizli, 2018,
<https://www.cnnturk.com/turkiye/denizliyi-sel-vurdu>

Advice 1: Road maintenances seem inadequate in Denizli. Landslide events can occur; therefore, roads must be maintained well and periodically. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups. Erosion measurements must be taken as well.

Advice 3: Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors. Denizli can be exposed to inland floods from İzmir, Muğla and Aydın directions. Maximum wind speed observed is 132.8 km/h, which is category 1 level. Büyük Menderes, Banaz stream, Çürüksu, Akçay and Dalaman streams must be controlled and planned well.

Kütahya:

- Flood disaster in Kütahya: one death, 2014,
<http://www.milliyet.com.tr/kutahya-da-sel-felaketi-1-olu-kutahya-yerelhaber-380726/>
- Hundreds thousands of fish destroyed due to floods, 2017,
<https://www.trthaber.com/haber/turkiye/sel-yuzunden-yuz-binlerce-balik-telef-oldu-329702.html>
- Flood damaged buildings in Denizli, 2018,
<https://www.sozcu.com.tr/2018/gundem/sel-kutahyada-evlere-zarar-verdi-2556107/>

Advice 1: Road maintenances seem inadequate in Kütahya. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from

roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors. Mountains must be observed well against snowmelt floods. Porsuk stream, Gediz, Kirmasti, Susurluk, Emet and Kocaçat must be observed and controlled well against possible flood disasters.

Afyon:

- 68 sheep destroyed in Emirdağ flood, 2018,
<http://www.hurriyet.com.tr/emirdagda-sel-nedeniyle-68-kucukbas-hayvan-tel-40827995>
- Flood disaster in Afyon, 2018,
<https://www.haberler.com/afyonkarahisar-da-sel-felaketi-2-11102695-haberi/>

Advice 1: Roads must be maintained well and periodically. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 3: Maximum wind speed observed in Afyon is 129.6 km/h, which is category 1. Afyon is an earthquake prone city. Mountains in Afyon must be observed well against snowmelt floods. Akarca, Kalı, Küfi streams, Sakarya, Porsuk, and Büyük Menderes must be observed and controlled well against floods.

Advice 4: Erosion control measurements such as seeding and afforestation, especially in mountain region are required. Afyon will be prone to debris flood when measurements are not taken. Forest fires in Afyon are a threat for future debris flood disaster as well.

Uşak:

- Flood disaster in Uşak, 2014,
<https://videonuz.ensonhaber.com/izle/usak-ta-sel-felaketi>
- Heavy rain in Uşak, 2017,
<http://www.milliyet.com.tr/usak-ta-saganak-yagis-usak-yerelhaber-2308700/>

Advice 1: Roads must be maintained well and periodically. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10.

Advice 2: The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors. Maximum wind speed observed in Uşak is 121 km/h in 1994, which is category 1. Mountains in Uşak must be observed well against snowmelt floods. Banaz stream and Gediz must be observed and controlled well against riverine floods.

6.3. Mediterranean Region Flood Risk Rankings

Table 6.7. Flash Flood City Risk Rankings in Mediterranean dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Max. Daily Prec. mm	Average Elevation m	AFRF mm	EFR	Population	Pop. Dens. per km ²	FRERR for 60 mm rain/ho ur Person
1.	Hatay	1121.6	432.1	85	426.40	19.47	1,609,856	274	5.62
2.	Antalya	1062.4	331.5	43	323.31	14.76	2,426,356	116	2.51
3.	Osmaniye	828.0	154.3	120	153.24	7.00	534,415	166	2.31
4.	K. Maraş	724.7	105.6	568	105.47	4.82	1,144,851	79	1.25

5.	Adana	644.6	129.0	23	125.38	5.73	2,220,125	157	2.80
6.	Mersin	592.1	199.5	6	179.81	8.21	1,814,468	116	2.26
7.	Isparta	564.3	108.6	1043	108.54	4.96	441,412	50	1.02
8.	Burdur	426.1	107.7	1025	107.66	4.92	269,926	38	1,03
Av	Mediterranean	745.5	196.0	364.1	191.23	8.73	10,461,409	124.5	2.35

*EFR values in the table must be multiplied by 10^{-3} to find exact EFR value.

Table 6.8. Flash Flood City Disaster Effect Rankings in Mediterranean Region.

Rank	City	FRERR for 60 mm rain/hour Person/mm	FEP %	RFEP %	Average Ranking Percentage Point
1.	Hatay	5.62	29.89	132.12	81.00
2.	Adana	2.80	14.89	15.82	15.36
3.	Antalya	2.51	13.35	256.28	134.81
4.	Osmaniye	2.31	12.29	6.89	9.59
5.	Mersin	2.26	12.02	32.92	22.47
6.	K. Maraş	1.25	6.65	12.93	9.79
7.	Burdur	1.03	5.48	3.86	4.67
8.	Isparta	1.02	5.43	1.3	3.37
Total	Mediterranean	18.8	100		

The cities that AFRE value is equal or greater than 110 are Hatay, Antalya, Mersin, Osmaniye and Adana. They will be under the sudden developed flash floods due to geographical characteristics and precipitation values. The EFR values which are equal or greater than 5.00 are same cities. FRERR value that are equal or greater than 2.00 are same cities too. The cities that RFEP values are equal or greater than 10 in Table 6.8 are same cities as well. Extra K. Maraş will be added as great flash flood risky city because average ranking point of K. Maraş is higher than the average ranking point of Osmaniye. There are 6 flash flood risky cities in Mediterranean Region which can be ranked like that;

1-Antalya	134.81
2-Hatay	81.00
3-Mersin	22.47
4-Adana	15.36
5-K. Maraş	9.79
6-Osmaniye	9.59

Some flood news from Turkish press services and advices related with the cities in Mediterranean Region are like that;

Antalya:

- 3 deaths in Antalya flood 2010,
<http://www.hurriyet.com.tr/gundem/antalyada-sel-3-can-aldi-13732674>
- Flood struck Antalya, 2013.
<https://www.sabah.com.tr/yasam/2013/04/15/antalyayi-sel-vurdu>
- Flood in Antalya, 2014,
<http://www.hurriyet.com.tr/gundem/antalya-siddetli-yagisa-teslim-27735961>
- Flood struck Antalya two times within 24 hours, 2018,
<https://www.sozcu.com.tr/2018/gundem/antalyada-ikinci-sok-vatandas-perisan-oldu-2562701/>
- Two deaths in Antalya cyclone, 2019,
<https://www.aydinlik.com.tr/antalya-daki-hortumda-can-kaybi-2-ye-yukseldi-turkiye-ocak-2019>

Advice 1: Road maintenances and control seem inadequate in Antalya. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 350 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Antalya is a red color city dependent on Anil imperial color system.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements,

which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Antalya is an earthquake prone city, which means the city can be exposed to tsunami. Maximum wind speed observed in the city is 139.3 km/h in 1969 according to Turkish State Meteorological Services. Category 1 hurricane in Saffir-Simpson scale can be observed in the city, which means sea level can exceed 14.5 m when the wind speed reaches this category 1 level. Therefore, coastal council must prepare the city against storm surges and tsunamis. On January 26th, 2019, such as storm surges due to category 1 wind speed occurred in Antalya. The news and video related with the event can be observed in the link as well.” <https://www.haberturk.com/son-dakika-antalya-da-yine-hortum-yaralilar-var-2302852>”

Advice 5: Erosion control measurements such as seeding and afforestation, especially in mountain region of Antalya are required. Antalya will be prone to debris flood when measurements are not taken. Forest fires in Antalya are a threat for future debris flood disaster as well.

Advice 6: Mountains must be observed well against snow accumulation and snowmelt flood. Aksu, Manavgat, Eşen, Göksu and other rivers and streams must be controlled well against floods as well by quality river basin management plans. Bridges and Dams must be maintained periodically and controlled well in those basins.

Hatay:

- Flood in Antakya, 2001,
<http://www.radikal.com.tr/turkiye/antakyayi-sel-aldi-597164/>
- Flood in Hatay Dört Yol, 5 deaths, 2013
<http://www.radikal.com.tr/turkiye/hatay-dortyolda-sel-felaketi-5-kisi-oldu-1142449/>
- Flood in Hatay: three deaths, 2014
<https://www.trthaber.com/haber/turkiye/hatayda-sel-felaketi-3-olu-145617.html>
- Flood in Hatay, 2016
<http://www.hurriyet.com.tr/gundem/hatayda-sel-felaketi-40115738>
- Flood in Hatay, 2019
<http://www.milliyet.com.tr/hatay-da-siddetli-yagis-bentleri-yikti-hatay-yerelhaber-3229901/>

Advice 1: Road maintenances and control seem inadequate in Hatay. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 450 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Hatay is an earthquake prone city which means the city can be exposed to tsunamis. Maximum wind speed observed in the city is 121.7 km/h in 1968 according to Turkish State Meteorological Services. Category 1 hurricane in Saffir-Simpson scale can be observed in the city, which means sea level can exceed 14.5 m when the wind speed reaches this category 1 level. Therefore, coastal council must prepare the city against storm surges and tsunamis.

Advice 5: The city remains in confluence zone of tributaries of Asi river; therefore, Asi must be planned and controlled well against flood by quality river basin management plans. Bridges and dams must be maintained periodically and controlled well in those basins. Amanos Mountain must be observed well against snowmelt flood and debris floods.

Adana

- Adana Flood 2014,
<https://www.haberturk.com/gundem/haber/955271-adanada-hayat-durdu>
- Adana Flood 2015,
<https://www.cnnturk.com/video/turkiye/adanada-siddetli-yagis-hayati-felc-etti>

- Adana Flood 2016,
<https://www.sabah.com.tr/fotohaber/yasam/adanada-sel-baskini>
- Adana Flood 2018,
<https://www.haberturk.com/son-dakika-adana-da-siddetli-yagmur-evleri-sular-altinda-birakti-2020621>
- Adana Flood 2019,
<https://www.haberturk.com/adana-haberleri/66135403-sokaklarini-su-basan-vatandaslar-evlerinde-mahsur-kaldiadanada-etkili-olan-yagis-nedeniyle>

Advice 1: Road maintenances and control seem inadequate in Adana. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Maximum wind speed observed in the city is 126.4 km/h in 2011 according to Turkish State Meteorological Services. Category 1 hurricane in Saffir-Simpson scale can be observed in the city, which means sea level can exceed 14.5 m when the wind speed reaches this category 1 level. Therefore, coastal council must prepare the city against storm surges.

Advice 5: The city remains in confluence zone of Seyhan and Ceyhan river basin; therefore, they must be planned and controlled well against floods by quality river basin management plans. Bridges and dams must be maintained periodically and controlled well in those basins. Bolkar Mountains, Aladağlar and Tahtalı Mountains must be observed well against snowmelt flood and debris flood.

Osmaniye

- Flood in Osmaniye destroyed bridges, 2005.
<http://www.hurriyet.com.tr/gundem/osmaniye-de-sel-kopruleri-yikti-306148>
- Flood in Osmaniye, 2011.
<https://www.aksam.com.tr/yasam/osmaniyede-sel-felaketi--47414h/haber-47414>
- Flood in Osmaniye, 2014
<http://www.milliyet.com.tr/osmaniye-de-siddetli-yagmur-sele-donustu-osmaniye-yerelhaber-322534/>
- Flood destroyed pedestrian bridge, 2015,
<http://www.milliyet.com.tr/kadirli-de-sel-sulari-yaya-koprusunu-osmaniye-yerelhaber-557501/>
- Two people rescued in Osmaniye from flood at the last moment, 2019,
<https://www.cnnturk.com/video/turkiye/sel-sularinin-ortasinda-kalan-iki-kisi-son-anda-kurtarildi>

Advice 1: Road maintenances and control seem inadequate. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 200 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do no

remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 3: Maximum wind speed observed in the Osmaniye is 157.3 km/h in 2008 according to Turkish State Meteorological Services. Category 2 in Saffir-Simpson scale can be observed in the city; therefore, city must be prepared against category 2 minimum. Inland flood can be observed and expected in Osmaniye after powerful storms in coastal cities in Mediterranean region.

Advice 4: The city remains in confluence zones of tributaries of the Ceyhan River; therefore, the river must be planned and controlled well against floods by quality river basin management plans. Bridges and Dams must be maintained periodically and controlled well in those basins. Mountains must be observed well against snowmelt flood and debris flood.

Mersin

- Flood in Mersin, 2001,
<http://www.hurriyet.com.tr/gundem/mersin-i-sel-aldi-40722>
- Flood paralyzed the life in Mersin, 2014,
<http://www.hurriyet.com.tr/gundem/mersinde-yagis-hayati-felc-etti-25928988>
- Disaster in Mersin, 2016,
<https://www.sabah.com.tr/fotohaber/yasam/mersinde-sel-felaketi>
- Flood in Mersin, 2017,
<https://www.sozcu.com.tr/2017/gundem/mersinde-sel-felaketinin-bilancosu-agir-1602154/>
- Flood in Mersin, 2017,
<http://www.gazetevatan.com/mersin-de-yagis-etkili-oldu-1053605-yasam/>

Advice 1: Road maintenances and control seem inadequate. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 250 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Maximum wind speed observed is 123.1 km/h in 2003 according to Turkish State Meteorological Services. Category in Saffir-Simpson scale can be observed in the city; therefore, the city must be prepared against category 1 minimum. Mersin is an earthquake prone and low-lying city as well, which might be exposed to tsunami. The city must be prepared against tsunami as well.

Advice 5: The Göksu River must be planned and controlled well against floods by quality river basin management plans. Bridges and dams must be maintained periodically and controlled well in those basins. Mountains must be observed well against snowmelt flood and debris flood.

K. Maraş:

- Flood disaster in K. Maraş, 2011,
<https://www.aksam.com.tr/yasam/kahramanmarasta-sel-felaketi--47208h/haber-47208>
- Flood closed the roads in K. Maraş, 2014
<http://www.hurriyet.com.tr/gundem/kahramanmarasta-sel-yollari-kapatti-27270480>
- 3 deaths in K. Maraş flood, 2018,
<https://www.haberturk.com/tv/burasi-turkiye/video/kahramanmarasta-sel-felaketi-3-kisi-hayatini-kaybetti/499258>

Advice 1: Road maintenances and control seem inadequate. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock

activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Maximum wind speed observed in the K. Maraş is 148.3 km/h in 2009 according to Turkish State Meteorological Services. Category 1 or 2 in Saffir-Simpson scale can be observed in the city; therefore, the city must be prepared against category 1 minimum. Inland flood can be observed and expected in K. Maraş after powerful storms in coastal cities in Mediterranean region.

Advice 5: The Ceyhan and Göksun River in K. Maraş must be planned and controlled well against floods by quality river basin management plans. Bridges and dams must be maintained periodically and controlled well. Mountains must be observed well against snowmelt flood and debris flood.

Burdur:

- Heavy rain in Burdur, 2015
<https://www.haberler.com/burdur-da-siddetli-yagis-7130431-haberi/>
- Flood closed road in Burdur, 2017,
<http://www.hurriyet.com.tr/burdurda-sel-yolu-kapatti-40480824>

Advice 1: Road maintenances and control seem inadequate. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting

and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Burdur Lake and mountains must be controlled well.

Advice 3: Maximum wind speed observed in the Burdur is 169.9 km/h in 2009 according to Turkish State Meteorological Services. Category 2 in Saffir-Simpson scale can occur in the city; therefore, the city must be prepared against category 2 minimum. Inland flood can be observed and expected in Burdur from Muğla and Antalya directions via high wind speeds.

Isparta:

- Flood in Isparta, 2014,
<https://www.sozcu.com.tr/2014/gunun-icinden/ispartada-sel-felaketi-527339/>
- Flood in Isparta, 2015,
<http://www.hurriyet.com.tr/ispartada-dolu-ve-yagmur-sele-neden-oldu-40541280>

Advice 1: Road maintenances and control seem inadequate. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically. Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Eğirdir, Kovada and Gölcük lakes together with the mountains in the city must be controlled well.

Advice 2: Maximum wind speed observed in the Isparta is 131.4 km/h in 2009 according to Turkish State Meteorological Services. Category 1 in Saffir-Simpson scale may occur in the city; therefore, the city must be prepared against category 1 minimum. Inland flood can be observed and expected in Isparta from Antalya direction via high wind speed.

6.4. Central Anatolia Region Flood Risk Rankings

Table 6.9. Flash Flood City Risk Rankings in Central Anatolia dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Max. Daily Prec. mm	Average Elevation m	AFRF mm	EFR	Population	Pop. Density per km ²	FRERR for 60 mm rain/hour Person
1.	Kırkkale	383.0	100.6	700	100.54	4.59	286,602	63	1.89
2.	Ankara	387.0	88.9	870	88.86	4.06	5,503,985	216	6.42
3.	Konya	322.4	73.7	1026	73.68	3.36	2,205,609	54	1.93
4.	Çankırı	411.9	73.4	730	73.66	3.36	216,362	29	0.81
5.	Yozgat	560.9	68.7	1418	68.67	3.14	424,981	30	0.61
6.	Kayseri	384.0	68.5	1071	68.48	3.13	1,389,680	81	2.43
7.	Karaman	331.1	68.0	1250	67.98	3.10	251,913	28	0.97
8.	Kırşehir	377.0	66.0	985	65.97	3.01	241,868	37	1,13
9.	Aksaray	344.8	65.8	900	65.77	3.00	412,172	52	1.74
10.	Eskişehir	366.0	65.7	732	65.67	3.00	871,187	63	1.98
11.	Sivas	428.7	55.0	1285	54.98	2.51	646,608	23	1.24
12.	Niğde	340.1	54.5	1208	54.48	2.49	364,707	49	1.66
13.	Nevşehir	413.0	40.7	1250	40.69	1.86	298,339	55	1.53
Avr.	Central Anatolian Region	388.5	68.4	1032.7	68.40	3.12	13,114,013	60	1.87

*EFR values in the table must be multiplied by 10^{-3} to find exact EFR value.

FRERR value that are equal or greater than 2.00 are two cities, which are Ankara and Kayseri; therefore, those cities are flash flood risky in the region.

Table 6.10. Flash Flood City Disaster Effect Rankings in Central Anatolia Region.

Rank	City	FRERR for 60 mm rain/hour Person/mm	FEP %	RFEP %	Average Ranking Percentage Points
1.	Ankara	6.42	26.38	8.59	17.49
2.	Kayseri	2.43	9.98	3.40	6.69
3.	Eskişehir	1.98	8.13	2.41	5.27
4.	Konya	1.93	7.93	7.86	7.90

5.	Kırıkkale	1.89	7.76	1.94	4.85
6.	Aksaray	1.74	7.15	1.30	4.23
7.	Niğde	1.66	6.82	0.83	3.83
8.	Nevşehir	1.53	6.29	0.41	3.35
9.	Sivas	1.24	5.09	4.00	4.55
10.	Kırşehir	1.13	4.64	1.18	2.91
11.	Karaman	0.97	3.99	1.52	2.76
12.	Çankırı	0.81	3.33	1.84	2.59
13.	Yozgat	0.61	2.51	4.17	3.34
Total	Central Anatolian Region	24.34	100		

Konya will be added to the highly flash flood risky cities in Central Anatolia Region because average ranking point of Konya is greater than the average ranking points of Kayseri. 3 cities in Central Anatolia Region are under the highly flash flood risks which can be ranked respectively like that;

1-Ankara	17.49
2-Konya	7.90
3-Kayseri	6.69

Ankara:

- Flood in Ankara, 2006
<http://www.hurriyet.com.tr/gundem/ankara-konya-karayolunda-sel-baskini-4624024>
- Flood in Ankara, 2011,
<https://www.sabah.com.tr/yasam/2011/08/12/ankarayi-su-basti>
- Road collapsed in Ankara due to flood, 2014,
<https://www.ensonhaber.com/ankarada-sel-nedeniyle-yol-coktu-2014-06-06.html>
- Flood in Ankara, 2017,
<https://www.sozcu.com.tr/2017/gundem/ankarada-sel-felaketi-2-1885678/>
- Flood in Mamak, 2018,
<https://www.cnnturk.com/video/turkiye/mamaktaki-sel-felaketinde-yeni-goruntuler-ortaya-cikti>

Advice 1: Road maintenances and control seem inadequate in Ankara. Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Subways or rail ways must be protected well against floods or disaster by railway companies. Station entrances must be raised, designed and protected well against rain water entrances. Enough pumps, valves, backup power for pumps, flood gates near the risky places and subway plug must be installed to prevent the floods or the interruptions in the railways or subways.

Advice 3: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 4: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber

harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 5: Kızılırmak, Ankara stream and Sakarya must be planned and controlled well in the city. Hillsides and mountain regions must be controlled well against debris flood. The maximum wind speed observed in the city is 126 km/h. The city must be prepared against category 1 level. Bridges and Dams must be maintained periodically and controlled well in those basins.

Kayseri:

- Flood in Kayseri 2007,
<https://www.haberler.com/kayseri-de-suksun-kasaba-halki-afet-yardiminin-haberi/>
- Landslide in Kayseri, one death, 2012,
<https://www.sabah.com.tr/yasam/2012/04/16/kayseride-heyelan-1-olu>
- Flood in Kayseri, 2014,
<http://www.hurriyet.com.tr/gundem/kayseride-sel-tehlikesi-ucuz-atlatildi-27045682>
- One death in Kayseri flood 2016
<https://www.haberler.com/kayseri-de-sel-can-aldi-8592410-haberi/>
- Flood and Landslide disaster in Kayseri, 2018,
<http://www.gunes.com/yasam/kayseride-sel-ve-heyelan-felaketi-861957>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Kızılırmak, Zamantı and Sarıçay must be planned and controlled well in the city. Hillsides and mountains such as Erciyes, Aladağ, Dumanlı, Binboğa and others must be observed and controlled well against debris flood and snowmelt flood in Kayseri. The maximum wind speed observed in the city is 143.6 km/h. The city must be prepared against category 1 level minimum. Lakes in the city must be observed and controlled well. Bridges and dams must be maintained periodically and controlled well in the basins.

Konya:

- Flood in Konya, 2018

<http://www.milliyet.com.tr/sel-felaketinin-yasandigi-bolgede-121-konya-yerelhaber-2862308/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned

dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Industrial facilities must be controlled well against floods. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Mountains must be observed and controlled well against debris and snowmelt flood. Göksu River in Konya and Tuz Lake must be observed well.

Eskişehir:

- Flood in Eskişehir, 2014.

<https://www.sabah.com.tr/galeri/yasam/eskisehirde-osbyi-sel-basti/6>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Industrial facilities must be controlled well against floods Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Sakarya and porsuk streams must be observed and controlled well. Bridges and Dams must be maintained periodically and controlled well in the basins. Mountains must be observed well against snowmelt flood and debris flood.

Kırıkkale:

- Flood in Kırıkkale 2018,

<https://www.cnnturk.com/turkiye/saganak-ve-sel-bu-kez-kirikkaleyi-vurdu?page=1>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Kızılırmak and its tributaries must be controlled well against riverine floods. Bridges and Dams must be maintained periodically and controlled well in the basins. Mountains must be observed well against snowmelt flood and debris flood.

Aksaray:

- Flood in Aksaray, 2015,

<https://www.sabah.com.tr/yasam/2015/06/03/aksarayda-sel-baskini>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Maximum wind speed observed in Aksaray is 136. 8 km/h. The city must be prepared against category 1. Hasan and Ekecek Mountain must be controlled well against snowmelt flood. Tuz Lake, Melendiz and Karasu streams must be observed and controlled well.

Niğde:

- Citizens rescued donkey from flood, 2018

<https://www.trthaber.com/haber/turkiye/nigdede-sele-kapilan-esegi-vatandaslar-kurtardi-371370.html>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be

built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Maximum wind speed observed in Niğde is 137.9 km/h. The city must be prepared against category 1. Mountains must be controlled well against snowmelt flood. Melendiz, Görgün Çayı and Uzandı creeks must be observed and controlled well.

Nevşehir:

- Flood in Nevşehir, 2014

<https://www.haberler.com/nevsehir-de-ekili-tarlalari-sel-ve-dolu-vurdu-6398954-haberi/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Niğde is a red color city in Anil Imperial color. Nevşehir is a red color city in Anil Imperial color system. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds

and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Maximum wind speed observed in Nevşehir is 125.3 km/h. The city must be prepared against category 1. Mountains must be controlled well against snowmelt flood and debris flood. Kızılırmak must be observed and controlled well.

Kırşehir:

- Flood in Kırşehir, 2018,

<https://www.cnnturk.com/turkiye/kirsehirde-sel-sonrasi-kriz-masasi-olusturuldu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Maximum wind speed observed in Nevşehir is 122.3 km/h in 1968. The city must be prepared against category 1. Mountains must be controlled well against snowmelt flood and debris flood. Kızılırmak and its tributaries must be observed and controlled well against riverine floods.

Karaman:

- <https://www.haberturk.com/karaman-haberleri/61193650-karamanda-sel-kamyoneti-devirdi>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Maximum wind speed observed in Karaman is 141.8 km/h in 1969. The city must be prepared against category 1. Mountains must be controlled well against snowmelt flood and debris flood. Gödet, Emenek and Berendi must be observed and controlled well against riverine floods.

Çankırı:

- Flood in Çankırı, 2006.

<http://www.hurriyet.com.tr/gundem/cankirida-sel-baskini-5177292>

Advice 1: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 2: Ilgaz Mountains must be controlled well against snowmelt flood and debris flood. Kızılırmak, Melan, Çerkeş, Acı and Tatlı streams must be observed and controlled well against riverine floods in Çankırı

Sivas:

- Flood in Sivas, 2014

<https://www.sozcu.com.tr/2014/gunun-icinden/sivas-ta-sel-felaketi-598155/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Sivas is a red color city in Anil Imperial color even if the city's maximum daily rainfall is below 60 mm. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Mountains must be controlled well against snowmelt flood and debris flood. Kızılırmak, Kelkit, Tohma streams must be observed and controlled well against riverine floods .in Sivas. Bridges and Dams must be maintained periodically and controlled well in the basin.

Yozgat:

- Flood in Yozgat, 2018,

<https://www.haberturk.com/yozyat-haberleri/61043185-yenifakilida-siddetli-yagmur-15-ev-ve-ekili-alarlara-zarar-verdi>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Maximum wind speed observed in Yozgat is 119.2 km/h in 1968. The city must be prepared against category 1. Mountains must be controlled well against snowmelt flood and debris flood. Kızılırmak, Delice and Yeşilırmak's Çekerek tributary in Yozgat must be observed and controlled well against riverine flood.

6.5. Black Sea Region Flood Risk Rankings

Table 6.11. Flash Flood City Risk Rankings in Black Sea Region dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Max. Daily Prec. mm	Average Elevation m	AFRF mm	EFR	Population	Pop. Dens. per km ²	FRERR for 60 mm rain/hour Person
1.	Rize	2296.1	244.0	4	519.69	23.73	348,608	89	9.37
2.	Zonguldak	1217.8	431.5	136	427.64	19.53	599,698	181	6.84
3.	Samsun	717.1	238.2	44	234.32	10.70	1,335,176	143	2.30
4.	Sinop	686.6	203.2	32	198.84	9.08	219,733	38	0.64
5.	Giresun	1288.0	184.1	84	181.28	8.28	453,912	66	3.54
6.	Bartın	1046.2	161.1	25	154.36	7.05	198,999	96	4.22
7.	Ordu	1038.4	171.3	10	153.51	7.01	771,932	130	2.88
8.	Düzce	827.4	118.0	160	117.39	5.36	387,844	151	2.10
9.	Trabzon	820.7	115.1	37	112.55	5.14	807,903	173	4.85
10.	Kastamonu	481.9	104.7	800	104.64	4.78	383,373	29	0.69
11.	Artvin	694.8	93.4	597	93.29	4.26	174,010	24	0.80
12.	Karabük	490.5	79.0	278	78.86	3.60	248,014	60	1.41
13.	Bolu	546.8	78.8	732	78.74	3.60	311,810	37	0.78
14.	Çorum	428.4	65.4	798	65.36	2.98	536,483	42	1.13
15.	Bayburt	441.8	61.5	1550	61.48	2.81	82,274	22	1.15
16.	Amasya	460.8	60.9	392	60.83	2.78	337,508	59	1.47
17.	Tokat	430.6	56.0	623	55.96	2.56	612,649	61	1.63
18.	Gümüşhane	463.7	51.7	1210	51.68	2.36	162,748	25	0.62
Avr.	Black Sea	798.8	139.9	417.3	152.8	6.98	7,972,674	79.2	2.58

*EFR values in the table must be multiplied by 10^{-3} to find exact EFR value.

Table 6.12. Flash Flood City Disaster Effect Rankings in Black Sea Region.

Rank	City	FRERR for 60 mm rain/hour Person/mm	FEP %	RFEP %	Average Ranking Percentage Points
1.	Rize	9.37	20.19	267.64	143.92
2.	Zonguldak	6.84	14.73	81.36	48.05
3.	Trabzon	4.85	10.45	5.35	7.90
4.	Bartın	4.22	9.09	5.70	4.40
5.	Giresun	3.54	7.63	32.08	19.85
6.	Ordu	2.88	6.20	16.02	11.11
7.	Samsun	2.30	4.95	40.43	22.69
8.	Düzce	2.10	4.52	3.23	3.87
9.	Tokat	1.63	3.51	1.50	2.50
10.	Amasya	1.47	3.17	1.08	2.12
11.	Karabük	1.41	3.04	1.39	2.21
12.	Bayburt	1.15	2.48	0.69	1.58
13.	Çorum	1.13	2.43	2.57	2.50
14.	Artvin	0.80	1.72	4.80	3.26
15.	Bolu	0.78	1.68	3.15	2.41
16.	Kastamonu	0.69	1.49	7.72	4.60
17.	Sinop	0.64	1.38	17.22	9.30
18.	Gümüşhane	0.62	1.34	0.89	1.11
Total	Black Sea	46.42	100		

Risky cities determined in Table 6.11 are Rize, Zonguldak, Samsun, Sinop, Giresun, Bartın, Ordu, Düzce and Trabzon because AFRF values of those cities are higher than 110. Kastamonu will be added to the highly flash flood risky city list in Black Sea Region because average ranking points of Kastamonu is higher than the average ranking points of Bartın and Düzce. Ten highly flash flood risk cities in Black Sea Region can be ranked respectively like that;

1-Rize	1 43.92	6-Sinop	9.30
2-Zonguldak	48.05	7-Trabzon	7.90
3-Samsun	22.69	8-Kastamonu	4.60
4-Giresun	19.85	9-Bartın	4.40
5-Ordu	11.11	10-Düzce	3.87

Some flood news from Turkish press services and advices related with the cities in Black Sea Region are like that;

Rize:

- Rize Flood 2002,
<https://www.evrensel.net/haber/132859/rize-de-urkuten-bilanco>
- Rize Flood 2007,
<http://www.hurriyet.com.tr/gundem/rize-de-sel-heyelan-7-olu-3-kayip-355041>
- Rize Flood 2010,
<https://www.evrensel.net/haber/132859/rize-de-urkuten-bilanco>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 250 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Landslide measurements must be taken because Rize is a highly landslide prone city. Population and its density must be controlled well although it seems okay and stable now. FRERR value in Rize seems low although average yearly precipitation is extremely high. State should never allow illegal buildings and structures; otherwise, more people can die in the city. The city is so prone to population growing when flood disasters are considered.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines.

Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Mountains must be controlled well against snowmelt flood and debris flood. The creeks in the city such as İyi dere, Büyükdere, Fırtına Deresi, Ortaköy Deresi and Çağlayan Deresi must be controlled well. Rize is the highest flood risky city in Turkey, which takes 2296.1 mm precipitation yearly. AFRF value for Rize is the highest in Turkey as 519.69. Coastal council must protect the city against storm surges and floods. Bridges and dams must be maintained periodically and controlled well.

Zonguldak:

- Flood in Zonguldak 2014
<https://www.haberturk.com/gundem/haber/955187-zonguldakta-sel-felaketi>
- Flood in Zonguldak 2015,
<https://www.sabah.com.tr/yasam/2015/09/30/zonguldakta-sel-baskini>
- Flood in Zonguldak 2017,
<http://www.milliyet.com.tr/zonguldak-bir-saatlik-saganak-gundem-2506855/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 450 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and

be maintained periodically. Flash flood risk is extremely high in Zonguldak; therefore, infrastructures must be always ready to eliminate highly precipitations. Landslide measurements must be taken because Zonguldak is a highly landslide prone city. Mining areas can create landslide and mudflow events in the city.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against mining sites, landslides and mudflow

Advice 3: Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Filyos, Gerede, Soğanlı and other small streams must be planned and observed well. Bridges and dams must be controlled and maintained well. Mountains must be controlled well against snowmelt flood and debris flood. Coastal council must prepare the city against storm surges and tsunamis.

Samsun:

- Flood in Samsun 2007,
<http://www.hurriyet.com.tr/gundem/samsun-savas-alani-gibi-7145912>
- Flood in Samsun 2012,
<https://www.sabah.com.tr/yasam/2012/07/04/samsunda-sel-faciayi-3-olu>
- Flood in Samsun 2014,
<http://www.hurriyet.com.tr/gundem/samsunda-sel-felaketi-26864318>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 250 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among

river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Yeşilırmak and Kızılırmak must be planned and observed well. Bridges and dams must be controlled and maintained well. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Coastal council must prepare the city against storm surges and tsunamis. Maximum wind speed observed in the city is 144 km/h according to Turkish State Meteorological Service. The city must be prepared against category 1 level minimum.

Sinop:

- Flood in Sinop 2002,
<http://www.hurriyet.com.tr/gundem/bu-kez-sinopta-sel-2-olu-3-kayip-38369787>
- Flood in Sinop 2013,
<https://www.sabah.com.tr/galeri/yasam/sinopu-sel-vurdu-593539299107/3>
- Flood in Sinop 2018,
<https://www.haberturk.com/sinop-haberleri/61608829-duragani-saganak-vurdu-hastaneyi-su-basti>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 250 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Gökırmak must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Lakes in city must be observed well. Coastal council must prepare the city against storm surges and tsunamis. Maximum wind speed observed in the city is 145.8 km/h according to Turkish State Meteorological Service. The city must be prepared against category 1 level minimum.

Giresun:

- Flood in Giresun 2009,
https://www.ntv.com.tr/turkiye/giresunu-sel-vurdu,cR-4EiXNak2GYiYzq_fDhg
- Flood in Giresun 2011,
<https://www.ntv.com.tr/turkiye/giresunda-sel-2-olu,bX3G-hHorUKIg9ix2CAPkg>
- Flood in Giresun 2018,
<https://www.cnnturk.com/guncel/giresunda-hastane-sular-altinda-kaldi?page=1>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 250 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: The streams such as Kelkit, Doğankent, Özlüdere, Gelevara, Yağlıdere and Pazarçayı must be planned and observed well. Bridges and dams must be controlled and maintained well. Mountains must be controlled and observed against snowmelt flood and debris flood. Coastal council must prepare the city against storm surges and tsunamis well. Maximum wind speed observed in the city is 161.3 in 1968 km/h according to Turkish State Meteorological Service. The city must be prepared against category 2 level minimum.

Bartın:

- Flood in Bartın 2006,
<https://www.cnnturk.com/turkiye/bartinda-sel-felaketinin-bilancosu>
- 1998 Flood in Bartın 2011,
http://www.pusulagazetesi.com.tr/m_2747/20-yilin-en-kotu-donemi-1998-seli-il-yazilari-ix/
- Flood in Bartın 2018,
<https://www.haberturk.com/bartın-haberleri/15774130-bartında-siddetli-yagis>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 200 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: The Bartın River must be planned and observed well. Bridges and dams must be controlled and maintained well. Mountains must be controlled and observed against snowmelt flood and debris flood. Coastal council must prepare the city against storm surges and tsunamis as well.

Ordu:

- Flood in Ordu 2011,
<https://www.ensonhaber.com/orduda-son-50-yilin-felaketi-yasandi-2011-08-19.html>
- Flood in Ordu 2016,
<https://www.aa.com.tr/tr/gunun-basliklari/orduda-sel-felaketi-2-olu/603283>
- Flood in Ordu 2018,
<https://www.cnnturk.com/turkiye/ordudaki-sel-felaketinin-bilancosu-aciklandi-tam-bin-100-ton>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 200 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Streams such as Melek, Bülbül, Çivil, Bulaman, Tuna suyu, Akçay and Elekçi must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must

be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Coastal council must prepare the city against storm surges and tsunamis. Maximum wind speed observed in the city is 136.8 km/h in 1968 according to Turkish State Meteorological Service. The city must be prepared against category 1 level minimum.

Düzce:

- Flood in Düzce 2009,
<https://www.ntv.com.tr/turkiye/duzcede-sel-yollari-cokertti,yVCNg26hqUyrnEZ8xLGBCQ>
- Flood in Düzce 2014,
<http://www.hurriyet.com.tr/gundem/duzceyi-sel-aldi-26563602>
- Flood in Düzce 2016,
http://www.akcakatv.com/haber-detay.asp?id=10092&Sel_nedeniyle_200_ev_bosaltildi

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds

and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Streams such as Büyük Melen, Küçük Melen, Asar suyu, Uğur suyu and Aksu deresi must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Coastal council must prepare the city against storm surges and tsunamis.

Trabzon:

- Flood in Trabzon 2015,
<https://www.haberler.com/trabzon-da-sel-ve-heyelanlar-korkuttu-1-7641178-haberi/>
- Flood in Trabzon 2016,
<https://www.haberturk.com/galeri/yasam/464047-trabzonda-sel-felaketi>
- Flood in Trabzon 2018,
<https://www.sabah.com.tr/webtv/yasam/trabzonda-sel-2-araci-yuttu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Streams such as Değirmendere, Karadere and other streams must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Coastal council must prepare the city against storm surges.

Kastamonu:

- Flood in Kastamonu 2007,
<https://www.haberler.com/kastamonu-da-sel-baskini-1-olu-haberi/>
- Flood in Kastamonu 2014,
<http://www.milliyet.com.tr/kastamonu-da-sel-hayati-felc-etti-kastamonu-yerelhaber->

[237131/](#)

- Flood in Kastamonu 2017,
<http://www.milliyet.com.tr/kastamonu-da-saganak-ve-sel-gundem-2463879/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Araç, Devrekani, Gökırmak and Devrez streams must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Coastal council must prepare the city against storm surges and tsunamis as well.

Artvin:

- Flood in Artvin 2015,
<https://www.haberturk.com/gundem/haber/1119888-artvin-hopada-sel-felaketinde-olusayisi-8e-yukseldi>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Çoruh, Altıparmak and Güngörmez streams must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Coastal council must prepare the city against storm surges as well. Dams, especially Deriner must be controlled and maintained well against dam failures.

Karabük:

- Flood in Karabük 2016,

<https://www.haberturk.com/gundem/haber/1189960-karabukte-sel-kabusu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Filyos, Soğanlı, Eskipazar Araç and Yenice streams must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well.

Bolu:

- Flood in Bolu 2014

<https://www.sozcu.com.tr/2014/gunun-icinden/boluda-sel-felaketi-526599/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Flood insurance and periodic water-proofing must

be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Bolu suyu, Mudurnu, Büyük Melen and Küçük Melen must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well.

Çorum:

- Flood in Çorum 2014,
<https://www.aksam.com.tr/guncel/corumda-sel-1-olu/haber-311156>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Delice, Çekerek, Budaközüi Ovacık suyu, Devrez, Çat suyu, and Mecitözü streams must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well.

Bayburt:

- Flood in Bayburt 2018,
<https://www.haberturk.com/bayburt-haberleri/61080730-bayburta-saganak-yagis-etkili-oldu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Çoruh must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well.

Amasya:

- Flood in Amasya 2009,

<https://www.cnnturk.com/2009/turkiye/05/23/amasyada.sel.1.olu/527860.0/index.html>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Flood insurance and periodic water-proofing must

be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Yeşilirmak must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well. Maximum wind speed observed in the city is 129.6 km/h in 1996 according to Turkish State Meteorological Service. The city must be prepared against category 1 level minimum.

Tokat:

- Flood in Tokat 2018,

<https://www.haberturk.com/tokat-haberleri/63199534-sel-sonrasi-yaralar-sariliyor>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Settlement council must be created for each district, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Tokat is a red color city in Anil Imperial color system. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 2: Yeşilirmak such as Kelkit, Tozanlı and Çekerek tributaries must be planned and observed well. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well. Maximum wind speed observed in the city is 176 km/h in 1978 according to Turkish State Meteorological Service. The city must be prepared against category 3 level minimum.

Gümüşhane:

- Flood in Gümüşhane 2014,

<https://www.haberler.com/gumushane-de-sel-felaketi-6611631-haberi/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically. Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Relief and evacuation centers are required. Inland flood can be observed in the city. Gümüşhane is a red color city in Anil Imperial color system. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Kelkit and Harşit streams must be planned and observed well in the city. Mountains must be controlled and observed against snowmelt flood and debris flood. Bridges and dams must be maintained periodically and controlled well.

6.6. Eastern Anatolian Region Flood Risk Rankings

Table 6.13. Flash Flood City Risk Rankings in Eastern Anatolia Region dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Max. Daily Prec. mm	Average Elevation m	AFRF	EFR	Population	Pop. Dens. per km ²	FRERR for 60 mm rain/hour Person
1.	Bitlis	1217.0	158.2	1545	158.08	7.22	349,396	39	4.43
2.	Bingöl	943.3	142.7	1177	142.59	6.51	281,205	34	1.66
3.	Tunceli	857.9	134.4	914	133.87	6.11	88,198	11	0.74
4.	Ağrı	522.0	125.9	1640	125.86	5.75	539,657	47	4.14
5.	Van	387.7	122.0	1661	121.97	5.57	1,123,784	53	3.15
6.	Erzincan	372.1	110.5	1214	110.47	5.04	236,034	20	0.62
7.	Muş	762.5	85.6	1300	85.55	3.91	407,992	50	2.26
8.	Hakkari	782.9	85.1	1720	85.06	3.88	286,470	40	2.94
9.	Ardahan	555.8	75.8	2200	75.78	3.46	98,907	19	0.79
10.	Kars	502.7	71.7	1750	71.68	3.27	288,878	29	1.33
11.	Elazığ	408.2	67.7	1015	67.67	3.09	595,638	64	1.80
12.	Erzurum	432.0	59.6	1893	59.59	2.72	767,848	30	1.60

13.	Malatya	376.0	52.6	977	52.58	2.40	797,036	66	2.02
14.	Iğdır	257.2	41.6	858	41.59	1.90	197.456	56	2.51
Avr.	Eastern Anatolia Region	598.4	95.24	1418.9	95.17	4.35	6,058,499	39.9	2.14

*EFR values in the table must be multiplied by 10^{-3} to find exact EFR value.

Risky cities determined are Bitlis, Bingöl, Tunceli, Ağrı, Van, Erzincan, Malatya, Muş, Hakkari and Iğdır in Table 6.13. AFRF values of Bitlis, Bingöl, Tunceli, Ağrı, Van and Erzincan are more than 110; therefore, they are flash flood risky cities. Maximum snow height observed in Bitlis is 343 cm in 1968 and average yearly precipitation is 1217 mm according to Turkish State Meteorological Service; therefore, b value and a value in the equations will be 6 and 2 for Bitlis respectively. FRERR and RFEP values will be calculated with this way. FRERR values of Malatya, Muş, Hakkari and Iğdır are more than 2.00 so they are flash flood risky cities too.

Table 6.14. Flash Flood City Disaster Effect Rankings in Eastern Anatolia Region.

Rank	City	FRERR for 60 mm rain/hour Person/mm	FEP %	RFEP %	Average Ranking Percentage Points
1.	Bitlis	4.43	14.77	30.01	22.39
2.	Ağrı	4.14	13.80	10.48	12.14
3.	Van	3.15	10.50	13.47	11.98
4.	Hakkari	2.94	9.80	4.47	7.13
5.	Iğdır	2.51	8.37	0.17	4.27
6.	Muş	2.26	7.54	5.03	6.29
7.	Malatya	2.02	6.74	1.38	4.06
8.	Elazığ	1.80	6.00	1.92	3.96
9.	Bingöl	1.66	5.54	17.47	11.51
10.	Erzurum	1.60	5.34	4.32	4.83
11.	Kars	1.33	4.43	2.83	3.63
12.	Ardahan	0.79	2.63	1.82	2.23
13.	Tunceli	0.74	2.47	13.54	8.01
14.	Erzincan	0.62	2.07	5.89	3.98
Total	Eastern Anatolia Region	29.99	100		

Erzurum will be included due to 4.83 average ranking points respectively which exceeded Erzincan's average ranking points in Table 6.14. Elazığ might be added to the list dependent on choice because the average ranking point difference between Erzincan and Elazığ are very close to each other as 0.2 points difference. The values of Elazığ can be exposed to changes so easily and enter this list. 11 cities in Eastern Anatolian region are under the highly flash flood risks which can be ranked respectively like that;

1-Bitlis	22.39	7-Muş	6.29
2-Ağrı	12.14	8-Erzurum	4.83
3-Van	11.98	9-Iğdır	4.27
4-Bingöl	11.51	10-Malatya	4.06
5-Tunceli	8.01	11-Erzincan	3.98
6-Hakkari	7.13		

Some flood news from Turkish press services and advices related with the cities in Eastern Anatolia Region are like that;

Bitlis:

- Flood in Bitlis 2006,
<https://www.haberler.com/bitlis-bitlis-te-sel-felaketi-2-olu-1-kayip-haberi/>
- Flood in Bitlis 2008,
<http://www.radikal.com.tr/turkiye/tatvanda-afetin-adi-sel-oldu-892713/>
- Flood in Bitlis 2018,
<https://www.haberturk.com/bitlis-haberleri/65387212-mutkide-hayat-durdusel-sulari-ve-heyelan-nedeniyle-85-yerlesim-yerine-ulasim-saglanamiyor>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 200 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads that accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do no remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do no remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Streams such as Bitlis çayı, Botan çayı, Karasu, Ağkız, Oranz Dereleri, Garsay suyu, Hizan suyu, Güzel Dere and Garzan Çayı must be planned and observed well. Bridges and dams must be maintained periodically. Mountains such as Suphan must be controlled well against snowmelt flood, debris flood and volcanic activity. Lakes in city must be observed well. Bitlis must be prepared against avalanche events too by authorities. Snowmelt flood potential is extremely high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims. Bitlis is an earthquake prone city as well. The city must be prepared against earthquake as well.

Van:

- Flood in Van 2007,

<https://www.haberler.com/van-da-sel-felaketi-1-olu-2-kayip-haberi/>

- Flood in Van 2008,

<http://www.hurriyet.com.tr/gundem/vanda-sel-1-olu-1-kayip-9620166>

- Flood in Van 2011,

<https://www.haberturk.com/yasam/haber/649254-vanda-sel-felaketi-4-olu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber

harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Streams such as Memedik çayı, Zilan suyu, Karasu, Bendimahi, Arpak and Hoşap Suyu must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Van must be prepared against avalanche events too by authorities. Snowmelt flood potential is high in the city. Van is an earthquake prone city too. Maximum wind speed observed in the city is 165.6 km/h according to Turkish State Meteorological Service; therefore, the city must be prepared against Category 2 level.

Bingöl:

- Flood in Bingöl 2017,

<http://beyazgazete.com/video/webtv/yasam-11/bingol-de-sel-felaketi-kamerada-459540.html>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems,

storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again.

Advice 4: Streams such as Murat, Peri suyu and Göynük suyu must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Bingöl must be prepared against avalanche events too by authorities. Snowmelt flood potential is very high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims. Bingöl is an earthquake prone city too. The city must be prepared against earthquake as well.

Iğdır:

- Flood in Iğdır 2015,

<http://www.milliyet.com.tr/sel-felaketinin-bilancosu-agir-oldu-igdir-yerelhaber-947677/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Iğdır is a red color city in Anil Imperial color system.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should

never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Aras River Basin must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Tuzluca Lake in city must be observed well. Snowmelt flood potential is high in the city.

Ağrı:

- Flood in Ağrı 2007,
<http://www.hurriyet.com.tr/gundem/deprem-gibi-sel-8-can-aldi-6598636>
- Flood in Ağrı 2010,
<https://www.evrensel.net/haber/187904/agri-da-3-bin-ev-sular-altinda-1-cocuk-oldu-4-kisi-yarali>
- Flood in Ağrı 2017,
<http://www.milliyet.com.tr/agri-da-sel--yerelhaber-2227054/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks

and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Streams such as Karasu, Aras, Murat suyu, Eleşkirt, Sarısu and Balık Çayı must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Ağrı must be prepared against avalanche events too by authorities. Snowmelt flood potential is extremely high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims. Ağrı is an earthquake prone city too. The city must be prepared against earthquake as well. The city must be prepared against category 1 level.

Malatya:

- Flood in Malatya 2006,
<https://www.haberler.com/malatya-malatya-da-sel-felaketi-haberi/>
- Flood in Malatya 2011,
http://www.cumhuriyet.com.tr/haber/diger/231900/Malatya_da_sel_baskini.html
- Flood in Malatya 2016,
<https://www.haberturk.com/gundem/haber/1222879-malatyada-sel-sularina-kapilan-genc-oldu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Malatya is a red color city in Anil Imperial color system. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian

areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Euphrates and its tributaries in the city must be planned and observed well. Bridges and dams must be maintained periodically. The city can be exposed to the effects of dam failure. Dams, especially Karakaya must be controlled and maintained well. Authorities should never allow the settlements which are close to dams. Distance parameter must be obeyed by authorities and citizens. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed. Malatya is an earthquake prone city too. The city must be prepared against earthquake. Earthquakes, erosion and landslides in the city with time can create cracks in the dams so earthquakes in the city might lead to dam failures, especially in Karakaya, which can create dam failure flood disaster in close settlements. Maximum wind speed observed in the city is 162 km/h according to Turkish State Meteorological Service. The city must be prepared against category 2 level minimum.

Elazığ:

- Flood in Elazığ 2007,
<https://www.haberler.com/elazig-da-sel-felaketi-haberi/>
- Flood in Elazığ 2017,
<https://www.haberler.com/elazig-da-evler-sel-sulari-altinda-kaldi-9504202-haberi/>
- Flood in Elazığ 2018,
<https://www.cnnturk.com/turkiye/elazigda-sel-25-kucukbas-telef-oldu?page=4>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Fırat (Euphrates) and its tributaries and Haringet çayı in the city must be planned and observed well. Bridges and dams must be maintained periodically. The city can be exposed to the effects of dam failure. Dams, especially Keban must be controlled and maintained well. Authorities should never allow the settlements which are close to dams. Distance parameter must be obeyed by authorities and citizens. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Elazığ is an earthquake prone city too. The city must be prepared against earthquake. Earthquakes, erosion and landslides in the city with time can create cracks in the dams so earthquakes in the city might lead to dam failures, especially in Keban, which can create dam failure flood disaster in close settlements. The city must be prepared against category 1 level minimum

Tunceli:

- Flood in Tunceli 2003,
<https://www.tgrthaber.com.tr/gundem/-115495.html>
- Flood in Tunceli 2006,
<https://www.haberler.com/tunceli-tunceli-de-sel-baskini-2-haberi/>
- Flood in Tunceli 2018,
<http://www.hurriyet.com.tr/yerel-haberler/tunceli/merkez/tuncelide-selin-tasidigi-tas-ve-toprak-yollari-40998308>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock

activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Murad, Munzur and Peri suyu in Tunceli must be planned and observed well. Laç, Hozat, Avuşkent, Geyiksuyu and Ormanyolu streams must be observed well too. Bridges and dams must be maintained periodically. The city can be exposed to the effects of dam failures. Dams, especially Keban must be controlled and maintained well. Authorities should never allow the settlements which are close to dams. Distance parameter must be obeyed by authorities and citizens. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Tunceli is an earthquake prone city too. The city must be prepared against earthquake. Earthquakes, erosion and landslides in the city with time can create cracks in the dams so earthquakes in the city might lead to dam failures, especially in Keban, which can create dam failure flood disaster in close settlements. Tunceli must be prepared against avalanche by authorities. Snowmelt flood potential is extremely high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims.

Muş:

- Flood in Muş 2012,
<http://www.gazetevatan.com/mus-ta-sel-baskini--442849-gundem/>
- Flood in Muş: Two deaths, 1 missing 2016,
<https://www.ulusal.com.tr/yurt/mus-ta-sel-felaketi-2-olu-1-kayip-h108705.html>
- Flood in Muş: Two deaths 2018,
<https://www.cnnturk.com/video/turkiye/musta-sel-can-aldi-2-olu>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do no remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do no remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Murad and Karasu must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Muş is an earthquake prone city too. The city must be prepared against earthquake. Muş must be prepared against avalanche by authorities. Snowmelt flood potential is extremely high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims.

Erzincan:

- Flood in Erzincan 2009,

<https://www.haberaktuel.com/sel-erzincanda-ekili-alanlari-vurdu-haberi-209386.html>

- Flood in Erzincan 2011,
<https://www.ensonhaber.com/erzincanda-sel-koca-koyu-yuttu-2011-07-18.html>
- Flood in Erzincan 2014,
<https://www.haberturk.com/gundem/haber/972693-sel-sulari-koydeki-eski-evleri-yikip-gitti>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber

harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Fırat (Euphrates) and its tributary Karasu must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Erzurum is an earthquake prone city too. The city must be prepared against earthquake. Erzurum must be prepared against category 1 level.

Erzurum:

- Flood in Erzurum 2018,

<http://www.hurriyet.com.tr/galeri-erzurumda-sel-felaketinin-bilancosu-agir-oldu-40844604>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhill roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantaged groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Landslide potential is high in the city. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Fırat (Euphrates) and its tributary Karasu, Çoruh, Örtü, Tortum, Aras and Hınıs must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Southern parts of the city are an earthquake prone. The city must be prepared against earthquake. Erzurum must be prepared against category 1 level. Erzurum must be prepared against avalanche by authorities. Snowmelt flood potential is very high in the city. Those snowmelts can be stored for

drinking, agricultural and livestock aims. Erzurum is a red color city in Anil Imperial color system.

Kars:

- Flood in Kars 2007,

<http://www.hurriyet.com.tr/gundem/karsta-sel-felaketi-50-hayvan-telef-oldu-7149182>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Erosion control measurement must be taken in agricultural areas, especially by agricultural engineers periodically. Agricultural area must be protected well against any kind of contaminations and any kind of grazing, timber harvesting. Settlement or urban development should never be allowed in this zone too except for the required water diversion channels, irrigation systems, storage units, advance treatment facilities and some required roads for agricultural machines. Agricultural areas must have a flood management plan for high precipitations as well. Run-off ponds and sediment traps must be built around the agricultural area to prevent the likelihood of flood and the direction of the flood waters or sediments into roads. Soakaways or swales systems must be built to prevent floods in agricultural areas and divert flood waters into tanks or ponds. Those agricultural and floodwaters can be directed into central advance agricultural water treatment facilities via pipes or channels. Those waters can be treated and reused for irrigation aims again and again. Riparian areas must be created between river and agricultural areas. Grazing, timber harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters. Riparian areas must be created between river and agricultural areas. Grazing, timber

harvesting and livestock activities must be planned in the area or locations behind the settlements, which do not remain among river, wetlands, agricultural areas and settlements. Livestock areas must be protected well against flood waters.

Advice 4: Aras, Arpa, Kura and Kars çayı must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Kars must be prepared against category 2 level minimum.

Hakkari:

- Flood in Hakkari 2018,
<https://www.haberturk.com/hakkari-de-sel-felaketinin-olusturdugu-tahribat-gun-agarinca-ortaya-cikti-2196178>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Zap suyu, Habur çayı, Botan suyu, Dicle (Tigris) and its tributaries must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. The city must be prepared against earthquake. Hakkari must be prepared against avalanche by authorities. Snowmelt flood potential is very high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims.

Ardahan:

- Flood in Ardahan 2016,

<https://www.haberler.com/ardahan-da-saganak-su-baskinina-neden-oldu-8558815-haberi/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Kura and Cara streams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Lakes in city must be observed well. Snowmelt flood potential is very high in the city. Those snowmelts can be stored for drinking, agricultural and livestock aims. Maximum wind speed observed in the city is 176 km/h in 2015 according to Turkish State Meteorological Service; therefore, the city must be prepared against category 3 minimum.

6.7. Southeastern Anatolia Region Flood Risk Rankings

Table 6.15. Flash Flood City Risk Rankings in Southeastern Anatolia Region dependent on precipitation and elevation.

Rank	City	Average Yearly Prec. mm	Max. Daily Prec. mm	Average Elevation m	AFRF mm	EFR	Population	Pop. Dens. per km ²	FRERR for 60 mm rain/hour Person
1.	Mardin	667.8	145.9	1150	145.82	6.66	829,195	94	1.62

2.	Şanlıurfa	451.3	119.5	547	119.40	5.45	2,035,809	105	2.68
3.	Adıyaman	710.9	105.9	669	105.79	4.83	624,513	82	1.33
4.	Siirt	714.3	102.9	895	102.82	4.69	331,670	60	0.97
5.	Şırnak	687.4	87.5	1350	87.46	3.99	524,190	73	1.22
6.	Gaziantep	552.8	73.6	840	73.55	3.36	2,028,563	295	12.37
7.	Kilis	492.4	71.7	680	71.65	3.27	142,541	99	2.32
8.	Diyarbakır	486.7	71.6	677	71.55	3.27	1,732,396	113	2.67
9.	Batman	489.4	69.2	550	69.14	3.16	599,103	128	3.01
Avr.	Southeastern Anatolia	583.7	94.20	817.6	94.13	4.30	8,847,980	116.7	3.13

Risky cities determined in Table 6.15 are Mardin and Şanlıurfa because AFRF values of those cities are more than 110; therefore, they are flash flood risky cities. FRERR values of Gaziantep, Kilis, Diyarbakır and Batman are more than 2.00 so they are flash flood risky cities too

Table 6.16. Flash Flood City Disaster Effect Rankings in Southeastern Anatolia Region.

Rank	City	FRERR for 60 mm rain/hour Person/mm	FEP %	RFEP %	Average Ranking Percentage Points
1.	Gaziantep	12.37	43.88	2.25	23.07
2.	Batman	3.01	10.68	1.21	5.95
3.	Şanlıurfa	2.68	9.51	13.73	11.62
4.	Diyarbakır	2.67	9.47	4.22	6.85
5.	Kilis	2.32	8.23	0.40	4.32
6.	Mardin	1.62	5.75	13.81	9.78
7.	Adıyaman	1.33	4.72	6.66	5.69
8.	Şırnak	1.22	4.32	4.16	4.24
9.	Siirt	0.97	3.44	4.58	4.01
Total	Southeastern Anatolia Region	28.19	100		

Adıyaman will be included in the flash flood risky city list due to 5.69 average ranking points, which is more than the average ranking points of Kilis. Kilis is in the list because FRERR value is more than 2.00. 7 cities Southeastern Anatolian region are under the highly flash flood risks which can be ranked respectively like that;

1-Gaziantep	23.07	5-Batman	5.95
2-Şanlıurfa	11.62	6-Adıyaman	5.69
3-Mardin	9.78	7-Kilis	4.32
4-Diyarbakır	6.85		

Some flood news from Turkish press services and advices related with the cities in Southeastern Anatolian Region are like that;

Gaziantep:

- Flood in Gaziantep 2011,
<https://www.cnnturk.com/2011/turkiye/04/11/guneydoguda.sel.felaketi.1.olu.2.kayip/612824.1/index.html>
- Flood in Gaziantep 2012,
<https://www.cnnturk.com/2012/turkiye/10/25/gaziantep.te.sel.3.olu/681943.0/index.html>
- Flood in Gaziantep 2014,
<https://www.haberler.com/gaziantep-te-sel-faciiasi-1-olu-6071088-haberi/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Fırat (Euphrates), Nizip, Afrin, Merziman and Alleben streams must be planned and observed well. Bridges and dams must be maintained periodically. Mountains must be controlled well against snowmelt flood and debris flood. Agricultural areas and livestock must be protected well

against flood waters.

Şanlıurfa:

- Flood in Şanlıurfa 2006,
<https://www.haberturk.com/yasam/haber/4209-sanliurfada-sel-felaketi-4-olu>
- Flood in Şanlıurfa 2012,
<https://www.sabah.com.tr/yasam/2012/10/27/urfa-sele-kapildi-2-olu-1-kayip>
- Flood in Şanlıurfa 2018,
<https://www.cnnturk.com/video/turkiye/sanliurfada-sele-kapilan-13-yasindaki-cocuk-hayatini-kaybetti>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Euphrates must be planned and observed well. Bridges and dams must be maintained periodically. Agricultural areas and livestock must be protected well against flood waters.

Mardin:

- Flood in Mardin 2006,
<https://www.haberler.com/mardin-guneydogu-daki-sel-felaketinin-ardindan-haberi/>
- Flood in Mardin 2015,
<https://www.aksam.com.tr/yasam/nusaybinde-sel-baskini/haber-456304>
- Flood in Mardin 2018,
<https://www.haberturk.com/mardin-haberleri/65090497-kiziltepede-sel-fistik-fidelerine-zarar-verditarlalar-su-altinda-kaldi>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Dicle (Tigris), Savur, Çağcağ, Buğur and other streams must be planned and observed well. Bridges and dams must be maintained periodically. The city must be prepared category 1 level minimum. Agricultural areas and livestock must be protected well against flood waters.

Diyarbakir:

- Flood in Diyarbakır 2006,
<https://www.haberler.com/diyarbakir-diyarbakir-da-sel-felaketi-5-olu-haberi/>
- Flood in Diyarbakır 2018,
<https://www.haberturk.com/diyarbakir-haberleri/65090965-diyarbakirda-sel-bir-koyu-ikiye-bolduergani-ilcesinde-bu-sabah-meydana-gelen-sel-nedeni-ile>
- Flood in Diyarbakır 2018,
<https://www.sabah.com.tr/yasam/2018/12/13/diyarbakirda-baraj-kapagi-koptu-sel-uyarisi>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Dicle (Tigris) must be planned and observed well. Bridges and dams must be maintained periodically. The city must be prepared category 1 level minimum. Northern parts of the city are an earthquake prone area. Agricultural areas and livestock must be protected well against flood waters.

Adiyaman:

- Flood in Adiyaman 2018,
<https://www.cnnturk.com/turkiye/adiyamanda-sel-ve-heyelan-hasara-yol-acti?page=1>
- Flood in Adiyaman 2018,
<https://www.sozcu.com.tr/2018/gundem/sel-120-hayvani-telefon-etti-2698421/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Fırat (Euphrates) must be planned and observed well. The depth of the river is high in Adiyaman. Bridges and dams must be maintained periodically. The city must be prepared category 1 level. Northern parts of the city are earthquake prone areas. Agricultural areas and livestock must be protected well against flood waters.

Batman:

- Flood in Batman 2006,
<http://www.hurriyet.com.tr/gundem/batmanda-sel-felaketi-8-olu-5361686>
- Flood in Batman 2014,
<https://www.haberler.com/batman-da-otomobiller-yagmur-suyunda-mahsur-kaldi-10820955-haberi/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well. Fırat (Euphrates) must be planned and observed well. The depth of the river is high in Adıyaman. Bridges and dams must be maintained periodically. The city must be prepared category 1 level. Northern parts of the city are earthquake prone areas. Livestock areas must be protected well against flood waters.

Kilis:

- Flood in Kilis 2010,
<https://www.haberler.com/kilis-te-saganak-yagmur-sele-dondu-2076812-haberi/>
- Flood in Kilis 2018,
<https://www.cnnturk.com/video/turkiye/kiliste-tahribatin-boyutu-gun-aydinlaninca-ortaya-cikti>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount

of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Afrin, Sabun, Balık and Sinnep streams must be planned and observed well. Bridges and dams must be maintained periodically. Livestocks and agricultural areas must be protected well against flood waters.

Şırnak:

- Flood in Şırnak 2018,

<https://www.ntv.com.tr/video/turkiye/sirnakta-siddetli-yagis-sele-yol-acti-2-cocuk-boguldu,46Ik9fB3iEeX1s-4IXEF7g>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 100 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Dicle (Tigris) and its tributary such as Habur and Kızılısu must be planned and observed well. Bridges and dams must be maintained periodically. Livestocks and agricultural areas must be protected well against flood waters.

Siirt:

- Flood in Siirt 2010,
<http://www.milliyet.com.tr/siirt-te-sel-sularina-kapilan-ogretmen-oldu-gundem-1157126/>

Advice 1: Roads must be maintained well and periodically. All measures must be taken against flood events, especially against electrocution from roadside. Sewage and rain collection system must be separated. Both systems and its channels must be designed or ready to collect the rainfall amount of 150 mm/h minimum. Before mostly rainy months, channels must be maintained and cleaned dependent on Table 4.10. The numbers of grids must be increased under the bridges. Swales must be built in sidewalks. Downhills roads which will accelerate waters must have underground storage tanks and be maintained periodically.

Advice 2: Settlement councils must be created for each district in the city, and the councils must produce the policies for disadvantages groups. Relief and evacuation centers are required. Erosion measurements must be taken as well. Settlements must be protected well against landslides and mudflow. Flood insurance and periodic water-proofing must be compulsory for the basement or ground floors, especially basements of hospitals must be protected well.

Advice 3: Dicle (Tigris) and its tributary such as Botan çayı must be planned and observed well. Bridges and dams must be maintained periodically. Livestocks and agricultural areas must be protected well against flood waters.

6.8. Results

Result 1: The lists of flood prone cities in Turkey were offered for each region in previous titles. The cities that average ranking points are more than 10.00 accepted as most risky cities. The study found that most flood risky cities in Turkey are **Rize 143.32, Antalya 134.81, Hatay 81.00**, Zonguldak 48.05, Istanbul 33.08, Muğla 32.94, İzmir 26.64, Gaziantep 23.07, Samsun 22.69, Mersin 22.47, Bitlis 22.39, Bursa 20.02, Giresun 19.85, Manisa 18.71, Ankara 17.49, Adana 15.36, Ağrı 12.14, Van 11.98, Şanlıurfa 11.62, Bingöl 11.51 and Ordu 11.11. Those cities are major flood disaster

cities in Turkey. Rize, Antalya and Hatay seem extreme risky. Those cities must be always active to eliminate possible disaster damages because they are very prone, and flood disaster expectations are very high in those cities. Other risky cities in Turkey explained so detailed in previous section. They must be prepared well against flood disaster too.

Table 6.17. Average Yearly Precipitation and Average Elevation in Turkey's Regions.

Rank	Region	Average Yearly Precipitation	Elevation
1.	Black Sea	798.8	152.8
2.	Mediterranean	745.5	346.1
3.	Aegean	671.2	582.9
4.	Marmara	666.2	119.8
5.	Eastern Anatolia	598.4	1418.9
6.	Southeastern Anatolia	538.7	817.6
7.	Central Anatolia	388.5	1032.7
Avr.	Turkey	629.6	638.6

Table 6.18. Flood Disaster Effects Ranking of the Regions in Turkey

Rank	Region	FRERR for 60 mm rain/hour Person/m m	FEP %	AFRF mm	EFR	Population	RFEP %	Average Ranking Percentage Points
1.	Marmara	6.22	29.88	129.37	5.91	25,033,874	85.48	57.68
2.	Southeastern Anatolia	3.13	15.03	94.13	4.30	8,847,980	31.78	23.41
3.	Black Sea	2.98	14.31	152.80	6.98	7,972,674	79.26	46.79
4.	Mediterranean	2.35	11.29	191.23	8.73	10,441,409	206.04	108.67
5.	Eastern Anatolia	2.14	10.28	95.17	4.35	6,058,499	32.56	21.42
6.	Aegean	2.13	10.23	114.92	5.25	10,529,432	82.85	46.54
7.	Central Anatolia	1.87	8.98	68.40	3.12	13,114,013	41.57	25.28
Total	Regions	20.82	100					

1-Mediterranean	108.67	5-Central Anatolia	25.26
2-Marmara	57.68	6-Southeastern Anatolia	23.41
3-Black Sea	46.79	7-Eastern Anatolia	21.42
4-Aegean	46.54		

Result 2: The study found that Black Sea is the third flash flood disaster affected region although the average precipitation is the first among the regions. Only Rize city increases average yearly precipitation of the Black Sea extremely. Average yearly precipitation of Black Sea and Mediterranean region seem close to each other in Table 6.17. The average yearly precipitation of Mediterranean would be higher than Black Sea when Rize is excluded.

Result 3: The total population of Mediterranean is 2.5 million higher than Black Sea, which increases the possible affected people from flood disasters. Climate trend supports extreme events in Mediterranean region so much than Black Sea as well. For example, Hatay which has 1,125 mm average yearly precipitation in Mediterranean region was exposed to daily 432.1 mm rainfall on 5 May, 2001, which was highest in the city's past. Furthermore, Antalya which has 1058.3 mm average yearly precipitation was exposed to 333.5 mm daily rainfall on 22 January 1998. However, Rize which has 2,296.1 mm average yearly precipitation in Black Sea region as first ranked city was exposed to daily maximum 244 mm rainfall on 7 July, 1929, which is lower than Hatay and Antalya. Even this information is enough to express that climate trend supports extreme events in Mediterranean region so much than Black Sea region. Forest fire potential is higher in Mediterranean than Black Sea as well, which means green area losses, higher erosion rate, higher debris flood and mudflow potential. Extreme maximum rainfall event in Black sea region was observed in Zonguldak on 1 August 1955 according to Turkish State Meteorological Service, which was daily 431.5 mm rainfall. Disaster managers must be aware that Zonguldak and close cities are prone to flood disaster, mudflow and debris floods.

Result 4: The study found that Marmara is the second mostly affected region from flood disaster although the average yearly precipitation is lower than Black Sea region because Marmara region is approximately 17 million people higher than Black Sea, which becomes enough to make it the second affected region in Turkey. Even small amount of rainfalls can lead to most losses than black sea due to extreme population and its density.

Result 5: Aegean region seems close to Black sea in rankings as well. It is about population again because Aegean region has 2.6 million more population than Black sea. When future trend is

considered, Aegean region might be more affected region from flood events than Black sea if population and its density increase.

Result 6: The average yearly precipitation is very low in Central Anatolia; however, population is higher, approximately two times than Eastern Anatolia region. Elevation of Central Anatolia is lower than Eastern Anatolia as well; therefore, high precipitation and snow accumulation in Eastern Anatolia's mountains can flow towards the close cities in Central Anatolia. Snowmelt flood and debris floods can be observed in Central Anatolia due to this elevation difference between Central and Eastern Anatolia. Central Anatolia remains in the confluence zones of Yeşilırmak and Kızılırmak as well; therefore, all these factors become enough to make the region fifth affected region even though average yearly precipitation is lowest region in Turkey.

Result 7: Southeastern Anatolia and Eastern Anatolia remain in the confluence zone of Euphrates and Tigris. The population of Southeastern is nearly 3 million higher than Eastern Anatolia and the elevation of the region is very low compared to Eastern Anatolia. Snow accumulation is very high in the Eastern Anatolia as well. Euphrates and Tigris roughly flow toward southeastern Anatolia from Eastern Anatolia, which makes the southeastern cities prone to riverine, snowmelt and debris flood, especially floods from the mountains that accumulates great snow volume in winter times. All these factors become enough to make the city more affected region from the floods compared to the Eastern Anatolia. Central Anatolia is not risky due to precipitation but about high population; however, Southeast and Eastern Anatolian regions are risky due to precipitation and snow accumulation even though their population is lower than Central Anatolia. When the flash flood effect is considered, southeastern Anatolia and Eastern Anatolia can exceed the Central Anatolia so easily in future trend because the values of those three regions seem so close to each other.

Result 8: There are 26 basins in Turkey. Especially 12 basins seem very risky among those 26 basins, which can create major flood damages and losses compared to the others. Those highly risky basins are like that respectively; 1-Eastern Black Sea Basin, 2-Middle Mediterranean Basin, 3-Küçük Menderes Basin, 4-Dicle (Tigris) Basin, 5-Yeşilırmak Basin, 6-Fırat (Euphrates), 7-Kızılırmak Basin, 8-Eastern Mediterranean Basins, 9-Sakarya Basin, 10-Büyük Menderes, 11-Western Black Sea Basin and 12-Asi Basin. Major flood damages and losses in Turkey can be minimized when those basins are managed well. Other remaining basins in Turkey are 13-Konya Closed Basin, 14-Ceyhan Basin, 15-Seyhan Basin, 16-Western Mediterranean Basin, 17-Meriç-Ergene (Evros-Maritsa) Basin, 18-Marmara Basin, 19- Aras Basin, 20-North Aegean Basin, 21- Çoruh Basin, 22- Burdur Lakes Basins, 23-Susurluk Basin, 24-Akarçay Basin, 25-Gediz Basin and 26- Van Basin. All those basins must be

managed well to prevent flood damages and losses. For all these basins, regional councils must be created in Turkey to audit the basins except for DSI. Directive 2007/60/EC on the assessment and management of flood risks can be reached from this link, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060>, which may be a pathfinder for the managers and citizens. Coordination among state organizations, companies and public against disaster are very important. Without coordination, it is not possible to be successful in the flood events. Tasks or duties must be determined with flood regulations. Institutions, organizations, companies, rescuers and citizens must know their tasks very well under the possible flood events. Revisions, updating, new regulations and the quality of those regulations are required always against complicated situation or the insufficiencies. The undetermined tasks among organizations cause to increase flood risks, losses, the damages or the disaster severity. It is clear that some water resources or lands cover the area of municipalities, provinces, or countries. The situation creates complicity, and it makes difficult to manage the flood risks too. Arrangements are required to cope with this complicity. Those arrangements might be national law, international law, state or union regulations, or other rules. States, authorities, managers and their tasks upon flood management issue need clear determinations. All these basins at above must be audited and managed by regional council against disasters or damages. Settlements must be managed against disasters by settlement councils and coastal council for coastal cities. All these efforts will support the sustainable cities, regions and countries, which help to transform those places in a balanced environment and eliminate disaster risks, damages and losses in there.

Result 9: Many municipality managements or governments that gave permission in the past to the home or buildings, or sectors in flood prone area inappropriately in Turkey and in other countries must implement compulsory flood insurance system to the people, especially the ones that live in highly flood risk regions until they rehabilitate those areas in a sustainable way. Buildings need solutions against flood events or risks. People must have flood disaster insurance automatically against a flood event. Governments must work together with insurance companies against all kind of natural disaster, not to witness disaster damages or losses so much.

7. CONCLUSION

In conclusion, main reasons of flood losses or damages researched in this study, and solutions produced dependent on the reasons or insufficiencies. Flood events that caused great damages or losses in the past became a guide for preventive solutions. River basins, low lying settlement areas, agricultural, industrial and rural areas, cities, hillsides, high population and high precipitation areas, settlements that close to water resources are risky regions for flood events. Those places need continuous observations, measures, preventive approaches, flood plans, strong infrastructures, early warning systems, hydrological and meteorological predictions, flood parameters, green solutions, struggle and advices as components to minimize the risks, damages and losses. The research aimed to explain those components to prevent flood events. The study introduced new flood equations to predict the risky places. The flood risks of regions as well as the flood risky cities in the Turkey through AFRF, EFR, FRERR, FEP and RFEP values were predicted. The settlements or cities can be predicted and evaluated by Anil Imperial Color System except for those values as well. In this work, conventional flood parameters and management concepts were questioned while new ones were produced. Formulation and determination of limit value of those parameters became a goal too, and a new flood parameter structure emerged through the determined parameters and its limits values. This study can be useful to predict flood risky places in regions or sub-regions or cities and prevent losses or damages due to flood or other disasters. Shortly, when those efforts in this study save a life in the future, the author of this work will feel serenity and peace, and understand that the work reached its exact aims.

REFERENCES

Abbott, P.F., Tabony, R.C., 1985. The estimation of humidity parameters, Meteorological Magazine, 114, 49-56.

Africa Recovery, United Nations, 2000. Floods take a serious economic toll, Vol.14#3 (October), page 13 (Part of Mozambique: Country in Focus). New York, NY 10017, U.S.A.

Airbus, Sentinel-5P Satellite Image,

<https://www.airbus.com/newsroom/press-releases/es/2017/08/Sentinel-5-Precursor-begins-final-journey-to-launch-site.html>. Date accessed January 2019.

Akcakocatv.com, 2016 Flood in Düzce,

http://www.akcakocatv.com/haber-detay.asp?id=10092&Sel_nedeniyle_200_ev_bosaltildi.

Date accessed February 2019.

Akşam, 2011. Flood disaster in K. Maraş,

<https://www.aksam.com.tr/yasam/kahramanmarasta-sel-felaketi--47208h/haber-47208>.

Date accessed February 2019.

Akşam, 2011. Flood in Osmaniye,

<https://www.aksam.com.tr/yasam/osmaniyede-sel-felaketi--47414h/haber-47414>.

Date accessed February 2019.

Akşam, 2014. Flood in Çorum,

<https://www.aksam.com.tr/guncel/corumda-sel-1-olu/haber-311156>. Date accessed February 2019

Akşam, 2015. Flood in Mardin,

<https://www.aksam.com.tr/yasam/nusaybinde-sel-baskini/haber-456304>. Date accessed March 2019.

Aksam, 2017. Sakarya flood disaster-Agricultural areas remained under water,

<https://www.aksam.com.tr/yasam/sakaryada-sel-felaketi-tarim-arazileri-sular-altinda-kaldi/haber-635529> . Date accessed February 2019.

Aljazeera News, 2017. Floods kill over 1,200 in India, Nepal and Bangladesh,
<https://www.aljazeera.com/news/2017/08/floods-kill-1200-india-nepal-bangladesh-170826230610924.html>. Date accessed March 2018.

Anadolu Agency, 2016. Flood in Ordu,
<https://www.aa.com.tr/tr/gunun-basliklari/orduda-sel-felaketi-2-olu/603283>.
 Date accessed February 2019.

Arizona University, Table of saturation mixing ratios, Hydrology & Atmospheric Sciences,
http://www.atmo.arizona.edu/students/courselinks/fall12/atmo336/lectures/sec1/Saturation_Mixing_Ratio_Tables.htm. Date accessed September 2018.

Arnoldus, H. M. L., 1980. An approximation of rainfall factor in the Universal Soil Loss Equation Assessment of erosion (M. De Boodt & D. Gabriels, eds.), Wiley, Chichester, U.K, 127-132.

Aydınlık, 2019. Two deaths in Antalya cyclone,
<https://www.aydinlik.com.tr/antalya-daki-hortumda-can-kaybi-2-ye-yukseldi-turkiye-ocak-2019>.
 Date accessed February 2019.

Baidya, S., 2017. Facts Legend Webpage-30 Yellow River Facts: Everything you need to know,
<https://factslegend.org/30-yellow-river-facts-everything-you-need-to-know/>.
 Date accessed May 2018.

Barabanova, K., 2014. The St. Petersburg Flood of 1824, Environmental & Society Portal,
<http://www.environmentandsociety.org/arcadia/st-petersburg-flood-1824>. Date accessed May 2017.

Bariot, 2007. Orographic lifting and rain shadow,
https://en.wikipedia.org/wiki/File:Rainshadow_copy.jpg, Date accessed August 2018.

Barro, J.R., Lee, J., 2010. A New Data Set of Educational Attainment in the World, 1950-2010, National Bureau of Economic Research, 1050 Massachusetts Avenue, Cambridge, U.S.A.

BBC News, 2002. Floods Costs into 'millions',
http://news.bbc.co.uk/2/hi/uk_news/scotland/2166701.stm. Date accessed August 2017.

BBC News, 2010. China's Three Gorges dam faces flood test, <https://www.bbc.co.uk/news/world-asia-pacific-10695272>. Date accessed July 2016.

BBC News, 2013. India floods: More than 5,700 people 'presumed dead', <https://www.bbc.com/news/world-asia-india-23282347>. Date accessed March 2018.

BBC News, 2018. Kerala floods: Relief teams rescue 22,000 as rain ease, <https://www.bbc.com/news/world-asia-india-45242793>. Date accessed September 2018.

Bhattacharya, T., 2012. Disaster Science and Management, Tata McGraw Hill Education Private Limited, New Delhi, India.

Blair, J.L., Eaton, L.S., Larsen, M.C., Wiecek, G.F., 2001. Debris-flow and flooding hazards associated with the December 1999 storm in coastal Venezuela and strategies for mitigation, Open File Report, 01-10144, U.S. Geological Survey.

Bidawi, P., 2013. India floods: a man-made disaster, The Guardian, International edition, <https://www.theguardian.com/commentisfree/2013/jun/28/india-floods-man-made-disaster>. Date accessed April 2018.

Binghamton-NY.gov-A Bioswale in Binghamton, The City of Binghamton Information Brochure, <http://www.binghamton-ny.gov/sites/default/files/files/2%20Bioswale%20Brochure%20May%202016.pdf>. Date accessed February 2019.

Buckley, S., 2006. What caused Philippines landslide? , BBC News, <http://news.bbc.co.uk/2/hi/asia-pacific/4723770.stm>, Date accessed September 2018.

Bursadabugün.com, 2014. Bursa remained under water, flood dragged the paving stones, <http://www.bursadabugun.com/haber/bursa-sular-altinda-sel-kaldirim-taslarini-surukledi-455350.html>. Date accessed February 2019.

Byers, A., Recharte, J., 2015. As glacial floods threaten mountain communities, a global exchange is fostering adaptation, NewSecurityBeat, the blog of Environmental Change and Security Program,

<https://www.newsecuritybeat.org/2015/04/glacial-floods-threaten-mountain-communities-global-exchange-fostering-adaptation/>. Date accessed September 2017.

CBC News, 2006. 1,500 missing as Philippine village buried,
<https://www.cbc.ca/news/world/1-500-missing-as-philippine-village-buried-1.616981>.
 Date accessed September 2018.

Central Intelligence Agency (CIA) Intelligence Memorandum, 1972. North Vietnam's Agriculture: Aftermath of the 1971 Floods, Directorate of Intelligence, U.S.A.

CNES-CALIPSO Spacecraft Image,
<https://cnes.fr/en/web/CNES-en/4091-calipso-to-launch-end-october.php>. Date accessed January 2019.

CNES Satellite Image,
<https://swot.cnes.fr/en/SWOT/index.htm>. Date accessed January 2019.

CNN, 1998. Floods spread misery across Asia: China, India, Japan, Bangladesh cope with devastation,
<http://edition.cnn.com/WORLD/asiapcf/9808/29/asia.flood.wrap/>. Date accessed October 2017.

CNN, 2010. Pakistan flood damage estimated at \$ 9.7 billion,
<http://edition.cnn.com/2010/WORLD/asiapcf/10/14/pakistan.flood.cost/index.html>.
 Date accessed September 2017.

CNN, 2017. Tsunami of 2004 Fast Facts,
<https://edition.cnn.com/2013/08/23/world/tsunami-of-2004-fast-facts/index.html>.
 Date accessed July 2018.

CNN TÜRK, 2009. Flood in Amasya 2009,
<https://www.cnnturk.com/2009/turkiye/05/23/amasyada.sel.1.olu/527860.0/index.html>.
 Date accessed February 2019.

CNN TÜRK, 2011. Flood in Gaziantep 2011,
<https://www.cnnturk.com/2011/turkiye/04/11/guneydoguda.sel.felaketi.1.olu.2.kayip/612824.1/inde>

x.html. Date accessed March 2019.

CNN TÜRK, 2012. Flood in Gaziantep,

<https://www.cnnturk.com/2012/turkiye/10/25/gaziantep-te-se-3-olu/681943.0/index.html>.

Date accessed March 2019

CNN TÜRK, 2014. A child drowned in Manisa flood,

<https://www.cnnturk.com/haber/turkiye/denizli-aydin-yolu-sele-teslim>. Date accessed February 2019.

CNN TÜRK, 2015. Adana Flood,

<https://www.cnnturk.com/video/turkiye/adanada-siddetli-yagis-hayati-felc-etti>.

Date accessed February 2019.

CNN TÜRK, 2017. Flood in Serinhisar,

<https://www.cnnturk.com/video/turkiye/denizliyi-sel-vurdu>. Date accessed February 2019.

CNN TÜRK, 2017. Yalova Flood, <https://www.cnnturk.com/video/turkiye/yalovayi-sel-aldi>.

Date accessed February 2019.

CNN TÜRK, 2018. Flood in Adıyaman 2018,

<https://www.cnnturk.com/turkiye/adiyamanda-sel-ve-heyelan-hasara-yol-acti?page=1>.

Date accessed March 2019.

CNN TÜRK, 2018. Flood in Bartın 2006,

<https://www.cnnturk.com/turkiye/bartinda-sel-felaketinin-bilancosu>. Date accessed February 2019.

CNN TÜRK, 2018. Flood caused death and missing in Muğla,

<https://www.cnnturk.com/video/turkiye/muglada-sel-can-aldi>. Date accessed February 2019.

CNN TÜRK, 2018. Flood in Denizli,

<https://www.cnnturk.com/turkiye/denizliyi-sel-vurdu>. Date accessed February 2019.

CNN TÜRK, 2018. Flood in Elazığ 2018,

<https://www.cnnturk.com/turkiye/elazigda-sel-25-kucukbas-telef-oldu?page=4>.

Date accessed February 2019

CNN TÜRK, 2018. Flood in Giresun 2018,

<https://www.cnnturk.com/guncel/giresunda-hastane-sular-altinda-kaldi?page=1>.

Date accessed February 2019.

CNN TÜRK, 2018. Heavy rain caused flood in Bodrum,

<https://www.cnnturk.com/video/turkiye/bodrumda-kuvvetli-saganak-sele-neden-oldu>.

Date accessed February 2019.

CNN TÜRK, 2018. Flood in Kırıkkale,

<https://www.cnnturk.com/turkiye/saganak-ve-sel-bu-kez-kirikkaleyi-vurdu?page=1>. Date accessed

February 2019.

CNN TÜRK, 2018. Flood in Kırşehir,

<https://www.cnnturk.com/turkiye/kirsehirde-sel-sonrasi-kriz-masasi-olusturuldu>. Date accessed

February 2019.

CNN TÜRK, 2018. Flood in Kilis,

<https://www.cnnturk.com/video/turkiye/kiliste-tahribatin-boyutu-gun-aydinlaninca-ortaya-cikti>.

Date accessed March 2019.

CNN TÜRK, 2018. Flood in Mamak,

<https://www.cnnturk.com/video/turkiye/mamaktaki-sel-felaketinde-yeni-goruntuler-ortaya-cikti>.

Date accessed February 2019.

CNN TÜRK, 2018. Flood in Muş: Two deaths,

<https://www.cnnturk.com/video/turkiye/musta-sel-can-aldi-2-olu>. Date accessed February 2019.

CNN TÜRK, 2018. Flood in Ordu,

<https://www.cnnturk.com/turkiye/ordudaki-sel-felaketinin-bilancosu-aciklandi-tam-bin-100-ton>.

Date accessed February 2019. .

CNN TÜRK, 2018. Flood in Şanlıurfa 2018,

<https://www.cnnturk.com/video/turkiye/sanliurfada-sele-kapilan-13-yasindaki-cocuk-hayatini->

kaybetti. Date accessed March 2019.

CNN TÜRK, 2018. Yalova flooded within 30 minutes,
<https://www.cnnturk.com/video/turkiye/yalova-30-dakikada-sele-teslim-oldu>.

Date accessed February 2019.

CNN TÜRK, 2019. Two people rescued in Osmaniye from flood at the last moment,
<https://www.cnnturk.com/video/turkiye/sel-sularinin-ortasinda-kalan-iki-kisi-son-anda-kurtarildi>.

Date accessed February 2019.

Chinadaily, Fighting China's Floods,
<http://www.china.org.cn/english/features/flood/131816.htm>. Date accessed October 2017

Chinadaily, Yangtze River cancerous with pollution,
http://www.chinadaily.com.cn/china/2006-05/30/content_604228.htm. Date accessed May 2017.

Chinasage, China's Geography: its Mountains, Basins, Rivers and Plains,
<http://www.chinasage.info/geography.htm>. Date accessed August 2017.

Chinasage, The Yellow River-Huang He,
<http://www.chinasage.info/yellowriver.htm>. Date accessed August 2017.

Courtney, C., 2018. The Nature of Disaster in China: The 1931 Yangzi River Flood, University of Cambridge, Cambridge University Press, Cambridge, U.K.

Cumhuriyet, 2010. Two deaths in Aydın flood 2010,
http://www.cumhuriyet.com.tr/haber/diger/203436/Aydin_da_sel_2_olu.html. Date accessed February 2019.

Cumhuriyet, 2014. Flood demolished the bridge in Bursa,
http://www.cumhuriyet.com.tr/haber/turkiye/124489/Bursa_da_sel_kopruyu_yikti.html.

Date accessed February 2019.

Cumhuriyet 2014. Flood in Gökçeada,
http://www.cumhuriyet.com.tr/haber/turkiye/67259/Gokceada_da_sel_felaketi.html. Date accessed

February 2019.

Cumhuriyet, 2014. Infrastructure' disaster, not flood in İstanbul, http://www.cumhuriyet.com.tr/haber/turkiye/96421/istanbul_da_sel_degil_altyapi_felaketi.html . Date accessed February 2019.

Dartmouth College, 1995. Flood Archive: 1995 Global Register of Major Flood Events, <http://www.dartmouth.edu/~floods/Archives/1995sum.htm>. Date accessed September 2017.

Davis, L.A., 2008. Natural Disasters, New Edition, Facts on File, Inc., New York, U.S.A.

Dawn, 2010. Pakistan: Homeless and hungry attack aid convoys, <https://www.dawn.com/news/857682>. Date accessed September 2017.

Dawn, 2011. Ten worst disasters in Pakistan, <https://www.dawn.com/news/661518>. Date accessed September 2017.

Delta Works, 2004. The North Sea Flood of 1953, <http://www.deltawerken.com/The-Flood-of-1953/1523.html>. Date accessed August 2018.

Dewan, A.M., Nishigaki, M., Komatsu, M., 2003. Floods in Bangladesh: A comparative hydrological investigation on two catastrophic events, Okayama University, Japan, Journal of the Faculty of Environmental Science and Technology, Vol.8, No.1, 53-62.

Directive 2007/60/EC on the assessment and management of flood risks, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060>. Date accessed November 2011.

Directory.eoportal.org- Sun glints off atmospheric ice crystals (circled in red) in this view captured by NASA's EPIC instrument on NOAA's DSCOVR satellite, <https://directory.eoportal.org/web/eoportal/satellite-missions/d/dscover>. Date accessed January 2019.

DSİ, I. National Flood Symposium, 10-12 May 2006, Ankara,

DSİ, II. National Flood Symposium, 20-22 March 2010, Afyonkarahisar,

DSİ, III National Flood Symposium, 29-30 April 2013, İstanbul.

DSİ, IV. National Flood Symposium, 23-25 November 2016, Rize

DutchNews.nl, 2016. Heavy storms over Holland bring flash flood, tear down trees, <https://www.dutchnews.nl/news/2016/06/heavy-storms-over-holland-bring-flash-floods-tear-down-trees/>. Date accessed June 2016.

Earthquake Engineering Research Institute (EERI) Special Earthquake Report, 2005. The Great Sumatra Earthquake and Indian Ocean Tsunami of December 6, 2004. Supported by National Science Foundation (NSF), Oakland, U.S.A.

Economist, 2017. Hurricane Harvey has exposed the inadequacy of flood insurance, <https://www.economist.com/news/finance-and-economics/21728631-flood-risk-tricky-insure-and-state-intervention-hinders-much-it>. Date accessed September 2017.

Emergency Management Australia Booklet-What to do before, during & after a flood, Australian Government, Attorney-General's Department, http://www.bom.gov.au/water/floods/document/What_todo_floods.pdf. Date accessed January 2019.

Emmanuel Hospital Association Report, 2018. Overall Update on Kerala Flood Relief of 2018 3rd September 2018, Disaster Management & Mitigation Unit, New Delhi, India.

Encyclopedia Britannica, North Sea Flood: Storm Surge, North Sea 1953, <https://www.britannica.com/event/North-Sea-flood>. Date accessed August 2018

Encyclopedia Britannica, Rajputana- Historical Region of India, <https://www.britannica.com/place/Rajputana/>. Date accessed May 2018.

Ensonhaber.com, 2004. Flood disaster in Uşak, <https://videonuz.ensonhaber.com/izle/usak-ta-sel-felaketi>. Date accessed February 2019.

Ensonhaber.com, 2011. Flood in Ordu, <https://www.ensonhaber.com/orduda-son-50-yilin-felaketi-yasandi-2011-08-19.html>. Date accessed February 2019.

Ensonhaber.com, 2014. Flood in İzmir,
<https://www.ensonhaber.com/izmirde-sel-felaketi-1-olu-2014-08-07.html>. Date accessed February 2019.

Ensonhaber.com. 2014, Road collapsed in Ankara due to flood,
<https://www.ensonhaber.com/ankarada-sel-nedeniyle-yol-coktu-2014-06-06.html>. Date accessed February 2019.

Ensonhaber.com, 2015. Flood in İzmir,
<https://www.ensonhaber.com/izmirde-sel-felaketi-1-olu-2014-08-07.html>. Date accessed March 2019.

ESA Cold Turkey Map on 10 January, 2019, captured by Sentinel-3,
https://www.esa.int/spaceinimages/Images/2019/01/Cold_Turkey. Date accessed January 2019.

ESA Cryosat-2 Image,
<https://www.esa.int/spaceinimages/Images/2009/09/CryoSat-2>. Date accessed January 2019.

ESA Greenland Ice Change, 2015 image,
https://www.esa.int/spaceinimages/Images/2018/11/Greenland_ice_change_2015. Date accessed January 2019

ESA Flood Map, 2014. Flood delineation map over the village of Balatun in northeastern Bosnia and Herzegovina based on Sentinel-1A data,
https://www.esa.int/spaceinimages/Images/2014/05/Flood_map. Date accessed May 2018.

ESA Flood Map, 2016. Flood delineation map generated with Sentinel-1B data,
https://sentinel.esa.int/web/sentinel/news/content/-/asset_publisher/BZewkR1itkH2/content/flood-delineation-map-generated-with-sentinel-1b-data. Date accessed May 2018

ESA-Flood Map, 2017. Queensland Flood map captured by Sentinel-2,
https://www.esa.int/spaceinimages/Images/2017/04/2017_Queensland_floods. Date accessed May 2018.

ESA Paradise Lost Map on 11 November, 2018, captured by Sentinel-5P,
<https://earth.esa.int/web/guest/content/-/article/paradise-lost>. Date accessed May 2018.

ESA Sentinel-1 SAR, Sentinel-1 Satellites,

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/overview>. Date accessed May 2018.

ESA Sentinel-2 MSI, Sentinel-2 Satellites,

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/overview>. Date accessed May 2018.

ESA Sentinel-3 OLCI, Sentinel-3 Satellites,

<https://earth.esa.int/web/sentinel/missions/sentinel-3/overview>. Date accessed January 2019.

ESA Sentinel-4 Satellite,

<https://sentinel.esa.int/web/sentinel/missions/sentinel-4/overview>. Date accessed January 2019.

ESA Sentinel-5 Satellite,

<https://sentinel.esa.int/web/sentinel/missions/sentinel-5/overview>. Date accessed January 2019.

EUMETSAT, 2018. Sentinel-3 OLCI True color, 8 May, 09:33 UTC,

https://www.eumetsat.int/website/home/Images/ImageLibrary/DAT_3913833.html. Date accessed January 2019.

Evrensel, 2002. Rize Flood

<https://www.evrensel.net/haber/132859/rize-de-urkuten-bilanco>. Date accessed February 2019.

Evrensel, 2010. Flood in Ağrı,

<https://www.evrensel.net/haber/187904/agri-da-3-bin-ev-sular-altinda-1-cocuk-oldu-4-kisi-yarali>.

Date accessed February 2019.

Evrensel, 2010. Rize Flood

<https://www.evrensel.net/haber/132859/rize-de-urkuten-bilanco>. Date accessed February 2019.

FEMA: The National Flood Insurance Program,

<https://www.fema.gov/national-flood-insurance-program>. Date accessed September 2017.

Fournier, F., 1960. Climat et erosion, P.U.F. Paris.

Gabbatiss, J., 2018. Antarctica melting faster than ever before posing significant threat to coastal cities, according to major study, The Independent,
<https://www.independent.co.uk/environment/antarctica-rising-sea-levels-climate-change-global-warming-melt-flooding-a8397406.html>. Date accessed July 2018.

Gazetevatan, 2006. Flood in Vize, 2006,
<http://www.gazetevatan.com/vize-de-de-sel-baskini-81229-gundem/>. Date accessed February 2019.

Gazetevatan, 2012. Flood in Muş,
<http://www.gazetevatan.com/mus-ta-sel-baskini--442849-gundem/>. Date accessed March 2019.

Gazetevatan, 2016. Flood disaster in Denizli,
<http://www.gazetevatan.com/denizli-de-sel-felaketi-985768-yasam/>. Date accessed February 2019.

Gazetevatan, 2017. Flood in Mersin,
<http://www.gazetevatan.com/mersin-de-yagis-etkili-oldu-1053605-yasam/>. Date accessed February 2019.

Global Institute of Sustainability, Universal Soil Erosion Equation-Arizona State University,
<https://www.asu.edu/clas/shesc/projects/medland/documents/soilerosion.pdf>,
 Date accessed January 2019.

Gotoh, H., Kakehi, Y., Suzuki, K., Takezawa, M., 2014. Assessment of the flood disaster management plans for the medical services in Tokyo and Fukuoka, Japan, Risk Analysis IX, WIT Press, Vol.47, 345.

Guernseydonkey.com, Global Wind Pattern,
<http://guernseydonkey.com/?p=18039>. Date accessed October 2018.

Gunn, A.M., 2010. A Student Guide to Climate and Weather: Weather Extremes, Greenwood, ABC-CLIO, LLC, California, U.S.A.

Gunter's Space Page-CloudSat Image,
https://space.skyrocket.de/doc_sdat/cloudsat.htm. Date accessed February 2019.

Gunes, 2018. Flood and Landslide disaster in Kayseri,
<http://www.gunes.com/yasam/kayseride-sel-ve-heyelan-felaketi-861957>. Date accessed March 2019.

Haberler.com, 2006. Flood in Bitlis,
<https://www.haberler.com/bitlis-bitlis-te-sel-felaketi-2-olu-1-kayip-haberi/>. Date accessed February 2019.

Haberler.com, 2006. Flood in Diyarbakır,
<https://www.haberler.com/diyarbakir-diyarbakir-da-sel-felaketi-5-olu-haberi/>. Date accessed March 2009.

Haberler.com, 2006. Flood in Manisa: one child death and two children missing, 2006,
<https://www.haberler.com/manisa-manisa-da-sel-felaketi-1-cocuk-oldu-2-haberi/>.
 Date accessed February 2019.

Haberler.com, 2006. Flood in Mardin,
<https://www.haberler.com/mardin-guneydogu-daki-sel-felaketinin-ardindan-haberi/>. Date accessed March 2019.

Haberler.com, 2006. Flood in Tunceli 2006,
<https://www.haberler.com/tunceli-tunceli-de-sel-baskini-2-haberi/>. Date accessed March 2019.

Haberler.com, 2007. Flood in Elazığ 2007,
<https://www.haberler.com/elazig-da-sel-felaketi-haberi/>. Date accessed February 2019.

Haberler.com, 2007. Flood in Kayseri 2007,
<https://www.haberler.com/kayseri-de-suksun-kasaba-halki-afet-yardiminin-haberi/>.
 Date accessed February 2019.

Haberler.com, 2007. Flood in Van,
<https://www.haberler.com/van-da-sel-felaketi-1-olu-2-kayip-haberi/>. Date accessed February 2019.

Haberler.com, 2010. Flood in Kilis,
<https://www.haberler.com/kilis-te-saganak-yagmur-sele-dondu-2076812-haberi/>. Date accessed March 2019.

Haberler.com, 2012. 14.000 decares of cultivated fields damaged,
<https://www.haberler.com/sakarya-da-sel-ve-dolunun-bilancosu-14-bin-dekar-3642059-haberi/>
 Date accessed February 2019.

Haberler.com, 2014. Flood in Batman 2014,
<https://www.haberler.com/batman-da-otomobiller-yagmur-suyunda-mahsur-kaldi-10820955-haberi/>. Date accessed March 2019.

Haberler.com, 2014. Flood in Gaziantep,
<https://www.haberler.com/gaziantep-te-sel-faciasi-1-olu-6071088-haberi/>. Date accessed March 2019.

Haberler.com, 2014. Flood in Gümüşhane 2014,
<https://www.haberler.com/gumushane-de-sel-felaketi-6611631-haberi/>. Date accessed February 2019.

Haberler, 2015. Flood in Trabzon 2015,
<https://www.haberler.com/trabzon-da-sel-ve-heyelanlar-korkuttu-1-7641178-haberi/>.
 Date accessed February 2019.

Haberler 2015. Heavy rain in Burdur,
<https://www.haberler.com/burdur-da-siddetli-yagis-7130431-haberi/>. Date accessed February 2019.

Haberler.com, 2016. Flood in Ardahan,
<https://www.haberler.com/ardahan-da-saganak-su-baskinina-neden-oldu-8558815-haberi/>.
 Date accessed March 2019.

Haberler, 2016. One death in Kayseri flood 2016
<https://www.haberler.com/kayseri-de-sel-can-aldi-8592410-haberi/>. Date accessed February 2019.

Haberler.com, 2017. A soldier martyred in Tekirdağ Flood 2017.
<https://www.haberler.com/flas-10172681-haberi/>. Date accessed February 2019.

Haberler.com, 2017. Flood in Elazığ
<https://www.haberler.com/elazig-da-evler-sel-sulari-altinda-kaldi-9504202-haberi/>. Date accessed

February 2019.

Haberler.com. 2017. Summer rain caused to flood in Aydın,
<https://www.haberler.com/aydin-da-yaz-yagmuru-sele-dondu-9726795-haberi/>. Date accessed
 February 2019.

Haberler.com, 2018. Citizens' camera recorded the flood disaster in Tekirdağ, 2018.
<https://www.haberler.com/tekirdag-daki-sel-felaketi-vatandas-kamerasinda-10994782-haberi/>.
 Date accessed February 2019.

Haberler.com, 2018. Flood disaster in Afyon,
<https://www.haberler.com/afyonkarahisar-da-sel-felaketi-2-11102695-haberi/>. Date accessed
 February 2019.

Habertürk, 2006. Flood in Batman,
<http://www.hurriyet.com.tr/gundem/batmanda-sel-felaketi-8-olu-5361686>. Date accessed March
 2019.

Habertürk, 2006. Flood in Şanlıurfa,
<https://www.haberturk.com/yasam/haber/4209-sanliurfada-sel-felaketi-4-olu>. Date accessed March
 2019.

Habertürk, 2011. Flood in Van,
<https://www.haberturk.com/yasam/haber/649254-vanda-sel-felaketi-4-olu>. Date accessed February
 2019.

Habertürk, 2012. 1-hour rain paralyzed Yalova, 2012,
<https://www.haberturk.com/gundem/haber/757365-1-saatlik-yagmur-yalovayi-felc-etti>.
 Date accessed February 2019.

Habertürk, 2012. Unbeliveable images in Tekirdağ, 2012
<https://www.haberturk.com/gundem/haber/787640-tekirdagda-akilalmaz-goruntuler>. Date accessed
 February 2019.

Habertürk, 2012. 3 deaths in Lüleburgaz,
<https://www.haberturk.com/gundem/haber/787767-luleburgazda-sel-3-can-aldi>. Date accessed February 2019.

Habertürk, 2014. Adana Flood,
<https://www.haberturk.com/gundem/haber/955271-adanada-hayat-durdu>. Date accessed February 2019.

Habertürk, 2014. Flood paralyzed the life in Kocaeli 2014,
<https://www.haberturk.com/video/haber/izle/kocaelinde-sel-hayati-felc-etti/127900>. Date accessed February 2019.

Habertürk, 2015, Flood in Artvin,
<https://www.haberturk.com/gundem/haber/1119888-artvin-hopada-sel-felaketinde-olu-sayisi-8e-yukseldi>. Date accessed February 2019.

Habertürk, 2016. Flood in Trabzon 2016,
<https://www.haberturk.com/galeri/yasam/464047-trabzonda-sel-felaketi>. Date accessed February 2019.

Habertürk, 2018. Adana Flood 2018,
<https://www.haberturk.com/son-dakika-adana-da-siddetli-yagmur-evleri-sular-altinda-birakti-2020621> . Date accessed February 2019.

Habertürk, 2018. Flood in Bartın,
<https://www.haberturk.com/bartin-haberleri/15774130-bartinda-siddetli-yagis>. Date accessed February 2019.

Habertürk, 2018. Flood in Bayburt 2018,
<https://www.haberturk.com/bayburt-haberleri/61080730-bayburтта-saganak-yagis-etkili-oldu>.
 Date accessed February 2019.

Habertürk, 2018. Flood in Bitlis,
<https://www.haberturk.com/bitlis-haberleri/65387212-mutkide-hayat-durdusel-sulari-ve-heyelan-nedeniyle-85-yerlesim-yerine-ulasim-saglanamiyor>. Date accessed February 2019.

Habertürk, 2018. Flood in Diyarbakır,
<https://www.haberturk.com/diyarbakir-haberleri/65090965-diyarbakirda-sel-bir-koyu-ikiye-bolduergani-ilcesinde-bu-sabah-meydana-gelen-sel-nedeni-ile>. Date accessed March 2019.

Habertürk, 2018. Flood in Edirne: one missing,
<https://www.haberturk.com/edirne-haberleri/65008711-edirne-sel-1-kisi-kayip>. Date accessed February 2019.

Habertürk, 2018. Flood in Karman,
<https://www.haberturk.com/karaman-haberleri/61193650-karamanda-sel-kamyoneti-devirdi>.
 Date accessed February 2019

Habertürk, 2018. Flood in Mardin,
<https://www.haberturk.com/mardin-haberleri/65090497-kiziltepede-sel-fistik-fidelerine-zarar-verditarlalar-su-altinda-kaldi>. Date accessed March 2019.

Habertürk, 2018. Flood in Sinop,
<https://www.haberturk.com/sinop-haberleri/61608829-duragani-saganak-vurdu-hastaneyi-su-basti>
 Date accessed February 2019.

Habertürk, 2018. Flood in Tokat
<https://www.haberturk.com/tokat-haberleri/63199534-sel-sonrasi-yaralar-sariliyor>. Date accessed February 2019.

Habertürk, 2018. Flood in Yozgat,
<https://www.haberturk.com/yozyat-haberleri/61043185-yenifakilida-siddetli-yagmur-15-ev-ve-ekili-alanlara-zarar-verdi>. Date accessed February 2019.

Habertürk, 2018. Flood struck the Sakarya, Kaynarca Mayor: The situation is desperate, 2018.
<https://www.haberturk.com/son-dakika-sakarya-yi-sel-vurdu-2162572>. Date accessed February 2019.

Habertürk, 2018. Flood swallowed the vehicles,
<https://www.haberturk.com/canakkale-de-sel-araclari-yuttu-2025766>. Date accessed February 2019.

Habertürk, 2018. Landslide in Gölcük 2018, <https://www.haberturk.com/kocaeli-haberleri/65552104-golcukte-heyelan-yol-kapandi-elektrik-telleri-koptu>. Date accessed February 2019.

Habertürk, 2018. Metro trips stopped between Yenikapı and Bayrampaşa stations, <https://www.haberturk.com/son-dakika-istanbul-da-metro-seferlerine-yagis-engeli-2074927>. Date accessed February 2019.

Habertürk, 2018. 3 deaths in K. Maraş flood, <https://www.haberturk.com/tv/burasi-turkiye/video/kahramanmarasta-sel-felaketi-3-kisi-hayatini-kaybetti/499258> . Date accessed February 2019.

Habertürk, 2019. Adana Flood, <https://www.haberturk.com/adana-haberleri/66135403-sokaklarini-su-basan-vatandaslar-evlerinde-mahsur-kaldiadanada-etkili-olan-yagis-nedeniyle>. Date accessed February 2019.

Habertürk, 2019. Flood in Manisa, <https://www.haberturk.com/manisa-haberleri/66041602-manisada-metrekareye-203-kilogram-yagis-dustusel-felaketi-nedeniyle-yaklasik-180-kisi>. Date accessed February 2019.

Habertürk, 2019. Tornado again in Antalya, there are injured people, <https://www.haberturk.com/son-dakika-antalya-da-yine-hortum-yaralilar-var-2302852>. Date accessed February 2019.

History, 2009. 1962 Avalanche kills thousands in Peru, <https://www.history.com/this-day-in-history/avalanche-kills-thousands-in-peru>. Date accessed September 2018.

History, 2009. 1963 Landslide kills thousands in Italy, <https://www.history.com/this-day-in-history/landslide-kills-thousands-in-italy>. Date accessed May 2018.

History Canada, 2018. August, 1971-Mysterious flood strikes North Vietnam, <https://www.history.ca/history-topics/latest/august-1-1971-mysterious-flood-strikes-north-vietnam/>. Date accessed August 2018.

Hürriyet, 2001. Flood in Mersin, 2001,
<http://www.hurriyet.com.tr/gundem/mersin-i-sel-aldi-40722>. Date accessed February 2019.

Hürriyet, 2001. One death and five missing,
<http://www.hurriyet.com.tr/gundem/sel-1-can-aldi-5-kisi-kayip-43240>. Date accessed February 2019.

Hürriyet, 2002. Flood in Sinop 2002,
<http://www.hurriyet.com.tr/gundem/bu-kez-sinopta-sel-2-olu-3-kayip-38369787>. Date accessed February 2019.

Hürriyet, 2005. Flood in Osmaniye destroyed bridges,
<http://www.hurriyet.com.tr/gundem/osmaniye-de-sel-kopruleri-yikti-306148>. Date accessed February 2019.

Hürriyet, 2006. Flood in Ankara,
<http://www.hurriyet.com.tr/gundem/ankara-konya-karayolunda-sel-baskini-4624024>. Date accessed February 2019.

Hürriyet, 2006. Flood in Çankırı,
<http://www.hurriyet.com.tr/gundem/cankirida-sel-baskini-5177292>. Date accessed February 2019.

Hürriyet, 2007. Flood in Ağrı,
<http://www.hurriyet.com.tr/gundem/deprem-gibi-sel-8-can-aldi-6598636>. Date accessed February 2019.

Hürriyet, 2007. Flood in Samsun.
<http://www.hurriyet.com.tr/gundem/samsun-savas-alani-gibi-7145912>. Date accessed February 2009.

Hürriyet, 2007. Rize Flood 2007,
<http://www.hurriyet.com.tr/gundem/rize-de-sel-heyelan-7-olu-3-kayip-355041>.
 Date accessed February 2015.

Hürriyet, 2008. Flood in Van,

<http://www.hurriyet.com.tr/gundem/vanda-sel-1-olu-1-kayip-9620166>. Date accessed February 2019.

Hürriyet, 2009. İstanbul's Flood Disaster: 31 Deaths,

<http://www.hurriyet.com.tr/gundem/istanbulda-sel-felaketi-31-olu-12441217>.

Date accessed February 2019.

Hürriyet, 2010. 3 deaths in Antalya flood

<http://www.hurriyet.com.tr/gundem/antalyada-sel-3-can-aldi-13732674>. Date accessed February 2019.

Hürriyet, 2012. Flood in Samsun,

<https://www.sabah.com.tr/yasam/2012/07/04/samsunda-sel-faciiasi-3-olu>. Date accessed February 2019.

Hürriyet, 2014. Flood closed the roads in K. Maraş,

<http://www.hurriyet.com.tr/gundem/kahramanmarasta-sel-yollari-kapatti-27270480>, Date accessed 2019.

Hürriyet, 2014. Flood in Antalya,

<http://www.hurriyet.com.tr/gundem/antalya-siddetli-yagisa-teslim-27735961>.

Date accessed February 2019.

Hürriyet, 2014. Flood in Düzce,

<http://www.hurriyet.com.tr/gundem/duzceyi-sel-aldi-26563602>. Date accessed February 2019.

Hürriyet, 2014. Flood in Kayseri,

<http://www.hurriyet.com.tr/gundem/kayseride-sel-tehlikesi-ucuz-atlatildi-27045682>. Date accessed February 2019.

Hürriyet, 2014. Flood in Samsun,

<http://www.hurriyet.com.tr/gundem/samsunda-sel-felaketi-26864318>. Date accessed February 2019.

Hürriyet, 2014. Flood paralyzed the life in Mersin,
<http://www.hurriyet.com.tr/gundem/mersinde-yagis-hayati-felc-etti-25928988>.

Date accessed February 2019.

Hürriyet, 2015. Century's disaster in Edirne,
<http://www.hurriyet.com.tr/gundem/edirnede-yuz-yilin-felaketi-28104747>.

Date accessed February 2019.

Hürriyet, 2015. Flood in Aydın,
<http://www.hurriyet.com.tr/venedik-e-donen-aydin-da-yagmur-manzaralari-37184871>.

Date accessed February 2019.

Hürriyet, 2015. Flood in Isparta,
<http://www.hurriyet.com.tr/ispartada-dolu-ve-yagmur-sele-neden-oldu-40541280>.

Date accessed February 2019.

Hürriyet, 2015. Flood struck the Bodrum,
<http://www.hurriyet.com.tr/gundem/bodrumu-sel-vurdu-30142019>. Date accessed February 2015.

Hürriyet, 2016. Flood in Hatay,
<http://www.hurriyet.com.tr/gundem/hatayda-sel-felaketi-40115738>. Date accessed February 2019.

Hürriyet, 2017. Flood closed road in Burdur,
<http://www.hurriyet.com.tr/burdurda-sel-yolu-kapatti-40480824> . Date accessed February 2019.

Hürriyet, 2018. Flood and hail struck Aydın two times in five days,
<http://www.hurriyet.com.tr/gundem/aydinda-sel-can-aldi-1-olu-16501145>. Date accessed February 2019.

Hürriyet, 2018. Flood in Erzurum,
<http://www.hurriyet.com.tr/galeri-erzurumda-sel-felaketinin-bilancosu-agir-oldu-40844604>.

Date accessed February 2019.

Hürriyet, 2018. Flood in Tunceli,
<http://www.hurriyet.com.tr/yerel-haberler/tunceli/merkez/tuncelide-selin-tasidigi-tas-ve-toprak-yollari-40998308>. Date accessed March 2019.

Hürriyet, 2018. Kocaeli's Flood Disaster- Many people stranded 2018,
<http://www.hurriyet.com.tr/gundem/kocaelide-8-kisi-selde-kayboldu-40910836>. Date accessed February 2019.

Hürriyet, 2018. 68 sheep destroyed in Emirdağ flood, 2018,
<http://www.hurriyet.com.tr/emirdagda-sel-nedeniyle-68-kucukbas-hayvan-tel-40827995>. Date accessed February 2019.

ILO, 2010. 5.3 million Job may have been affected by the floods in Pakistan, press release,
https://www.ilo.org/islamabad/info/public/pr/WCMS_144470/lang--en/index.htm.
 Date accessed September 2017.

Independent Online (IOL) Daily News, 2018. How to deal with flash floods, South Africa,
<https://www.iol.co.za/dailynews/how-to-deal-with-flash-floods-14003899>. Date accessed February 2019.

India: South West Monsoon - Flood Situation Report, 2005. A flood report from Government of India, Published on 27 July 2005, India Meteorological Department, India.

International Federation of Red Cross and Red Crescent Societies (IFRC) Report, 2002. China: Flash Floods Appeal no: 16/2002 Operations Update No.5, Published on 31 December, 2002, Geneva, Switzerland.

International Federation of Red Cross and Red Crescent Societies (IFRC) Report, 2007. China: Floods Emergency Appeal No. MDRCN002 Operations Update No.4 Published on 03 November, 2007, Geneva, Switzerland.

JAHA, 2018. Facts about the 1889 flood: Statistics about the great disaster,
<https://www.jaha.org/attractions/johnstown-flood-museum/flood-history/facts-about-the-1889-flood/>. Date accessed September 2018.

Janardhanan, A., 2015. Chennai hospital tragedy: Power failure caused deaths, say kin, The Indian Express,
<https://indianexpress.com/article/india/india-news-india/chennai-hospital-tragedy-power-failure-caused-deaths-say-kin/>. Date accessed June 2018.

JAXA- Global Precipitation Measurement/Dual-frequency Precipitation Radar Image,
<http://global.jaxa.jp/projects/sat/gpm/>. Date accessed January 2019

Kagy, G., 2012. Long Run Impacts of Famine Exposure: A Study of the 1974-1975 Bangladesh Famine, Preliminary Draft, University of Colorado, U.S.A.

Kemink, E., 2002. Flood Management in the Lower Reach of Yellow River, M.Sc, Thesis, Delft University of Technology, Netherlands.

Kerr, J., 2014. Tropical Cyclone Mahina: Bid to have deadly March 1899 weather event upgraded in record books,

<http://www.abc.net.au/news/2014-12-26/cyclone-mahina/5964342>. Date accessed September 2018

Kirby, A., 2001. Plan to tame Yangtze floods, BBC News,
<http://news.bbc.co.uk/2/hi/science/nature/1595327.stm> . Date accessed October 2017.

Kocaelihaberci.com, 2013. İzmit Flood, <http://www.kocaelihaberci.com/izmit-sele-teslim-h4026.html> . Date accessed February 2019.

Li, R., 2001. General Introduction to the Yellow River, Draft version, Delft, Netherlands.

Lorge, P., 2005. War, Politics and Society in Early Modern China, 900-1795, Routledge, Taylor and Francais Group, London and New York, U.S.A.

MacDonald, M., 2018. What to do if your car is trapped in a flash flood, Suzuki Auto,
<https://blog.suzukiauto.co.za/blog/what-to-do-if-your-car-is-trapped-in-a-flash-flood>. Date accessed February 2019.

Manguard, S., 2010. The Himalayas Map,
https://commons.wikimedia.org/wiki/File:Himalayas_Map.png. Date accessed November 2017.

Manning's n values, 2018. Forestry Sciences Laboratory, Oregon State University,
http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm,
 Date accessed November 2018.

Manisahaberler.com, 2018-Flood in Manisa,
<http://www.manisahaberleri.com/manisa/son-yillarin-en-buyuk-sel-felaketi-h85538.html>.
 Date accessed February 2019.

Marmarahaber.com, 2013. Flood in Kırklareli,
<http://www.marmarahaber.com.tr/haber/18709/kirklarelinde-sel-baskini.html>. Date accessed
 February 2019.

Met Office, 2018. Altostratus Clouds,
<https://www.metoffice.gov.uk/learning/clouds/mid-level-clouds/altostratus>.
 Date accessed October 2018.

Met Office, 2018. Stratocumulus Clouds,
<https://www.metoffice.gov.uk/learning/clouds/low-level-clouds/stratocumulus>.
 Date accessed October 2018.

Milliyet, 2010. Flood in Siirt,
<http://www.milliyet.com.tr/siirt-te-sel-sularina-kapilan-ogretmen-oldu-gundem-1157126/>.
 Date accessed March 2010.

Milliyet, 2011. Flood in Tekirdağ 2011,
<http://www.milliyet.com.tr/tekirdag-i-sel-aldi--gundem-1441812/>. Date accessed February 2019.

Milliyet, 2014. Flood disaster in Kütahya: one death,2014,
<http://www.milliyet.com.tr/kutahya-da-sel-felaketi-1-olu-kutahya-yerelhaber-380726/>.
 Date accessed February 2019.

Milliyet 2014, Flood in Kastamonu,
<http://www.milliyet.com.tr/kastamonu-da-sel-hayati-felc-etti-kastamonu-yerelhaber-237131/>.
 Date accessed February 2019.

Milliyet 2014, Flood in Osmaniye,
<http://www.milliyet.com.tr/osmaniye-de-siddetli-yagmur-sele-donustu-osmaniye-yerelhaber-322534/> . Date accessed February 2019.

Milliyet 2015. Flood destroyed pedestrian bridge,
<http://www.milliyet.com.tr/kadirli-de-sel-sulari-yaya-koprusunu-osmaniye-yerelhaber-557501/>.
 Date accessed February 2019.

Milliyet, 2015. Flood in Iğdır,
<http://www.milliyet.com.tr/sel-felaketinin-bilancosu-agir-oldu-igdir-yerelhaber-947677/>.
 Date accessed February 2019

Milliyet, 2015. Flood in Sakarya caused to deaths,
<http://www.milliyet.com.tr/sakarya-da-sel-can-aldi-gundem-2078322/>. Date accessed February 2019.

Milliyet, 2016. Flood in Nazilli,
<http://www.milliyet.com.tr/aydin-da-sel-hayati-felc-etti-gundem-2292965/>. Date accessed February 2019.

Milliyet, 2017. Flood in Ağrı,
<http://www.milliyet.com.tr/agri-da-sel--yerelhaber-2227054/>. Date accessed February 2019.

Milliyet, 2017. Heavy rain in Uşak, 2017,
<http://www.milliyet.com.tr/usak-ta-saganak-yagis-usak-yerelhaber-2308700/>. Date accessed February 2019.

Miliyet, 2017. Flood in Kastamonu,
<http://www.milliyet.com.tr/kastamonu-da-saganak-ve-sel-gundem-2463879/>. Date accessed February 2019.

Milliyet, 2017. The city remained under the floodwaters. Even vehicles dragged in İzmir,
<http://www.milliyet.com.tr/izmir-de-sokaklar-dereye-dondu-gundem-2459099/>. Date accessed February 2019.

Milliyet, 2017. Unbelievable images in İstanbul, <http://www.milliyet.com.tr/son-dakika-istanbul-da-saganak-gundem-2492144/>. Date accessed July 2017.

Milliyet, 2018. Flood in Konya, 2018

<http://www.milliyet.com.tr/sel-felaketinin-yasandigi-bolge-de-121-konya-yerelhaber-2862308/>. Date accessed February 2019.

Milliyet, 2019. Flood in Hatay

<http://www.milliyet.com.tr/hatay-da-siddetli-yagis-bentleri-yikti-hatay-yerelhaber-3229901/>. Date accessed February 2019.

NASA Aura-Aerosol Satellite Image captured by Aura,

<https://aura.gsfc.nasa.gov/science/feature-20120305c.html> . Date accessed January 2019.

NASA Aura-Aura Satellite Image,

<https://aura.gsfc.nasa.gov/about.html>. Date accessed January 2019.

NASA Earth Observatory- NASA's Aqua Satellite,

<https://earthobservatory.nasa.gov/features/OrbitsManeuver>. Date accessed January 2019.

NASA Earth Observatory, 2004. Floods in India and Bangladesh,

<https://earthobservatory.nasa.gov/images/4642/floods-in-india-and-bangladesh>,

Date accessed July 2018.

NASA Earth Observatory, 2004. Severe floods sweep across Haiti and the Dominican Republic,

<https://earthobservatory.nasa.gov/images/13253/severe-floods-sweep-across-haiti-and-the-dominican-republic>. Date accessed September 2018.

NASA Earth Observatory, 2006. Flooding in the Southern Philippines,

<https://earthobservatory.nasa.gov/images/16116/flooding-in-the-southern-philippines>.

Date accessed September 2018.

NASA Earth Observatory, 2018. Kerala Flood 2018 captured by Sentinel 2,

<https://earthobservatory.nasa.gov/images/92669/before-and-after-the-kerala-floods>. Date accessed January 2019.

NASA Goddard Space Flight Center-Precipitation Measurement Mission, TRMM Satellite Image,

<https://pmm.nasa.gov/image-gallery/trmm-satellite>. Date accessed January 2019.

NASA Goddard Space Flight Center-Tropical Rainfall Measuring Mission (TRMM),
<https://trmm.gsfc.nasa.gov/>. Date accessed January 2019.

NASA Sea Level Change observations from space- Jason-3 begins mapping the ocean,
<https://sealevel.nasa.gov/resources/82/jason-3-begins-mapping-the-ocean>. Date accessed January 2019.

NASA Visible Earth-Aqua Satellite Image, Record Low Snowpack in Afghanistan,
<https://visibleearth.nasa.gov/view.php?id=91851>. Date accessed January 2019.

NASA Visible Earth, 2008. Floods on the Yellow River,
<https://visibleearth.nasa.gov/view.php?id=19723>. Date accessed May 2017.

NASA, 2011. Hurricane Bill nears Cuba in 2009. A vertical profile from the Cloud-Aerosol Lidar and Infrared Pathfinder satellite (CALIPSO) is overlaid on an image from the Moderate-resolution Imaging Spectroradiometer (MODIS),
<https://www.nasa.gov/topics/earth/features/diabar.html>. Date accessed January 2019.

NASA Jet Propulsion Laboratory (JPL)-CloudSat passes over Hurricane Michael,
<https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA22753>. Date accessed January 2019.

NASA Jet Propulsion Laboratory (JPL)-Grace Data,
<https://gracefo.jpl.nasa.gov/data/grace-data/>. Date accessed January 2019.

NASA Jet Propulsion Laboratory (JPL)-GRACE-FO tracks the evolution of Earth's water cycle by monitoring changes in the distribution of mass on Earth,
<https://gracefo.jpl.nasa.gov/news/140/grace-fo-resumes-data-collection/>. Date accessed January 2019.

NASA Jet Propulsion (JPL)-GRACE FO Indian Ocean December 2004 Earthquake Signal,
https://www.jpl.nasa.gov/news/press_kits/grace-fo/mission/why-more-grace/. Date accessed January 2019.

NASA Jet Propulsion (JPL)- Ocean Surface Topography from Space, Jason-3 Satellite Image,
<https://sealevel.jpl.nasa.gov/missions/jason3/>. Date accessed January 2019.

NASA Jet Propulsion Laboratory (JPL)-Tigris and Euphrates Water Storage, 2003-2009,
<https://gracefo.jpl.nasa.gov/resources/60/tigris-and-euphrates-water-storage-2003-to-2009/>.

Date accessed January 2019.

Nash, J.R., 1976. Darkest Hours: A narrative encyclopedia of worldwide disasters from ancient times to present, The Rowman & Littlefield Publishing Group, Inc., Maryland, U.S.A.

National Flood Relief Commission (NFRC) Report, 1933. Republic of China Report of the National Flood Relief Commission 1931-1932. National Flood Relief Commission (NFRC), Shanghai, China.

Natural Resources Conservation Service (NRCS) New Jersey-United States Department of Agriculture (USDA)-Contour Farming Image,

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/technical/cp/?cid=nrcs141p2_018675.

Date accessed February 2019.

Natural Water Retention Measures (nwrn.eu)-A retention pond image,

<http://nwrn.eu/measure/retention-ponds>. Date accessed February 2019.

NOAA-Deep Space Climate Observatory, Satellite and Information Service,

<https://www.nesdis.noaa.gov/content/dscovr-deep-space-climate-observatory>.

Date accessed January 2019.

NTV, 2008. Flood in Şırnak 2018,

<https://www.ntv.com.tr/video/turkiye/sirnakta-siddetli-yagis-sele-yol-acti-2-cocuk-boguldu,46Ik9fB3iEeX1s-4IXEF7g>. Date accessed March 2019.

NTV, 2009. Flood in Düzce 2009,

<https://www.ntv.com.tr/turkiye/duzcede-sel-yollari-cokertti,yVCNg26hqUyrnEZ8xLGBCQ>. Date accessed February 2019.

NTV, 2009. Flood in Giresun 2009,

https://www.ntv.com.tr/turkiye/giresunu-sel-vurdu,cR-4EiXNak2GYiYzq_fDhg. Date accessed February 2019.

NTV, 2011. Flood in Giresun

<https://www.ntv.com.tr/turkiye/giresunda-sel-2-olu,bX3G-hHorUKIg9ix2CAPkg>. Date accessed February 2019.

NTV, 2012. Flood in Bodrum,

<https://www.ntv.com.tr/turkiye/bodrumu-sel-aldi,1aP4YyYPvEuu0q1NbxFQJA> . Date accessed February 2019.

NWRM-Natural Water Retention Measures (nwrn.eu)-Strip cropping along contour lines (UK),

<http://nwrn.eu/measure/strip-cropping-along-contours>. Date accessed February 2019.

Pakmet, 2010. Rainfall Statement July 2010: Rainfall recorded in mm during past 24 hours,

https://web.archive.org/web/20100820185911/http://www.pakmet.com.pk:80/FFD/index_files/rainfalljuly10.htm. Date accessed August 2018.

Palanithurai, G., 2009. Panchayats in Disaster Preparedness and Management: Gujarat, Orissa, Andhra Pradesh and Tamil Nadu with Successful Case Studies, Supported by Action Aid India International, Concept Publishing Company, New Delhi, India.

Panagos, P., Borrelli, P., Meusburger, K., Alewell, C., Lugato, E., Montanarella, L., 2015. Estimating the soil erosion cover-management factor at the European scale, Land Use Policy, Vol.48, 38-50.

Pusulagazetesi, 2011. 1998 Flood in Bartın 2011,

http://www.pusulagazetesi.com.tr/m_2747/20-yilin-en-kotu-donemi-1998-seli-il-yazilari-ix/. Date accessed February 2019.

Radikal, 2001. Flood in Antakya,

<http://www.radikal.com.tr/turkiye/antakyayi-sel-aldi-597164/>. Date accessed February 2019.

Radikal, 2008. Flood in Bitlis,

<http://www.radikal.com.tr/turkiye/tatvanda-afetin-adi-sel-oldu-892713/>. Date accessed February 2019.

Radikal, 2013. Flood in Hatay Dörtüöl, 5 deaths,

<http://www.radikal.com.tr/turkiye/hatay-dortuolda-sel-felaketi-5-kisi-oldu-1142449/>. Date accessed

2019.

Reuters, 2007. China's 2006 natural disasters killed over 3,000,
<https://www.reuters.com/article/idUST13083>. Date accessed May 2017.

Royal Meteorological Society, 2018. The Beaufort Modern Scale,
<https://www.rmets.org/resource/beaufort-scale>. Date accessed September 2018.

Sabah, 2006. Disaster in Mersin,
<https://www.sabah.com.tr/fotohaber/yasam/mersinde-sel-felaketi>. Date accessed February 2019.

Sabah, 2009. Flood Disaster Images in Tekirdağ,
https://www.sabah.com.tr/yasam/2009/09/08/tekirdagdan_sel_felaketi_goruntuleri. Date accessed February 2019.

Sabah, 2010. Flood caused to a death, school cancelled,
https://www.sabah.com.tr/yasam/2010/10/14/bursada_okullar_tatil?paging=false . Date accessed February 2019.

Sabah, 2011. Flood in Ankara,
<https://www.sabah.com.tr/yasam/2011/08/12/ankarayi-su-basti>. Date accessed February 2019

Sabah, 2012. Landslide in Kayseri, one death,
<https://www.sabah.com.tr/yasam/2012/04/16/kayseride-heyelan-1-olu>. Date accessed February 2012.

Sabah, 2012. Flood in Şanlıurfa,
<https://www.sabah.com.tr/yasam/2012/10/27/urfa-sele-kapildi-2-olu-1-kayip>. Date accessed March 2019.

Sabah, 2013. Flood in Sinop
<https://www.sabah.com.tr/galeri/yasam/sinopu-sel-vurdu-593539299107/3>. Date accessed February 2019.

Sabah, 2013. Flood struck Antalya,

<https://www.sabah.com.tr/yasam/2013/04/15/antalyayi-sel-vurdu>. Date accessed February 2019.

Sabah, 2014. Flood in Eskişehir,

<https://www.sabah.com.tr/galeri/yasam/eskisehirde-osbyi-sel-basti/6>. Date accessed February 2019 .

Sabah, 2014. One person is missing in Sakarya flood,

<https://www.sabah.com.tr/yasam/2014/06/06/sakaryada-sel-1-kisi-kayip?paging=false>.

Date accessed February 2019.

Sabah, 2015. Flood in Aksaray,

<https://www.sabah.com.tr/yasam/2015/06/03/aksarayda-sel-baskini>. Date accessed February 2019.

Sabah, 2015. Gale and Heavy precipitation in Yalova,

<https://www.sabah.com.tr/yalova/2015/05/07/yalovada-firtina-ve-saganak-yagis>. Date accessed February 2019.

Sabah, 2016. Adana Flood,

<https://www.sabah.com.tr/fotohaber/yasam/adanada-sel-baskini>, Date accessed February 2019.

Sabah, 2017. Flood struck Bodrum,

<https://www.sabah.com.tr/yasam/2017/03/09/bodrumu-sel-vurdu>. Date accessed February 2019.

Sabah, 2017. Midnight flood disaster in Çanakkale,

<https://www.sabah.com.tr/fotohaber/yasam/canakkalede-gece-yarisi-sel-felaketi/10>. Date accessed February 2019.

Sabah, 2018. Flood in Diyarbakır 2018,

<https://www.sabah.com.tr/yasam/2018/12/13/diyarbakirda-baraj-kapagi-koptu-sel-uyarisi>.

Date accessed March 2019.

Sabah, 2018. Flood in Trabzon 2018,

<https://www.sabah.com.tr/webtv/yasam/trabzonda-sel-2-araci-yuttu>. Date accessed February 2019.

Scienmag.com- NASA's GPM Satellite Examines Weakening Tropical Cyclone Kenanga,
<https://scienmag.com/nasas-gpm-satellite-examines-weakening-tropical-cyclone-kenanga/>.

Date accessed January 2019.

Sepahban, L., 2014. Earth in Action: Floods, Abdo Consulting Group, Inc, Minnesota, U.S.A.

Shah, S., 1999. Coping with Natural Disasters: The 1998 floods in Bangladesh, World Bank, prepared for the Summer Research Workshop on Poverty and Development, July 6-8, 1999, Washington, D.C, U.S.A.

Singh, R., 2018. Soil Loss Estimation Lecture, Department of Agricultural and Food Engineering, Indian Institute of Technology, Kharagpur,
<https://www.youtube.com/watch?v=lMAq2nQLyuw>. Date accessed January 2019.

Sözcü, 2014. Flood in Bolu
<https://www.sozcu.com.tr/2014/gunun-icinden/boluda-sel-felaketi-526599/>.

Date accessed February 2019.

Sözcü, 2014. Flood in Isparta,
<https://www.sozcu.com.tr/2014/gunun-icinden/ispartada-sel-felaketi-527339/>.

Date accessed February 2019.

Sözcü, 2014. Flood in Sivas,
<https://www.sozcu.com.tr/2014/gunun-icinden/sivas-ta-sel-felaketi-598155/>.

Date accessed February 2019.

Sözcü, 2017. Flood in Ankara,
<https://www.sozcu.com.tr/2017/gundem/ankarada-sel-felaketi-2-1885678/>. Date accessed February 2019.

Sözcü, 2017. Flood in Mersin,
<https://www.sozcu.com.tr/2017/gundem/mersinde-sel-felaketinin-bilancosu-agir-1602154/>.

Date accessed February 2019.

Sözcü, 2018. Flood in Adıyaman 2018,
<https://www.sozcu.com.tr/2018/gundem/sel-120-hayvani-telefon-etti-2698421/>. Date accessed March 2019.

Sözcü, 2018. Flood damaged buildings in Denizli,
<https://www.sozcu.com.tr/2018/gundem/sel-kutahyada-evlere-zarar-verdi-2556107/>. Date accessed February 2019.

Sözcü, 2018. Flood paralyzed the life in Bilecik,
<https://www.sozcu.com.tr/2018/gundem/bilecikte-sel-hayati-felc-etti-2629072/>. Date accessed February 2019.

Sözcü, 2018. Flood struck Antalya two times within 24 hours,
<https://www.sozcu.com.tr/2018/gundem/antalyada-ikinci-sok-vatandas-perisan-oldu-2562701/>.
 Date accessed February 2019.

Sözcü, 2018. Heavy rain captured the Bursa, 2018.
<https://www.sozcu.com.tr/2018/gundem/bursayi-su-basti-sel-kamyonu-surukledi-2429929/>. Date accessed February 2019.

Sözcü, 2018. İstanbul Flood,
<https://www.sozcu.com.tr/2018/gundem/istanbulu-sel-aldi-2-2620807/>. Date accessed January 2019.

Sözcü, 2019. Flood in İzmir,
<https://www.sozcu.com.tr/2019/gundem/izmirde-sel-karayolu-kapandi-mahsur-kalanlar-var-3079892/> . Date accessed February 2019.

Sözkocaeli.com, 2017. Flood Victim Kocaeli, <http://www.sozkocaeli.com/gundem/kocaeli-sel-magduru-h14523.html>. Date accessed February 2019.

Spaceflight 101.com -Deep Space Climate Observatory (DSCOVR) Image,
<https://spaceflight101.com/dscovr/>. Date accessed January 2019.

Sucic, D.S., Sekularac, I., 2014. Bosnia, Serbia hit by worst flooding in 120 years, Reuters.
<https://www.reuters.com/article/us-balkans-flood/bosnia-serbia-hit-by-worst-flooding-in-120-years-three-die-idUSBREA4E0AX20140515> , Date accessed July 2018.

Swarajya, 2018. After floods now drought? High- temperature increases fear of drought in parts of Kerela, Published on 15 September, 2018,
<https://swarajyamag.com/insta/after-floods-now-drought-high-temperature-increases-fear-of-drought-in-parts-of-kerala>. Date accessed September 2018.

Takahashi, T., Nakagawa, H., Satofuka, Y., Kawaike., K., 2001. Flood and sediment disasters triggered by 1999 rainfall in Venezuela; a river restoration plan for an alluvial fan, Disaster Prevention Research Institute, Kyoto University, Journal of Natural Disaster Science, Vol.23, No.2, 65-82.

Takvim, 2009. 4 children lost their lives, 2009 Yalova Flood,
https://www.takvim.com.tr/yasam/2009/11/02/4_cocugu_sel_aldi. Date accessed February 2019.

Taylor, J., 2009. The Generalissimo: Chiang Kai-Shek and the Struggle for Modern China, Massachusetts: Belknap Press of Harvard University Press. pp. 154-155, U.S.A.

TGRT, 2003. Flood in Tunceli,
<https://www.tgrthaber.com.tr/gundem/-115495.html>. Date accessed March 2019.

TGRT, 2005. Flood in Manisa,
<https://www.tgrthaber.com.tr/haber/273834.html>. Date accessed February 2019.

The Guardian, 1978. Archive: monsoon floods cut off Delhi's four million population, 1978,
<https://www.theguardian.com/world/2017/sep/06/floods-monsoon-delhi-india-bangladesh-archive-1978>. Date accessed March 2018.

The NEWS Minute, 2018. Volunteers can send relief materials to Kerala through Amazon, here's how,
<https://www.thenewsminute.com/article/volunteers-can-send-relief-materials-kerala-through-amazon-here-s-how-86788>. Date accessed February 2019.

The New York Times, 1927. Hundreds perish in Algerian flood: Water spread over an area of fifty miles east of the city of Oran. Dam breaks, 150 drown many houses and bridges are carried away- Train with 300 passengers is marooned,

<https://www.nytimes.com/1927/11/28/archives/hundreds-perish-in-algerian-flood-waters-spread-over-an-area-of.html>. Date accessed September 2018.

The New York Times, 1971. Flooding reported in Vietnam,

<https://www.nytimes.com/1971/08/31/archives/flooding-reported-in-north-vietnam.html>.

Date accessed August 2018.

The New York Times, 1992. Flash flood in an Afghan valley kills at least 400, officials say,

<https://www.nytimes.com/1992/09/05/world/flash-flood-in-an-afghan-valley-kills-at-least-400-officials-say.html> . Date accessed September 2018.

The Telegraph, 2011. Philippines flooding: death toll increases to nearly 1,500,

<https://www.telegraph.co.uk/news/worldnews/asia/philippines/8978731/Philippines-flooding-death-toll-increases-to-nearly-1500.html>. Date accessed September 2018.

The Washington Post, 1993. Monsoon floods kill 983 in Asia,

https://www.washingtonpost.com/archive/politics/1993/07/22/monsoon-floods-kill-983-in-asia/d18e723d-2750-4a3e-bc7b-024c72eab346/?utm_term=.dfd9e92cfb4e. Date accessed May 2017.

Tiwary, D., Mohan, V., 2013. Uttarakhand floods: Epidemic looms as people complain of fever, diarrhea, The Times of India, New Delhi, India,

<https://timesofindia.indiatimes.com/india/Uttarakhand-floods-Epidemic-looms-as-people-complain-of-fever-diarrhoea/articleshow/20770540.cms>. Date accessed June 2018.

TRT Haber, 2014. Flood in Hatay: three deaths,

<https://www.trthaber.com/haber/turkiye/hatayda-sel-felaketi-3-olu-145617.html>. Date accessed February 2019.

TRT Haber, 2017. Hundred thousand of fish destroyed due to floods,

<https://www.trthaber.com/haber/turkiye/sel-yuzunden-yuz-binlerce-balik-telef-oldu-329702.html>.

Date accessed February 2019.

TRT Haber, 2018. Citizens rescued donkey from flood, 2018

<https://www.trthaber.com/haber/turkiye/nigdede-sele-kapilan-esegi-vatandaslar-kurtardi-371370.html> . Date accessed February 2019.

Türkiye, 2013. Bursa flooded in summer month due to water release from dam,

<https://www.turkiyegazetesi.com.tr/yasam/42019.aspx> . Date accessed February 2019.

Ulusal, 2016. Flood in Muş: Two deaths, 1 missing,

<https://www.ulusal.com.tr/yurt/mus-ta-sel-felaketi-2-olu-1-kayip-h108705.html>. Date accessed February 2019.

United Nations Disaster Relief Organization (UNDRO) Reports, 1987. Bangladesh-Cyclonic Storm/Tidal Surge June 1987 UNDRO Situation Reports 1-15, United Nations Department of Humanitarian Affairs, Geneva, Switzerland.

United Nations Disaster Relief Organization (UNDRO) Reports, 1991. China-Floods June 1991 UNDRO Situation Reports 1-9. UNDRO 91/1045, United Nations Department of Humanitarian Affairs, Geneva, Switzerland.

United Nations Disaster Relief Organization (UNDRO) Reports, 1992. India Floods Nov 1992 UNDRO Information Reports 1-2. UNDRO 92/0766, United Nations Department of Humanitarian Affairs, Geneva, Switzerland.

United Nation Development Programme (UNDP) Human Development Report, 2010. The Real Wealth of Nations: Pathways to Human Developments, 20th Anniversary Edition, New York, USA.

United Nation Development Programme (UNDP) Human Development Report, 2013. The Rise of the South Human Progress in a Diverse World, Technical Notes, New York, USA.

UNDP, 2018. Human Development Index Trends, 1990-2017.

<http://hdr.undp.org/en/composite/trends>. Date accessed January 2019.

Vietnam News, 2015. Yen Bai showcases series of culture, tourism events-Terraced landscapes,

<https://vietnamnews.vn/life-style/274989/yen-bai-showcases-series-of-culture-tourism-events.html#xF605Pyus8p3ebAR.97>. Date accessed February 2019.

Weather Online, 2018. Nimbostratus,
<https://www.weatheronline.co.uk/reports/wxfacts/Nimbostratus.htm>. Date accessed October 2018.

WMO, 2018. International Cloud Atlas, Cumulonimbus,
<https://cloudatlas.wmo.int/observation-of-clouds-from-aircraft-descriptions-cumulonimbus.html>.
 Date accessed October 2018.

WMO, 2018. International Cloud Atlas, Cumulus Congestus,
<https://cloudatlas.wmo.int/cumulus-congestus.html>. Date accessed October 2018

Wordpress.com., 2014. Relative Humidity determination via dry bulb and wet bulb temperature,
<https://kisigcsegeography.files.wordpress.com/2014/01/humid.jpg>. Date accessed September 2018.

World Reseources Institute, 2015. World's 15 Countries with the Most People Exposed to River Floods,
<https://www.wri.org/blog/2015/03/world-s-15-countries-most-people-exposed-river-floods>.
 Date accessed February 2018.

Tufty, B., 1969. 1001 Questions Answered about Earthquakes, Avalanches, Flood and Other Natural Disasters, Dove Publications, Inc., New York, U.S.A.

Tyrell, W., 2016. Engineeringclicks Webpage-Engineering Disasters: Banqiao Dam Failure,
<https://www.engineeringclicks.com/banqiao-dam/>. Date accessed July 2018.

U.S Standard Atmosphere, 1976, National Aeronautics and Space Administration (NASA), U.S. Government Printing Office, Washington, D.C., October, 1976.

Winchester, S., 2004. The River at the Center of the World: A Journey up the Yangtze, and Back in Chinese Time, Macmillan, England.

Wooten, T., Sandesera U., 2011. No one Had a Tongue to Speak: The Untold Story of One of History's Deadliest Floods, Prometheus Books, New York, U.S.A.

Xinhua, 2004. China has brought flood under control,
<https://reliefweb.int/report/china/china-has-brought-flood-under-control>. Date accessed June 2017.

Yamunan, S., 2015. In Cuddalore, desperate crowds snatch relief material from trucks, The Hindu, <https://www.thehindu.com/news/national/tamil-nadu/in-cuddalore-desperate-crowds-snatch-relief-material-from-trucks/article7958703.ece>. Date accessed April 2018.