ISTANBUL TECHNICAL UNIVERSITY ★ INFORMATICS INSTITUTE

CREATION OF WEB-BASED APPLICATION FOR EARTHQUAKE HAZARD ANALYSIS BY GIS AND AHP

M.Sc. THESIS

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Department of Applied Informatics

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ BİLİŞİM ENSTİTÜSÜ

CBS VE AHP YARDIMIYLA DEPREM TEHLİKE ANALİZİ İÇİN WEB TABANLI BİR UYGULAMANIN OLUŞTURULMASI

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FOREWORD

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ABBREVIATIONS

AHP	**:** Analytic Hierarchy Process
AJAX	**:** Asynchronous JavaScript And XML
API	**:** Application Programming Interface
ASP	**:** Active Server Pages
CGI	**:** Common Gateway Interface
CGI	**:** Common Gateway Interface
CLR	**:** Common Language Runtime
CSS	**:** Cascading Style Sheets
DHTML	**:** Dynamic HTML
DNS	**:** Domain Name Server
DOM	**:** Document Object Model
EHM	**:** Earthquakes Hazard Map
FTP	**:** File Transfer Protocol
FTP	**:** File Transfer Protocol
GIS	**:** Geographic information System
GWIS	**:** Geographical Weather Information System
GWS	**:** Google Web Server
HTML	**:** Hyper Text Markup Language
HTTP	**:** Hypertext Transfer Protocol
IDE	**:** Integrated Development Environment
IIS	**:** Internet Information Server
IMS	**:** Internet Map Server
JSON	**:** JavaScript Object Notation
JSP	**:** Java Server Pages
JVM	**:** Java Virtual Machine
MCDA	**:** Multi-Criteria Decision Analysis
MCDM	**:** Multi-Criteria Decision Making
MMF	**:** Main Marmara Fault
NGA	**:** Next-generation Attenuation Models
OGC	**:** Open GIS Consortium

OSI **:** Open System Interconnection
P2P **:** Peer- To Peer
RMI **:** Remote Method Invocation
SMTP **:** Simple Mail Transfer Protocol
SQL **:** Structured Query Language
SSL **:** Secure Socket Layer
SVG **:** Scalable Vector Graphics
UGC **:** User Generated Content
WCS **:** Web coverage service
WFS **:** Web feature service
WMS **:** Web map service
WWW **:** World Wide Web
XML **:** Extensible Markup Language

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CREATION OF WEB-BASED APPLICATION FOR EARTHQUAKE HAZARD ANALYSIS BY GIS AND AHP

SUMMARY

In recent years, the distribution of geospatial information on the Internet has been a binding factor for information providers. The Internet allows all levels of the community access to geospatial information and provides media to handle location-related information without any restrictions on the location.

Recently, GIS and database management systems have developed rapidly, but there are still many diverse issues that challenge most researchers, developers, professionals and public users in this area. The most important and oldest of these issues, which are still ongoing in geospatial systems and applications, is spatial data access for efficient decision-making.

At present, with the increasing and generalized use of web applications and evolution of graphical hardware, one of the most interesting problems deals with realistic real-time visualization of virtual environments on web browsers. This project shows web based application for Earthquake hazard parameters analysis by interactive map on the World Wide Web.

Web-based GIS is developed from various web maps and client server architecture to distributed maps. As such, the Internet reconfigures all functions of information systems, including data collection, storage, retrieval, analysis and visualization. Geographic information systems (GIS) originate from a range of web and GIS technologies, a recognized technique consisting mainly of data processing tools Moving towards Web GIS led to fading high cost of GIS system, release of system specific databases, and the enormous software developer efforts on upgrading the system. Moreover, disseminating spatial information on the Internet improves decision-making processes and making it more effective and faster. The present study using the parameters of the EHM, topography, distance to epicenter, soil classification, liquefaction, and fault/focal mechanism, as main inputs to develop and implement Web GIS framework for analysis of earthquake parameters by interactive hazard maps integrating web AHP for Kucukcekmece region, which offer possibilities to access the right data in the right time to make the right decisions. In this study Web GIS architecture is described and implemented using programming languages such as ASP.net, C#,Node.js, JQuery and Javascript, In addtition to using some tool such as ArcGIS Server and ArcMap as a source of spatial information, also the study included creating API as protocols to interact that tools with programming languages and ArcGIS API for javascript. The work also utilized Web client technologies such as HyperText Markup Language (HTML5), CSS, bootstrap and jQuery for providing flexibility and more interactivity. The study demonstrates that web GIS in combination with disaster management geographic information system

(GIS) is very useful and vital tools for visualizing and improving the decision-making processes, and mature alternative to traditional GIS.

CBS VE AHP YARDIMIYLA DEPREM TEHLİKE ANALİZİ İÇİN WEB TABANLI BİR UYGULAMANIN OLUŞTURULMASI

ÖZET

Son yıllarda, internetteki coğrafi bilgilerin dağılımı bilgi sağlayıcılar için bağlayıcı bir faktör olmuştur. İnternet, topluluğun tüm seviyelerinin coğrafi bilgilere erişmesine izin verir ve konumla ilgili herhangi bir kısıtlama olmadan konumla ilgili bilgileri ele alması için medya sağlar. Depremler, Dünyada yaşayan herkes, sismik olarak aktif bölgelerde yaşayan dünya nüfusunun% 20'si ve kaçınılmaz bir risk oluşturur ve gelecek 50 yıl boyunca, gezegenimizin nüfusunun yarısı, dünyanın 50 en büyük şehrinde ve 200 kilometreden daha büyük depremlerde yaşayacaktır. 7 dereceden ve daha fazla.

Türkiye, dünyanın en sismik olarak aktif bölgelerinden biri olarak kabul edilir. İstanbul'un güneyinde Marmara Denizi'nin altında patlayan M ≥ 7 deprem olasılığı önümüzdeki 30 yılda yaklaşık% 35-70'dir. Ayrıntılı planlara duyulan ihtiyaç ve deprem azaltma, müdahale ve geri kazanım için zarar değerlendirme analizi yapılması için ileri bilimsel araçların geliştirilmesi, depremlerin yıkıcı olaylarının ortaya çıkması nedeniyle çok önemli hale gelmiştir.Depremlerin insan yaşamı, altyapı ve ekonomi üzerinde büyük etkisi var. Kısa vadeli bir felaket olmasına rağmen, etkisi yıllarca sürebilir. Depremler büyüklük, hız, frekans, süre ve coğrafi konum (merkezin konumu) ile tanımlanır ve insanları yok etme ve şehirleri yok etme gücüne sahip olanlara hissetmeyecekleri ışık yoğunluğuna göre değişebilir. Sismik önlemler, depremin tekrarını ve bir süredir meydana gelen şiddetini içerir.

Deprem bir giriş yer hareketi parametresi veya bir spektral tepki değeri olarak tanımlanmaktadır. Entegre görselleştirme, zararı değer kaybına çeviren zarar fonksiyonları göz önüne alındığında, fiziksel ve ekonomik etkiyi değerlendirmek için tehlike, kırılganlık ve envanter değerlendirme parametrelerinin kullanılması için temel bir çerçevedir.

Coğrafi Bilgi Sistemi teknolojisi, mekansal verileri mekansal olmayan verilerle birleştiren ve mekansal aramaları ve kaplamaları gerçekleştiren önemli bir araçtır, yalnızca farklı mekansal verileri saklamak için değil, aynı zamanda karmaşık coğrafi problemleri çözme ve yeni ve mekansal katmanların entegrasyonu yoluyla faydalı bilgiler.

Bölgelerin deprem tehlikesi analizi önlem almak için ve coğrafi bilgi sistemlerinin etkin bir şekilde kullanılmasını gerektirmektedir. Bu nedenle, mekansal ve öznitelik verileri ile birlikte oluşturulan tematik haritalar, afet öncesi, afet sırasında ve sonrasında felaketle ilgili senaryolar oluşabilecek felaketlerle kurulabilir.

CBS ile birlikte yapılan analiz sonucunda, bölgeler tehlike değerine göre belirlenebilir. Herhangi bir felaket meydana gelmeden önce, felaket sırasındaki can ve mal kaybını azaltmak mümkündür ve sonrasında yüksek riskli bölgelere yönelik çalışmalar yürütülerek CBS, afet sonrası toplama alanları için en uygun yerleri belirleyebilir.

Açıkçası, hızla gelişen ve geniş bilgi teknolojisi ve İnternet uygulamasıyla, bu geleneksel CBS'ler ciddi zorluklarla karşı karşıya kalmaktadır. Geleneksel CBS'lerin bu şekilde yönetilen ve kapalı bir çerçevesi, bir sistemin tek bir bilgisayara kurulması için gereken tüm donanım, yazılım, veri ve programı talep eder.

Bu nedenle, İnternet tabanlı ve mekansal bilgileri paylaşma ve görevleri organize etme avantajına sahip Web CBS'i geliştirmek, sismik araştırmacılar için acil bir görev haline geldi.

Web GIS, coğrafi bilgi kaynağını genişletmeye, veri toplama maliyetini azaltmaya, mekansal verilerin kullanım verimliliğini arttırmaya ve ilgili bilgilerin yerbilimleriyle iletişimini desteklemeye yardımcı olacaktır.

Deprem parametrelerini Web-GIS teknolojisi ile herhangi bir Web düğümünden birleştirerek, kullanıcılar deprem tehlikesi haritasına dinamik bir harita olarak gözatabilirler, böylece uzaysal sorgulama ve analiz yapılabilir ve karar doğrudan İnternet üzerinden yapılabilir, CBS fonksiyonunun Web'e eklenmesi bilgi yayınlama sistemi, bu avantaj, kullanıcıların Web üzerinden bilgi sorgulamalarına kolaylık sağlarken, CBS'in daha geniş alanlara etkinliğini sağlayabilir, böylece CBS uygulanabilir, uygulanabilir ve paylaşılabilir hale gelir.

Son zamanlarda, CBS ve veri tabanı yönetim sistemleri hızla gelişti, ancak bu alandaki çoğu araştırmacı, geliştirici, profesyonel ve kamu kullanıcısına meydan okuyan birçok farklı konu var. Jeo-uzamsal sistemler ve uygulamalarda hala devam eden bu sorunların en önemlisi ve en eskisi, etkin karar alma için mekansal veri erişimidir.

Günümüzde, web uygulamalarının artan ve genel kullanımı ve grafiksel donanımın evrimi ile birlikte, en ilginç sorunlardan biri, sanal ortamların web tarayıcılarında gerçekçi gerçek zamanlı görselleştirilmesiyle ilgilidir. Bu proje, World Wide Web'deki interaktif harita ile Deprem tehlikesi parametrelerinin analizi için web tabanlı uygulamayı göstermektedir.

Web-GIS'in en güçlü özelliklerinden biri, araştırmacılar ve karar vericilerin dikkate alabileceği haritalar arasındaki hızlı karşılaştırmadır. Web-GIS çözümü, yüksek düzeyde bilgi için devam eden talebe açık bir cevaptır

Genel olarak afet yönetim sistemlerinde kullanılan haritaların çoğu, "etkileşimli olmayan" statik haritalar olarak üretilen geleneksel CBS'ye dayanan özellikle deprem tehlike haritaları, karar vericilerin ve CBS kullanıcılarının kullanımına ilişkin bazı sıkıntılar var. geleneksel CBS ve bu tür haritalama ile başa çıkmada bazı zorluklar; mekansal sorgulama, analiz yapma ve hatta tahmin ve karar verme, bu problemler hızlı kararlar almak ve mekansal verilerin derin ve hızlı analizini yapmaktır. geleneksel sistemin belirli yazılım kullanıcılarının haritalara göz atması ve güncellemesi gerekir ve bu yazılımın uygulamalarını kullanırken ARCMap, ARCView, vb. kullanımları sırasında mevcut yazılım ve araçlarını ele almaları kolay değildir.

Bu nedenle, CBS geleneksel sistemini güçlendirmek için güçlü bir ihtiyaç, Başka bir deyişle, “bu sorunların üstesinden gelmek” şiddetle tavsiye edilir.

CBS yazılımı ve veri tabanı Yönetim Sistemlerinin hızlı gelişimine rağmen, birçok konu araştırmacılar, geliştiriciler, profesyoneller ve alandaki kamu kullanıcıları için zorlayıcıdır. Mekansal sistemler ve uygulamalardaki en eski ve halen devam eden sorunlardan biri, özellikle hızlı ve etkili kararlar gerektiren afet yönetim sistemlerinde karar vermede etkin bir şekilde kullanmak için mekansal verilere erişimdir.

Etkileşimli deprem tehlike haritası oluşturmak için Web-GIS teknolojisinin uygulanması ve coğrafi verilerin ve deprem parametrelerinin ağırlıkları ile birlikte dağıtılması, karar vericilerin mevcut verilerle hızlı, doğru ve verimli bir şekilde başa çıkmalarına yardımcı olur.

Web tabanlı CBS, çeşitli web haritalarından ve istemci sunucu mimarisinden dağıtılmış haritalara kadar geliştirilmiştir. Bu haliyle, İnternet veri toplama, saklama, geri alma, analiz ve görselleştirme dahil olmak üzere tüm bilgi sistemlerinin fonksiyonlarını yeniden yapılandırmaktadır.

Coğrafi bilgi sistemleri, web ortamındaki uzamsal verilerin depolanması, alınması, yönetimi ve analizi için kullanılan veri işleme araçlarından oluşan tanınmış bir teknik olan çeşitli web ve CBS teknolojilerinden kaynaklanmaktadır. Web tabanlı CBS'e geçiş, CBS sisteminin yüksek maliyetinin azalmasına, sisteme özel veritabanlarının yayınlanmasına ve sistemin iyileştirilmesi konusunda devasa yazılım geliştirici çabalarına yol açtı.

Ayrıca, internet üzerinden mekansal bilgilerin yayılması karar alma süreçlerini iyileştirir ve daha etkili ve daha hızlı hale getirir. Bu çalışma, doğru verilere doğru zamanda doğru kararlar verebilmek için olanaklar sunan Web AHP ve Web CBS'i entegre ederek online tehlike haritaları oluşturmak için deprem parametrelerinin analizi için WebGIS çerçevesini geliştirmeyi ve uygulamayı amaçlamaktadır.

.Bu çalışmada web tabanlı Web CBS mimarisi ASP.net, C #, Node.js, JQuery ve Javascript gibi bazı programlama dilleri kullanılarak tanımlanmış ve uygulanmıştır. bilgi, ayrıca çalışma bu araçları programlama dilleri ve javascript için ArcGIS API ile etkileşime sokmak için protokoller olarak API oluşturma dahil.

Çalışma aynı zamanda esneklik ve daha fazla etkileşim sağlamak için HyperText Markup Language (HTML5), CSS, bootstrap ve jQuery gibi Web istemcisi teknolojilerini kullandı. Çalışma, web CBS'in afet yönetimi coğrafi bilgi sistemi ile birlikte kullanılmasının, karar alma süreçlerini görselleştirmek ve iyileştirmek için çok faydalı ve hayati bir araç olduğunu ve geleneksel CBS'e alternatif olduğunu göstermektedir.

1. INTRODUCTION

Earthquakes create an unavoidable risk to everyone living on Earth, 20% of the world's population living in seismically active areas, and over the next 50 years, half of our planet's population will live in the world's 50 largest cities and 200 kilometers away from earthquakes greater than 7 degrees and more (Tucker et al., 1994).

Turkey is considered one of the most seismically active region in the world. The probability of $M \geq 7$ earthquake rupturing beneath the Sea of Marmara at the south of Istanbul is approximately 35-70% in the next 30 years. The need for detailed plans and the development of advanced scientific tools for conducting loss assessment analysis for earthquake mitigation, response and recovery become crucial by occurrence of the catastrophic events of earthquakes (Karaman et al., 2008b).

Earthquakes have a major impact on human life, infrastructure and economy. Although it is a short-term disaster, its impact could last for years. Earthquakes are described by size, speed, frequency, duration and geographical location (location of the center) and can vary in their intensity of light that they will not feel, to those who have the power to exterminate people and destroy cities. Seismic measures include the recurrence of the earthquake and its magnitude that occurred for a period (Al-Dogom, 2018).

Earthquake is described as an input ground motion parameter or a spectral response value. Integrated visualization is an essential framework in which to use the assessment parameters hazard, fragility and inventory in order to evaluate physical and economic impact, given the loss functions that translate damage into loss of value (Karaman et al., 2008a).

Geographical Information System (GIS) technology is an essential tool that associates spatial data with non-spatial data, and perform spatial searches and overlays, not only the ability to store different spatial data but also the ability to solve complex geographic problems and generate new and useful information through the integration of spatial layers (Vera et al, 2013).

Earthquake hazard analysis of regions is required to take precautions, and should require using geographic information systems (GIS) effectively. Therefore, the thematic maps created with spatial and attribute data together, scenarios related to pre-disaster, during and post-disaster can be established with the disaster that can occur.

The result of analysis accomplished together with GIS, regions can be determined according to the hazard value. Before any disasters occur, it is possible to lessen the loss of life and property at the time of disaster and afterwards by carrying out studies aimed at high risk districts, GIS can determine the most suitable places for collection areas after disaster (Sabah et al., 2017).

GISs are autonomous and closed which run on personal PCs and built by different departments using various GIS software according to their appeals. So GISs can't be shared, that will not result only in data storing redundancy and wasting the resource of software and hardware, but also result in low efficiency, high cost and difficulty to improve and maintain the systems.

Obviously, with the rapid development and wide application of information technology and Internet, these traditional GISs are faced with severe challenges. This kind of self-governed and closed framework of the traditional GISs request all hardware, software, data and program needed by a system to be installed on an individual computer (QU Chun-y, et al, 2002).

Therefore developing the Web GIS which is based on Internet and has the advantage of sharing spatial information and organizing tasks become an urgent mission for seismic researchers.

Web GIS will help to enlarge the source of geographical information, reduce the cost of data collecting, increase the utilizing efficiency of spatial data and promote the communication of the related information in geosciences (Hao Gong, et al, 2017).

By merging earthquake parameters with Web-GIS technology from any Web node, users can browse earthquake hazard map as a dynamic map, so that spatial query and analysis can be performed and the decision is made directly on Internet, Adding the function of GIS to Web information publishing system, this advantage gives convenience for users to inquire information through Web, on the other hand, it can provide effectiveness of GIS to more wide fields, so that, GIS becomes operable, practicable and sharable (QU Chun-y, et al, 2002).

One of the strongest capabilities of Web-GIS is the quick comparison between maps, by which researchers and decision makers could take into consideration. The Web-GIS solution is an obvious answer to the ongoing demand for high levels of information (Vera et al, 2013).

1.1. Problem of Statement

Most of the maps utilized in disaster management systems in general, and earthquake hazard maps in particular, based on traditional GIS which are produced as "non-interactive" static maps. There are some troubles facing the decision makers and GIS users regarding to use of traditional GIS, and some difficulties in dealing with this type of mapping to perform spatial query, analysis and even make prediction and decision. These problems are making quick decisions and conducting a deep and rapid analysis of spatial data. In addition to them, there are specific software users of the traditional system should have to browse maps and update it, and it is not easy for them to deal with the availablesoftware and its tools during utilizing the applications of this software as: ARCMap,ARCView, etc.

Therefore, a strong need to enhance GIS traditional system, In other words, "overcomes these problems" is strongly recommended.

1.2. Justification of Research

Despite the rapid development of GIS software and database Management Systems, many issues are challenging researchers, developers, professionals and public users in the field. One of the oldest and still continuing issues in geospatial systems and applications is access to spatial data to use it efficiently for decision making,particularly in disaster management systemswhich require quick and efficient decisions.

Applying of Web-GIS technology to build interactive earthquake hazard map and disseminating geospatial data and earthquake parameters with their weights which leadingto help decision makers to deal with available data, quickly, accurately and efficiently.

1.3. Aim and Objectives

This research aims to build and develop an interactive map for earthquake parameters integration with AHP approach using Web GIS technology by which an objective and clear methodology is to be presented to facilitate spatial analysis of the "küçükçekmece" region in Istanbul. To achieve this aim, the following objectives are to be considered:

- Develop an objective methodology with clear stages that can enhance spatial analysis and consequently save time and efforts in decision-making processes.
- Creating a new Web GIS that is easy to be used, this new Web GIS friendly tool will enhance the opportunities of managing the spatial data in better quality and sufficient accuracy, and finally performs full spatial data analysis online, and the analysis results will appear on an interactive map directly.

1.4. Methodology

To achieve the objectives of this research, there are three stages starting from data collecting, data analysis, conclusion and recommendations related to the topic of the study.

The study can be broadly divided into three stages:

- <u>The first stage:</u>
  Includes literature reviews; which based on the primary data collection "Attribute Data and Spatial Data" by reviewing books, similar studies, scientific papers, magazines, articles, web sites and others.
- <u>The second stage:</u>
  Includes many practical steps, as the following:
  - Analyzing the collected data.
  - Multi criteria decision analysis and AHP tool.
  - System design.
  - Coding and implementation of web GIS technology.
  - Testing and integration .
  - Operation and maintenance.

- <u>The Third stage:</u>
  Conclusion and recommendations with references to the objectives of this research.

2. ANALYTICAL HIERARCHY PROCESS (AHP)

2.1 Introduction

Analytical Hierarchical Process (AHP) is one of the most commonly used and popular techniques since the inception of MCDA methods, applied to solve wide range of decision problems requiring consideration of large number and variety of criteria so as to acquire most optimum and viable results and outcome through a systematic evaluation procedure from available alternatives. The decision problem in AHP is broken down into a hierarchical form of sub-problems and criteria more easily understandable so they can be separately analysed and through systematic evaluation of elements and assignment of weights, comparisons are made, selecting the most feasible alternative as the best solution. AHP is nowadays, extensively applied in business, social, industrial, operational, management and research areas, stimulating growing interest especially with integration of GIS within the research community spanning fields of environmental, transportation and urban planning, agriculture, forestry, waste management, hydrology, geology/geomorphology, natural hazard and risk management. In this study, AHP is selected to determine the factor weights of the influencing parameters in an earthquake hazard scenario and integrated with GIS for simulating results of AHP on a spatial web environment, generating an earthquake hazard map (EHM).

2.2 Development of AHP

AHP emerged around the mid-1970s when it was first developed by Prof. Thomas L. Saaty, and later from the 1980s and 1990s, its increasing applications in wide research areas and its effectiveness in complex decision making led more MCDA users into opting to using AHP techniques, which allows consideration of both objective and subjective factors in ranking and selection of decision alternatives. Being one of the most widely used tools, many decision-makers and researchers have successfully applied AHP in different fields that include planning, business, management, engineering fields, site and selection of optimal alternatives, resource allocations, forecasting, conflict resolution, optimization, public policy decisions, environment and health care (Vaidya and Kumar, 2006; Bhushan and Rai, 2004). Additionally, the central reason for the popularity of AHP for mapping hazard risks and its elements is its straightforward implementation within a GIS environment allowing for users to quickly derive weights associated with criteria map layers. Availability of software packages that have incorporated AHP (pairwise comparison) approach into GIS has also led to the popularity use of AHP (Malczewski and Rinner, 2015). Further, AHP's flexibility enables it to be integrated with other different techniques (such as linear programming, fuzzy logic, etc.), allowing the user to maximize the full benefits from combined approaches thereby better achieving the desired goal and it can also be used as a consensus building tool especially in emergency management circumstances that involve group decision-making or multiple stakeholders (Vaidya and Kumar, 2006; Malczewski, 2004; Malczewski, 2006). Therefore, this study employed the use of AHP technique.

2.3 Basic Principles

AHP technique assists in structuring complex problems, measurements and synthesizes rankings whose model structure can then be modified easily and applied to any decision-making problem with provision of basic mathematical tools for criteria evaluation. Criteria can be converted easily to numerical values eventhough they are subjective (Bhushan and Rai, 2004).

The AHP approach involves first breaking down the decision problem into a hierarchy of sub-problems, easily comprehensible and that can be subjectively evaluated. Conversion of the subjective evaluations into numerical values and their subsequent processing to rank each alternative on a numerical scale is done (Bhushan and Rai, 2004). Systematic evaluation of the various elements in the built hierarchy structure is accomplished by comparison of the elements to one another, two at a time, by pairwise comparison. This approach greatly reduces the conceptual complexity of the decision-making analysis in AHP (Saaty, 1980). The pairwise comparison is theproportionalassessment of the dominance of acomponent over another with respect to the pairwise comparison scale (Table 2.1).

Table 2.1: Pairwise comparison scale for AHP criterion evaluation (Saaty, 1980).

Intensity of importance	Definition
1	Equal importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, very strong
9	Extreme importance
Reciprocals of above	If activity ***i*** has one of the above non-zero numbers assigned to it when compared with activity ***j***, then ***j*** has the reciprocal value when compared with ***i***

The procedures and methodology of AHP for any decision problem can be described in four (4) general steps and can be summarized by process flowchart in Figure 2.1.

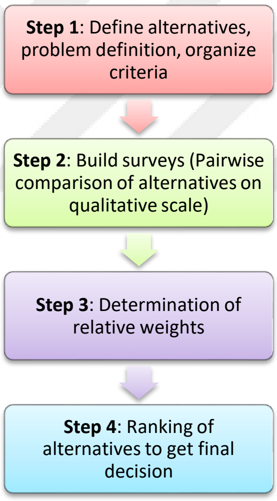

Figure 2.1:AHP process flow chart.

Step 1, begins with stating and definition of the decision problem and identification and determination of the goal, main and sub-criteria and alternatives, that influence the behavior. The decision problem is structured and decomposed into a hierarchy of goals, criteria, sub-criteria and alternatives. The relationships and impact of criteria and alternatives on each other can easily be observed and interpreted once the hierarchy structure is constructed. Figure 2.2 illustrates the goal, hierarchy structured into the main criteria(C_n) and sub-criteria that have an effect on the result and choice in the presence of alternatives (L_n).

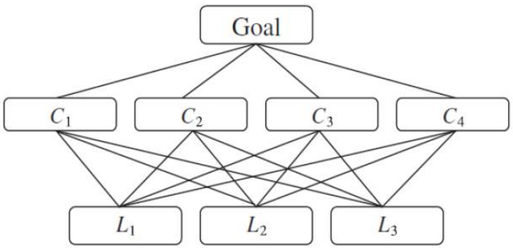

Figure 2.2: Illustration of hierarchy structured into criteria and sub-criteria and alternatives (Malczewski, 2006).

Step 2, involves pairwise comparison on a qualitative scale where data is collected from decision-makers, experts or stakeholders corresponding to the hierarchical structure, resulting in development of a pairwise comparison matrix. Usually, experts are given a questionnaire from which preferences and opinions are obtained that represent each criterion in comparison to others. Criteria is evaluated, as a rule, based on range of values, from 1 to 9, as shown in Table 4.1 (Bushan and Rai, 2004; Aitzhanov, 2016). Scores 1,3,5,7,9 are regarded as levels of main evaluation while scores, 2,4,6,8 may also be used to express comparison with more precision.

Each of the elements in the matrix is compared with another at a higher level in pairs with respect to the importance on the related subject. At each of the levels, a hierarchy is constructed by the comparisons and the outcome of this, will be a positive pairwise comparison matrix A = a_{ij} as shown in equation 2.1, created by the decision-maker, that has reciprocal elements of comparisons for all a_{ji} = $1/1a_{ij}$, and for i, j = 1,2,….., n (Harker, 1989).

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & \vdots \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{2.1}$$

Step 3, involves computation of the relative weights for each element of the hierarchy. After the pairwise comparison matrices are formed, the weight vector, W = $[w_1, w_2, \ldots, w_n]^T$, is calculated, referred to as the Saaty's eigenvector procedure.

This is achieved via two (2) procedures. First, by normalization of the pairwise comparison matrix using the given formula in equation 2.2.

$$a_{ij}^{*} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \text{, } for\ all\ j = 1, 2, \ldots, n \tag{2.2}$$

The second procedure is calculation of the weights by formula, in equation 2.3.

$$w_i = \frac{\sum_{j=1}^{n} a_{ij}^{*}}{n}, \qquad for\ all\ i = 1, 2, \ldots, n \tag{2.3}$$

There exists a relationship between the vector weights, w, and the pairwise comparison matrix, A, as noted by Saaty (1980), and this is defined in the following equation 2.4.

$$Aw = \lambda_{max} w \tag{2.4}$$

The consistency index (CI), which provides a measure or estimate of the departure from consistency of the judgements is given by equation 2.5.

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2.5}$$

Where λ_{max} is the maximum eigenvalue of the pairwise comparison matrix, and n is the order of the matrix. Comparisons made by AHP are subjective and the inconsistency is tolerated through the redundancy amount in the approach (Bhushan and Rai, 2004).

To complete the calculation procedures, using equation 2.6 above, the consistency ratio (CR) is computed using equation 4.6 below, where the random index (RI) is obtained from the consistency index of a randomly generated pairwise comparison matrix (Saaty, 1980).

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{2.6}$$

The RI, is the consistency index of a randomly generated pairwise comparison matrix and whose value increases with the number of elements being compared, i.e., increases with increasing number of elements being compared (Malczewski, 1999). The values of RI from matrices of order 1–10 can be found from Saaty’s (1980) work in a standard table (Table 2.2) using random generated matrices for each size of matrix, n (Harker, 1989).

Table 2.2: Random Inconsistency Index (Saaty, 1980).

n	1	2	3	4	5	6	7	8	9	10
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

At each hierarchy level, there is too, a control process for the pairwise comparisons. If CR < 0.10, the ratio indicates an acceptable level of consistency in the pairwise comparisons. If CR ≥ 0.10, the ratio values are reflective of inconsistent judgements and in such cases, the user should re-examine the original values in the pairwise comparison matrix, A and repeat the procedure. By use of equation 2.7 below, the measure of the pairwise comparisons of all the individuals involved in the decision process are combined by taking the geometric means of all (Saaty, 1980; Malczewski, 1999).

$$a_{ij}^{hp} = \sqrt[Q]{\prod_{q=1}^{Q} a_{ij}^{q}} \tag{2.7}$$

where a^{q}_{ij} is an element of matrix A of an individual q (q = 1, 2, …, Q), and a^{hp}_{ij} is geometric mean of all individuals a^{q}_{ij}. The group CR is calculated according to equations 2.5 and 2.6.

Step 4, finally, is the aggregation of the relative weights of the decision elements by multiplying them successively from down to the beginning of the hierarchy. This is done to ascertain the best alternatives/strategies.

There are also three main concepts behind the AHP technique; they can be listed as follows (Bhushan & Rai, 2004):

- AHP is analytic – mathematical and logical reasoning for getting the decision. It assists in analysing the main problem on a logical basis and provides conversion of experts' subjective opinion into a numeric value, which can be calculated through formulas and might be easily discussed and explained to others.
- AHP structures the problem as a hierarchy, which helps to understand the problem and solve it by dividing it into small sub-problems, that is easy to deal with individually. Psychology studies suggest that human beings are able

to keep in mind and compare only 7 ± 2 things at time. Thus, it is necessary to apply AHP in any problem that accounts large number of criteria and sub-criteria to deal with.

- AHP defines a process for decision making. Being one of the most commonly used MCDM, AHP also provides a methodology of solving a problem. Collaboration between experts' inputs, revision and learning's helps to reach collective decision

2.4 Application Areas

As earlier highlighted, the AHP has been successfully applied in many wide ranging decision and management problem domains spanning across different disciplines and research areas that include project planning, marketing, healthcare, defence, social sciences, economic forecasting, new product pricing, policy evaluation, energy, research and development, manufacturing, etc. In addition to being applied successfully in all these areas, AHP has developed as a widely accepted approach and methodology for decision-making and as a technique, evolved over the years to be applied in conjunction with other mathematical modelling, and analysis techniques (Bhushan and Rai, 2004) such as GIS and other decision support systems.

AHP has been applied widely in various applications spanning across areas such as marketing (Davies, 2001), energy policy (Kim and Min, 2004), resource allocation (Cheng and Li, 2001), suitability analysis (Banai-Kashani, 1989), site selection for fire services (Erden and Coskun, 2010), environmental impact assessment (Ramanathan, 2001) and risk analysis (Millet and Wedley, 2002).

3. AHP MODEL

3.1 Introduction

In this study, the application of AHP technique based on the study of Erden and Karaman 2012, we have adopted this study, because it used the same layers and criteria as inputs to AHP technique. The following steps have been applied in Erden and Karaman study to calculate the weights for each criterion. In turn, we carried these weights and processed them through Web GIS environment.

3.2 Pairwise Comparison of Criteria

In this study, determination of weights to be applied to each of the five (5) criteria map reclassified layers for resulting earthquake hazard map generation, was based on the pairwise comparison technique of AHP where each of the elements/criteria was compaired two at a time. The compared reclassified map layers were field topography (FT), source to site distance (DS), soil classification (SC), liquefaction potential (LP), and fault mechanism (FM).

A survey was conducted through questionnaires that were prepared and filled in by ten (10) respondents reflecting their preferences and expert opinions. These constituted people, academics and stakeholders from various disciplines such as Civil, Geomatics, Geology, and Geophysics Engineers related to the subject area of earthquake disasters and emergency management.

The sample respondent's preference matrix and the final group judgment matrix reflecting all the respondents' preferences and opinions was arrived at using the geometric mean computation approach suited for aggregation of group judgments.

From the final group judgment matrix, the weights of the each of the map criteria layers were computed using the appropriate formula from earlier AHP weight calculation steps. The λ_{max}, CI and CR were also computed. Since the consistency ratio (CR) determined for all the pairwise comparison matrix was 0.01, which is less than 0.1, this was indicative of consistent judgements used in the whole approach. The weights for all the five (5) map criteria layers determined is as shown in the last column of Table 3.1 will carry on the internet to be used in building online earthquakes hazard map.

Table 3.1 : Pairwise comparison matrix for one respondent (a) and for final group judgment (b).

(a)

Criteria	FT	DS	SC	LP	FM
FT	1	0.17	0.25	0.33	1
DS	6	1	3	5	7
SC	4	0.33	1	3	4
LP	3	0.20	0.33	1	3
FM	1	0.14	0.25	0.33	1
λ_{max}= 5.2		CI = 0.04		CR=0.04 < 0.1	

(b)

Criteria	FT	DS	SC	LP	FM
FT	1	0.17	0.21	0.20	0.70
DS	5.99	1	1.70	1.96	3.32
SC	4.82	0.59	1	1.28	1.85
LP	5.12	0.51	0.78	1	2.27
FM	1.42	0.30	0.54	0.44	1
λ_{max}= 5.1		CI = 0.01		CR=0.01 < 0.1	

Table 3.2 : Criteria, their class value ranges and their calculated criteria priority/weight.

	Criteria	Class Values				Weights/ Priorities
		1	2	3	4	
		No/Low Risk	→	→	Major Risk	
1	FT (field topography)	0-10	10-15	15-30	>30	0.06 (6%)
2	DS (source-to-site distance) [km]	22.21-19.80	19.80-17.38	17.38-14.97	14.97-12.55	0.38 (38%)
3	SC (soil classification) [m/s]	800-760	760-360	360-180	180-50	0.24 (24%)
4	LP (liquefaction potential)	104-103	103-102	102-101	101	0.22 (22%)
5	FM (fault/focal mechanism)	0.45-0.53	0.53-0.61	0.61-0.68	0.68-0.76	0.10 (10%)

4. WEB BASED GEOGRAPHIC INFORMATION SYSTEM

4.1 Introduction

Recently, GIS and database management systems have developed rapidly, but there are still many diverse issues that challenge most researchers, developers, professionals and public users in this area. The most important and oldest of these issues, which are still ongoing in geospatial systems and applications, is spatial data access for efficient decision-making (Bendib et al., 2016).

At present, with the increasing and generalized use of web applications and evolution of graphical hardware, one of the most interesting problems deals with realistic real-time visualization of virtual environments on web browsers. This project shows web based application for Earthquake hazard parameters analysis by interactive map on the World Wide Web.

The earthquake hazard Map information system for Kucukcekmece region in Istanbul city collects various data consisting of earthquake parameters and AHP tool. Earthquake hazard interactive map is designed and built with Web GIS phases. This system is designed to help specialists and decision-makers in management of earthquake hazard and forecasting based on historical data collected to earthquakes, so the system through interfaces help the user in management earthquakes hazard parameters and weights and update them and making future decisions based on the system results.

4.2 The Web and GIS

The advent of the Internet and web has helped the development of human civilization, paved the way for the rapid dissemination of information, Allowing for unprecedented knowledge-based society and change the way we live and work.

Internet technology reduces the cost of data management and distribution of information to mass usages, and therefore Web-based information systems evolve as applications worldwide (Ozturan et al., 2004). GIS or Internet-based WebGIS is one of the areas developed as an online service that is very useful because of the rapid development of web technology and GIS (Liu et al., 2009).

Web-GIS platform made geographic information accessible to everyone and it has broadened its reach significantly by abstracting geographic data into standard spatial services like travel Apps, disaster & emergency services, tourism, natural resource management and etc (Agrawal, 2017).

Network infrastructure is the hardware and software resources of an entire network that enable network connectivity, communication, operations and management of an enterprise network. It provides the communication path and services between users, processes, applications, services and external networks or the internet.

An Enterprise Web GIS Solution combines the knowledge of complex GIS systems with the standards and best practices of Information Technology to design and implement an end-to-end system that deliver geospatial data services, tools and applications on the web.

4.2.1 The internet, the web

The Internet dates back to 1960s during the Cold War, Where the U.S. Department of Defense Advanced Research Project Agency (ARPA) initiated a research project to create a network of geographically separated computers that could exchange information even if some of the nodes stopped functioning or were destroyed in the event of nuclear attack. In 1969, this research successfully connected the main-frames of four western universities Stanford University; University of California, Santa Barbara; University of California, Los Angeles; and Utah State University (Figure 4.1) leading to the invention of the Internet. The network, ARPANet, was the nucleus of the global Internet. The Internet is gradually expanding with the increasing number of computers, including government agencies, research institutes and universities. By the end of 1989, more than 100,000 computers were globally connected to the Internet (Internet Society, 2003).

Access to the Internet was limited and did not gain popularity until the 1970s. Before then, the services available over the Internet mainly consisted of e-mail, Usenet News (a way to provide news to Internet users before the Web was invented), file transfer, and Telnet (a protocol that allows you to log in to another computer and operate the computer remotely). The Internet was complex to use, its content was not nearly as rich as it is today, and its users were mostly professionals from research institutes and government agencies.

Figure 4.1: ARPANet, which successfully connected the mainframes of four western universities, is recognized as the predecessor of the global Internet steadily (International Telecommunication Union, 2010).

In 1990, the Internet usage equation was changed and the World Wide Web had been borned. Tim Berners-Lee invented (HTTP) Hypertext Transfer Protocol, HTML (Hypertext Markup Language) and URL (Uniform Resource Locator), where he developed the first Web server that transfers and shares files more easily than previously (Netcraft, 2010).

Where the spread and use of the World Wide Web has changed the way we live and work; changed the role of the computer from the account to the communication and entertainment, resulting in the diversity and increasing content on the Internet, as the number of Internet users and the spread of the web steadily (International Telecommunication Union, 2010).

The terms Internet and the World Wide Web are synonymous in the minds of many, but they have different meanings: The Internet is a massive network of networks that connects millions of computers worldwide. Computers connected to the Internet can communicate with one another with a number of protocols such as HTTP, IRC (Internet relay chat), IM (instant messaging), SMTP (Simple Mail Transfer Protocol), FTP (File Transfer Protocol), Telnet, and P2P (peer- to-peer).

While The World Wide Web is a system of interlinked hypertext documents and programs that can be accessed via the Internet primarily by using HTTP. While

HTTP is only one of the protocols the Internet supports, the Internet's chief attraction for a large number of users is the content accessible on the Web and the activities the Web facilitates. So it is that the Web is the "face" of the Internet (Douglas, 1995).

The Internet is still sweeping the world and expanding and entering all walks of life and details, from wired networks into wireless networks, fed by the popularity of the mobile Web, or wireless Web. The advances of mobile devices such as smart phones and wireless communications technologies, including wifi (wireless fidelity) and the 3G (third-generation) cellular networks, have facilitated its spread. The Internet, especially the World Wide Web, has become an integral part of our daily lives and a basic means of meeting everyday needs (Skarlatidou et al., 2013).

4.2.2 GIS

GIS technology responds to the type of "where" questions related the place, and then makes smart and ideal decisions based on space and location.

GIS is a system of hardware, software, and procedures that capture, store, edit, manipulate, manage, analyze, share, and display georeferenced data (Web GIS: Principles and Applications, 2010).

GIS technology has been around since before the Internet and the Web. The first operational GIS was developed in 1962 by Roger Tomlinson for Canada's Federal Department of Forestry and Rural Development. Called the Canada Geographic Information System (CGIS), it was used for Canadian land inventory and planning. Tomlinson has become known as the "father of GIS" for his pioneering work developing CGIS and promoting GIS methodology (Tomlinson, 2008).

GIS is the science and technology supporting GeoDesign, a systematic methodology for geographic planning and decision-making. The GeoDesign GIS application can help people understand and analyze the world's problems and design alternatives that can lead the world to a better future (Steinitz, 1990).

GIS has the ability to produce more than just pretty maps, although GIS isconventionally used to make a myriad of maps using different scales, themes, and symbols. More importantly, GIS has powerful analytical functions that turn data into useful information.

GIS can link disparate data on the basis of general geography, uncover hidden relationships, patterns and trends that are not readily apparent in spreadsheets or statistical packages, and create new information that supports informed decision-making. For example, as shown in (Figure 4.2), the real world can be drawn into a number of spatial data layers, including land use, elevation, imagery, parcels, and streets. Each layer represents a different attribute of real world data. This data can be presented in two or three-dimensional maps. GIS can be used to conduct analysis to solve real-world problems such as finding earthquake-prone areas, what will be the total damage to property, and what alternative plans are made to mitigate risks (Dangermond, 2009a).

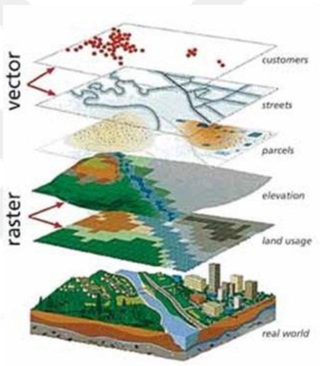

Figure 4.2: GIS abstracts the real world into data models consisting of multiple layers (Web GIS: Principles and Applications, 2010).

4.2.3 GIS on the internet

The Internet GIS refers to a network-based GIS tool that uses the Internet as an essential means of providing access to distributed data and other information, spatial information dissemination and GIS analysis. Development of platforms that integrate GIS based on the Internet since the last two decades. Many projects have attempted to use Internet-based GIS platforms to help their target audiences (eg public users, decision makers, communities, governments and researchers) overcome the challenges of limited availability of data resources and effective analytical tools. For example, different platforms have been developed in the areas of natural resource management (Berry et al., 2011). and natural hazards and risk management (Aye et al., 2015), (Aye et al., 2016).

The use of Geographic Information System (GIS) and the Internet has changed the way organizations use geographic information. Therefore, GIS is being expanded into new industries. Local governments, corporations, utilities, and higher education institutions are some examples of industries that have begun to apply GIS in day-to-day work. GIS is more than just a program because GIS is a visual and analytical tool that helps users understand or visualize this information in a map model and enable users to manage this information interactively and analytically. This contributes to the increased use of GIS. Therefore, GIS can be built on the Internet as a decision-making system in disaster management departments. It informs and presents data as a result of answering spatial questions (Gonzalez, 2001).

GIS has benefited greatly from the Internet model of broadband connectivity and the momentum generated by the Web. The web has unlocked the power of GIS, from offices to laboratories. GIS has been placed in the homes of millions and in the hands of billions, making them usable in all industries, from government and business to education and research (Web GIS: Principles and Applications, 2010).

The EHM System of collects data related to earthquake hazard and then transforms this data to interactive platform, store, query, analyze, present this data to the user with various formats on the interactive map based on the Web with the aim of increasing the efficiency and progress of decision making.

4.2.4 Integration web with GIS

Internet, Web and traditional disciplines have created many new disciplines, and Web GIS is one of these disciplines. GIS has evolved rapidly on the Internet since 1993, especially in the "Web 2.0" era. Geographic information system (GIS) has largely changed the way geographic information is obtained, transmitted, disseminated, shared and visualized. Represents an important milestone in the history of GIS (Web GIS: Principles and Applications, 2010).

4.3 WEBGISOrigins and Evolution

In 1993, the Xerox Corporation Palo Alto Research Center (PARC) developed a Web-based map viewer, marking the origin of Web GIS. The Xerox PARC Map Viewer was an experiment in allowing retrieval of interactive information on the Web, rather than providing access to strictly static files (Putz, 1994). The website provides simple map zoom capabilities, layer selection functions, and map drop conversion functions. Users can use the Map Viewer in a Web browser and click a function link. The Web browser then sends an HTTP request to the Web server. The web server will receive the request, perform mapping operations, create a new map, and return it to the web browser that requested it. The web browser will then receive and display the map image. This was in operating the GIS system within the web browser, which shows that users anywhere on the Internet can use GIS without locally installing it, an feature that traditional desktop GIS does not have.

The GIS community quickly adopted this concept of using GIS functions in Web browsers. Subsequently, numerous Web GIS applications have emerged. Here are a few examples:

- In 1994, the Canadian National Atlas info Service discharged the primary on-line version of the National Atlas of North American country. it's associate interactive mapping information processing system that enables the general public to spot variety of knowledge layers like roads, rivers, body boundaries and environmental zones, then submit a map request. The server will opt for the suitable code to make maps on demand, and voters will read the map atlas on-line reception while not having to travel to a office to visualize the results.
- Susan Huse (1995) at the University of California, Berkeley, developed GRASSLinks as a part of her PhD treatise. GRASS (Geographic Resources Analysis Support System) was a desktop GIS tool then, and its functions weren't exposed to the net. Huse enforced associate interface between the net server and GRASS that allowed users to pick out information layers from their browser and submit requests to the net server. The server forwarded the request to GRASS, wherever buffer, overlay, categorization, and mapping operations were happening, and also the results were came back to users. GRASSLinks was associate early example that incontestible that net GIS
- might transcend mapping and question to perform subtle analysis (Web GIS: Principles and Applications, 2010).

4.4 WEB GIS in WEB 2.0

Web 2.0 is first introduced by Darcy DiNucci (1999). Web 2.0 suggests a new version of the World Wide Web, but does not refer to new update to any technical specification, but refers to incremental changes in the ways developers and end users use the Web. With the advent of dot com technology during 2001, where it was a turning point for the Web, so the web has become more important than ever, with the emergence of new and exciting applications and sites with surprising regularity (Web GIS: Principles and Applications, 2010).

Internet-based applications known as the World Wide Web (WWW) give Internet users unlimited powers to access and disseminate information and services. In the area of GIS, the Internet has played an important role in developing new aspects of technology that open many doors to expand options for building spatially enabled Web applications. The software developed to build these types of systems differs in terms of cost, efficiency, scalability, durability, security, support and ease of use. Various system architecture appeared on the Internet GIS. Because the Internet is an effective solution, administrations can use GIS along with Web technologies to unlock their data location components in one central location or where they have contributed, such as information departments (Usun, 2011).

Commercial Web mapping applications such as Google Maps, Google Earth, Microsoft Bing Maps (formerly Virtual Earth), Yahoo Maps, and MapQuest are usually considered good examples of Web 2.0. These sites typically provide detailed maps and high-resolution ground imagery in many areas.

Professional GIS companies adopting Web 2.0 principles and design patterns in GIS production lines on the Internet to facilitate the sharing, collaboration, and integration of geospatial information on the Internet. The ESRI product lines, for example, include these principles (Web GIS: Principles and Applications, 2010):

- Harnessing collective intelligence: Web 1.0, was characterized by read only content and the information flow from top down. Web 2.0 has support a read write Web that features plenty of user generated content (UGC) and a reverse information flow.

- Spatial web services in particular provide editing services, ArcGIS Server's mashup capabilities for organizations to gather and share geographic knowledge, and enhance collaboration between the geospatial community. The ArcGIS.com and ArcGIS community maps program provide a platform technology for organizations to share data, maps, and applications. Data is collected, sometimes increasing, published as services, and hosted by ESRI over the web.
- The Web as a platform: Web is a platform for developing computing and software. Among these development are software as service, which software capabilities such as Web services, Web applications, and cloud computing, providing dynamically scalable and often virtualized resources as a service on the Web. ESRI ArcGIS Server allows organizations to publish their authoritative base maps, and geoprocessing functions as Web services.
- Lightweight programming models: Web services from multiple agencies can be easily integrated, or mashed up, using the ArcGIS REST or lightweight ArcGIS APIs for JavaScript, and Microsoft. This lead to create powerful Web GIS applications that increasing performance to enterprise workflows simple, quick, and dynamic.
- Mobile solutions: ESRI Developing GIS systems in range of mobile platforms, including Apple iPhone and Google Android and Research in Motion BlackBerry. Users can retrieve data, view maps, and use analytical models directly from ArcGIS Server. The mobile clients can also publish geospatial data collected or verified in the field along with field photos and videos directly to ArcGIS Server. Server data is updated in real time to support and quick decision making.
- A rich user experience: Developers can create rich Web GIS applications with the use of ArcGIS APIs for JavaScript, Flex, and Silverlight. The interface integrates multimedia effects and animations to improve user satisfaction and increase productivity. The user can see the results as a 2D map viewer or a 3D virtual globe. The interactive interfaces enable user to perform advanced analysis by calling ArcGIS Server behind the scenes.

Through these properties that make Web 2.0 applications are interactive, GIS companies pursue to follow the principles of providing a rich user experience, increasing user participation, and by providing lightweight APIs the users can create their own applications (Maguire 2008).

4.5 The Concept of WEB GIS

The web-based GIS facilitate the widespread use and dissemination of spatial information and services, and enhance technology to a much larger audience than previously presented. The Internet tool supporting the quick and efficient information exchange, which helps individuals make important decisions faster. Web GIS started launching GIS on web browsers and evolved into a Web GIS serving desktop clients and mobile devices as well as web browser clients.

GIS is a type of distributed information system. The simplest forms of Web GIS must have at least a server and client, where the server is the Web application server, and the client is a Web browser, a desktop application, or a mobile application (Figure 4.3). The server has a URL so customers can find it on the web. The client then relies on the HTTP specification to send requests to the server. The server performs the requested GIS process and sends a response to the client, again via HTTP. The response format can be HTML used by the web browser client, but can also be in other formats such as binary image, XML (Extensible Markup Language), or JSON (JavaScript Object Audit).

Web GIS is any GIS that uses Web technologies. In a narrower definition, Web GIS is any GIS that uses Web technology to communicate between components.

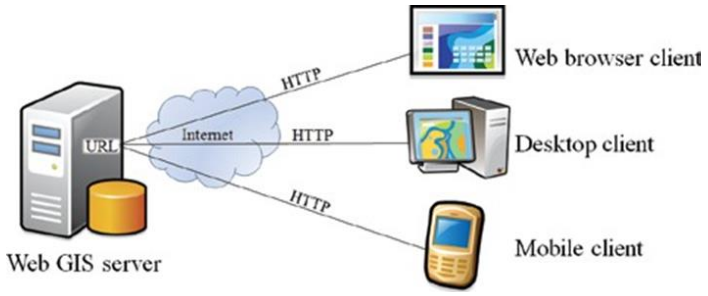

Figure 4.3: The simplest architecture of Web GIS should have at least a Web application server and a client (Web GIS: Principles and Applications, 2010).

Web GIS is further defined by the following:

HTTP, among many Web technologies, is the main protocol used by the different components of Web GIS to communicate with each other. If the Internet is down, some thick clients can still function based on caches and preloaded data or functions, but most clients will stop functioning.

The simplest architecture of Web GIS is a two-tier system that involves a server and one or more clients. A Web GIS is not just the software running on your computer, But more importantly, the servers that are somewhere on the Web, or "in the cloud" Sometimes, the server and the client can run on one computer, but they are actually two separate components, both in software, infrastructure and in the mode of operation (Fu, Sun, 2011).

Geographic information systems (GIS) are closely related to two other terms: Internet GIS and the geospatial Web. Internet GIS and Web GIS are often used synonymously. Strictly speaking, however, the two are slightly different. The Internet supports many services, and the Web is only one of them. GIS that uses any of the Internet services, and not just the Web, can be considered Internet GIS making Internet GIS theoretically broader than Web GIS (Figure 4.4). In reality, the Web is the chief attraction of the Internet and is the most commonly used Internet service. Thus, Web GIS is the most pervasive form of Internet GIS.

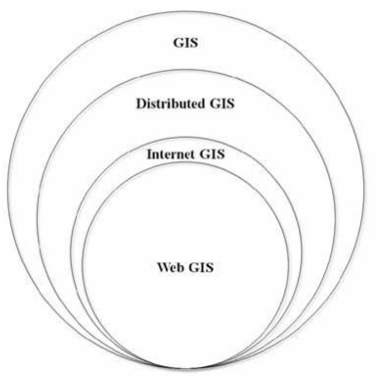

Figure 4.4: Web GIS is shown in relation to other related GIS terms (International Telecommunication Union, 2010).

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4.6 WEB GIS Characteristics

The Internet and the Web removed the space limitations of cyberspace, allowing instant access to information across the web without regard to how far the user and the server might be away from each other. This quality gives Web GIS inherent advantages Comparison to traditional desktop GIS, including the following:

- Global reach: A developer can present Web GIS applications to the world, and the world can use these applications. A users can access Web GIS applications from anywhere by their computer or cell phone.
- Large number of users: the users can used a traditional desktop GIS by only one user at a time, while a Web GIS can be used by unlimited of users simultaneously. This requires much higher performance and scalability for Web GIS than for desktop GIS.
- Better cross-platform capability: Most Web GIS clients are web browsers. There are Web browsers such as Google Chrome, Mozilla Firefox, Internet Explorer, Apple Safari, and for diverse operating systems, including Microsoft Windows, Linux, and Apple Mac OS. Because the Web browsers are largely compatible with HTML and JavaScript standards, Web GIS that depend on HTML clients typically supports different operating systems. Web GIS that relies on Java, .NET, and Flex clients can run on multiple platforms where the required run time environment is installed.
- Low cost as averaged by the number of users: The vast majority of Internet content is free to end users, and this applies to Web GIS. In general, you do not need to purchase a program or pay to use Web GIS. Organizations that need to provide GIS capabilities to many users can also keep the costs of GIS on the web low. Instead of buying and setting up a desktop GIS for each user, the organization can set up only one Web GIS server, and this common system can be shared among many users from home, at work, or in the field.
- Easy to use for end users: Desktop GIS is designed for professional users with years of training and experience in GIS. Web GIS is designed for a wide audience, including public users who may not know about GIS. Therefore,

Web GIS is commonly designed for simplicity, intuition and convenience, making it much easier for end users than desktop GIS.

- Real time update: but Web GIS, one update works for all clients, making updating a lot easier. Where the program and data are updated on the server, so all Web GIS clients will get automatic updates, because the update web GIS process is synchronous. That means easy maintenance for Web GIS and greatly improved timeliness for GIS, making Web GIS a good fit for delivering real time information.

Web GIS is able to perform all GIS functions involving spatial information, including capture, storage, editing, manipulation, management, analysis, sharing, and visualization. Web mapping, as the interface for Web GIS, is the most frequently used function. GIS data and analysis are usually presented as maps. Each location on the map has features that support operations such as identity identification and querying (Peng, 2003).

The Web GIS has just gone beyond mapping. It also provides analytical functions supporting decision making in particular, those related to daily life, such as measuring distances and areas, and finding the optimal driving path (i.e., navigation), Traffic tracking software and other programs that have enabled a large audience to access spatial data easily, at any time, and without restrictions for optimum decision making.

The distribution of geospatial information on the Internet is an effective factor for information providers. Internet allows all to access geospatial information, and provides tools for processing geo-related information without location restrictions. Web-based GIS is developed from different web maps and client server architecture to distributed maps. Therefore, the Internet reconfigures all functions of information systems, including: data collection, storage, retrieval, analysis and visualization. The high cost of GIS, the issuance of system databases, and the tremendous efforts of the software developer to improve the system have faded with integration GIS with the Internet. In addition, the dissemination of spatial information on the Internet improves decision making processes.

GIS software's have enabled users to view spatial data in its right format. As a result, the interpretation of spatial data has become increasingly easy and simple to understand. Yet, not everyone can have access to GIS, and the users don't able to spend the time necessary to use it efficiently. Web GIS become an inexpensive and easy way to disseminate geospatial data and moreover it has tools for deep online analysis to geographical data. Many organizations are interested in distributing maps and processing tools without restricting time and location to users (Rifaat, 2018).

Development of the Web and expansion of the Internet provide two key capabilities that can greatly help geoscientists. First, the Web allows visual interaction with data directly. By Web Server, the clients can produce maps. Because the maps and charts are published on the Internet, other clients can view these updates, helping that to speed up the evaluation process. Second, because of the near ubiquitous nature of the Internet, Geospatial data are widely accessible. Client can work on it from almost anywhere. Both of these features change the way that do decision-makers and owners of organizations to do their work to take best decisions to the near future. The combination of easy access to data and visual presentation of it addresses some of the primary difficulties which facing GIS audience (Gillavry, 2000).

GIS on the Internet is not without drawbacks. The basic problem is speed. GIS relies on intensive use of graphics. Also in case of vector data, the number of requests that reach the GIS servers is very large depends on the amount of vector drawing on the map, which requires high Internet speed to respond to that large number of requests. The speed of communication over the Internet can be used extensively for graphics very slowly for users. It will not match the complexity of customized GIS programs such as "ArcInfo &ArcView", or "MapInfo"In the near future. On the other hand, Web GIS does not require the same resources as these programs. Powerful computers, intensive training and expensive website licenses are not required to resolve the geographic information system at the website level (Strand, 1998).

4.7 Transferring Raster and Vector Geographic Data Over The Internet

Progressive data transmission techniques are typically used to share data over the Internet: A subset of data is first sent and then gradually improved by subsequent stages. The advantages of progressive transmission include efficient data transmission (when sending smaller files), fast response, and perhaps only the most relevant details. In addition to being able to perform initial processes on part of data sent, these techniques, the users can realize that the details of the currently displayed representation are good enough for their purpose, so they can interrupt downloading more detailed representations (stored in larger files). Therefore, both time and disk space can be saved. This is especially important for users in the field who try to download datasets of interest. Even if the fully detailed version is needed, they can start working with a rough version while more details are added incrementally.

For raster images the data is efficiently compressed with different techniques and sent to the user. The full resolution image is reconstructed on the user's machine by gradually adding detail to coarser versions. The success of progressive raster transmission relies on the availability of effective compression techniques for such data: these techniques provide good compression ratios while causing low information loss. Furthermore, they are efficient and relatively easy to implement.

These mechanisms are applied also in the spatial domain: These mechanisms are also applied in the spatial domain: Raster geospatial datasets “including high resolution satellite images, scanned maps, and aerial photos” can be progressively exchanged from server to a client. This is acceptable for applications that primarily include visualization. However, the raster version of the data may not be sufficient in some applications, including contexts that involve processing actual object. In these cases, vector representation of data is required. Vector data sets consist of groups of spatial entities in the form of points, polylines, and polygons linked through spatial relationships. Examples include thematic maps, city maps, and road network maps (Alberto et al, 2007).

With the exception of attribute data, the crucial question for using GIS on the Internet is data format (vector or raster), which is used to transfer data to the client. To transfer data to the client, the map is converted to any space raster or vector format appropriate. When you transfer raster, we can use a standard Web browser without an extension, because the Web browser displays GIF and JPEG. That means the data on the server must be converted to a raster format. The data volume is due to the size of the known image and the original data on the server is secure where only the image is sent to the client. The disadvantage of the use raster data is the lack of convenience in dealing with aspects of mapping, such as the problem of lines. Moving an object using the mouse can’t distinguish single objects. In addition, connecting to the server is necessary for each request from the client. Because of reduced vector data size, it transmits faster than raster data. Vector data is processed by a standard Web browser with extended functions (using plugins). The user finds more flexibility and performing wider analysis during using vector data. For example, single objects can be selected directly or highlighted. Another advantage of using vector data is local processing; it is not necessary to connect to the server for each browser action executed. The amount of vector data sent over the Web can be three to four times the amount of bitmaps required for an equivalent analysis, resulting in faster response time and greater productivity (Nayak, 2000). Disadvantages of using vector data over internet are changing data volume; the amount of data varies with the selected area. To avoid duplication of data in client side, it must provide dynamic circularization. Distributing vector data may also expose copyright rules. The choice of transfer data model (vector or raster) varies according to the current applications and infrastructure. There is some Software offer optional transferring of vector or raster data may provide advantages. It may allow a pre-selection with raster data, and after that, loading of the actual vector data with possibility of subsequently local process (Leukert, Reinhardt, 2000).

Different federations are developing future standard formats to transfer data over the Internet. The Open GIS consortium (OGC) provides Geography Markup Language (GML). GML shall allow the transfer and storage of geographic information in Extensible Markup Language (XML). Geographic information includes both features and geometry of geographic features. The W3C offers scalable vector graphics SVG, a language for describing a 2D vector and mixed vector / raster graphics in XML (w3.org, 2019).

4.8 WEB GIS Development Cycle

Improving a Web GIS isn't simple as buying the suitable hardware and software. Many strategies were proposed to provide effective implementation (Alesheikh & Helali, 2001). The implementation techniques have scientifically evaluated and revised, in order to meet the requirements of TTO project with the minimum cost and time. (Figure 4.5) displays the Web GIS development cycle, that is explained by 8 main activities beginning with the requirement analysis and ending with web GIS use and maintenance.

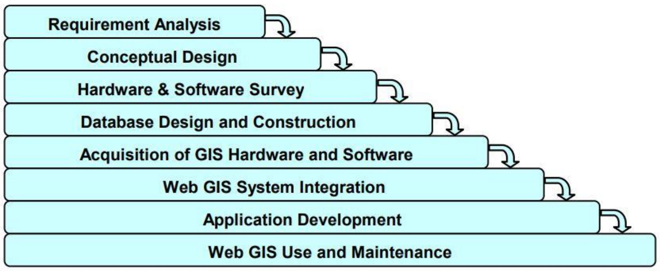

Figure 4.5: Web GIS Development Cycle (Alesheikh & Helali, 2001).

4.8.1 Requirement analysis

While developing the GIS project, creating a list of common functions and special functions is necessary. The essential functions are the mains visualization functions such as Pan Zoom, in addition to, the developed functions like the object information, spatial query and the shortest way.

4.8.2 Conceptual design

The conceptual design process of the web GIS project include the following:

- Determine how and in which format the result will be.
- Decide on which group will be added.
- How the service will be provided.
- Determine necessary data and data models.
- Choose the appropriate architecture for the client and the server, according to our project, the architecture was chosen providing the users with access to interactive maps.Hardware & Software.

4.8.3 Hardware andsoftware

This stage is very significant while creating a Web GIS application. The selected software must be practical and independent from the hardware and operating system. At Web GIS application, a huge amount of data downloaded by users, so that it is very important to have an excellent internet speed both for the client and the server.

4.8.4 Database design and construction

This stage of the Web GIS development process aimed to specify "how" the Web GIS executes the required applications. Database design involved:

- Identifying how graphics and non-graphic files will be structured.
- Which is the active layer and in what level the layers should be disclosed.
- How GIS products will be presented (map sheet, report, etc.).
- How file access can be restricted.

Completing the previous activities result in:

- Determining a source (document, digital file, map) for each structure.
- Setting-up the real database design (logical/physical design)
- Defining steps for transforming data from source to the database.
- Selecting procedures for managing and protecting the database.

4.8.5 Acquisition of GIS hardware and software

Choosing a GIS hardware and software can benefit in the designs of procedures and database, which has the ability to realize the important functions of the information, moreover, the field of GIS project and the needs have to be taken into consideration while choosing it.

4.8.6 WEB GIS system integration

At this stage, the Web GIS hardware and software obtained and data converted. The purpose of this stage is to combine different components of the hardware and software, and try them to be sure that they work as predicted, and to start with all proceedings necessary to employ the GIS.

4.8.7 Application development

At this stage, the application has been established by running the programs that were initiated and acquired above. While improving the application, interface layout and programming processes should be used, and it must be user friendly.

4.8.8 WEB GIS use and maintenance

The latest step to implement the web GIS is using the system, with systemintegration and checking all applications available in the application.

4.9 WEB GIS Architecture

The former of online interactive map was Xerox Alto Research Center in 1993, after that, the number of web-based GIS applications increased dramatically (Su et al, 1999). In general, there are two main architictures of these applications: Thin Client and Fat Client (Abel et al., 1998).

Internet allows communities to access geospatial information easily, and provides means to process geo-related information without location restrictions. Web based GIS are matured from various Web maps and client-server architecture to distributed ones. Publicizing spatial information through the Internet enhances the decision-making procedures (Gillavry, 2000).

4.9.1 Architecture and data flow in WEB GIS setup

Generally, the data flow between user and web server in the web browser begins from client's request, scenario or tool to a web server that hosts the website holding html documents, videos, images, style-sheets, JavaScript files, etc. During this process, some tasks take place such as inquiring the Domain Name Server (DNS) to detect the IP address of the web server, after that, Open System Interconnection (OSI) model will secure the level of communication between the client and Web server. The requests will arrive web servers after passing through safety rules and load balancers. The whole connection between client and web server occurs using the Hypertext Transfer Protocol (HTTP) (Forouzan, 2006). Master Web servers include Apache, Novell's NetWare server, Microsoft's Internet Information Server (IIS), NGNIX, Google Web Server (GWS) and Domino servers from IBM (Sean, 2016).

Consequently, there is a need for other server with a GIS engine that will gather inputs as Georeferenced data and turn it into compressed formats like PNG, JPG or GIF. In the other side, the outputs can be of XML based as a vector format (e.g. KML, GML).

In order to make the mapping activity commercial of the shelf (COTS) software like ArcGIS server and free and open source software (FOSS) like MapServer, MapGuide, GeoServer, Mapnik, QGIS server are available (Peterson, 2012). Commonly, the GIS engine is installed in a server that provide certain services.

Open Geospatial Consortium (OGC) outlined a set of standards for classifying geographic data and make categories of information more accessible. The OGC standard result in development of services (OGC.com, 2019).

There are two functions of the web mapping service: (i) Get-Capabilities that clarifies the capabilities of a server, such as determining the supported file structures, the available map categories, and the method of display, (ii) Get-Map that determine the needs of database which scans the request and establishes the map-based data from the requirements that outlined by Get-Capabilities, then, the requested data package sent to the web mapping service (Peterson, 2012).

Web map service (WMS) referred to a geo-referenced map images in a raster format such as PNG, GIF, or JPG, it can also be in a vector format.

Web coverage service (WCS): referred to a geographical area that can be put on a map but can't be edited or analyzed, WCS is useful for conveying coverage that consist of items such as data points, paths, or pixels defined with vectors.

Web feature service (WFS): allow clients to request, update, create and delete geographical features, and provide them with essential information from the map that is usually pursued in an XML format like KML or GML.

GIS Engine such as Geo-Server brings geographic data from a variety of database and non-database formats like Postgre-SQL, Geo-Tiff, Oracle Spatial, Shape file. However, using a discrete Database Server result in optimizing serving of data to the GIS Engines (OGC.com, 2019).

Non-spatial data is ordinarily stored in relational database and provides Structured Query Language (SQL) to inquire, handle and extract data; databases like Postgre-SQL will support spatial functions with extensions like Post-GIS, the geometry extension like Post-GIS enables all features such as viz, line, point, and polygon.

Spatial database is a vital component in Web-GIS structure because it allows data to be stored and inquired, and can be represented either in vector or raster forms (Karnatak, 2012), (Figure 4.6) shows typical architecture of a WebGIS environment.

WebGIS implementation is mainly a Client/Server model, the client makes a simple request that be processed at the server side, in the other hand, in the 'thick client' approach, the client is more powerful through adding supplementary modules and plugins.

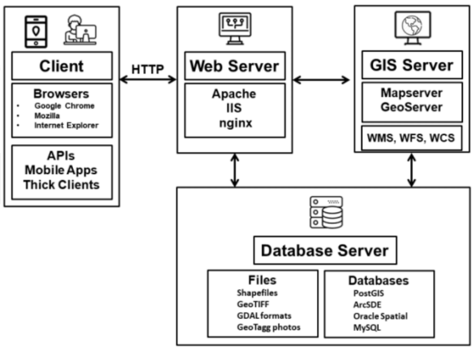

Figure 4.6 : Typical Architecture of Web GIS Environment (Pandey, 2018).

To perform a GIS analysis tasks, a three tiers establish the model (client, web server and map server). The geo-processing engaged to server side and client-side tasks, the client actually is a Web browser and the server-side consists of a Web Server, Web GIS software and Database.

The client used to reclaim maps to image or vector file formats through HTTP, TCP/IP requests, and web server works as a mediator transfers client’s requests to be handled in the map server tier. (Figure 4.7) clarifies how the model works (Alesheikh et al., 2002).

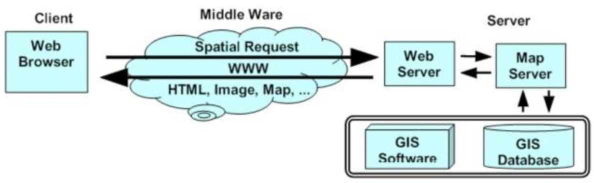

Figure 4.7 : How a typical Web GIS model works (Alesheikh & Helali, 2001).

This model of networks vastly exists in companies, where some devices act as servers and others act as clients.

Recent programming can produce software ingredients, and send them to the client before running it in the client device,

such as Java classes, plug-ins, and ActiveX components, typically, this occurs in the thick client GIS that allows most processing work locally on the client machine. Both thin and thick-client systems have some advantages and disadvantages, but they aren't the optimum solution in terms of benefiting from network resources (Funad, 2009).

4.9.2 Thin client architecture (server side applications)

In the client side, interfaces are used to connect with server and present the outcomes, and the server does all processes. Whereas, in the server side, internet GIS and web server execute all GIS analysis and map retrieval procedures (Vatsa vai et al. 2000). The server devices generally are stronger than the client ones, and run the centralized resources. (Figure 4.8) shows schematic communication between Web browser, Web Server and GIS server.

On the Web Server side, it is possible to connect the GIS with the World Wide Web; CGI, Active Server Pages (ASP), Web Server Application Programming Interface (API), Java Server Pages (JSP) (Alesheikh, 2001).

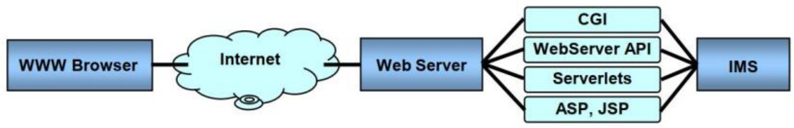

Figure 4.8: Server Side Applications (Alesheikh & Helali, 2001).

In the client side, the user has no need to know anything about the IMS relationships at the server side, but the application developers should be familiar with these mechanisms. This Architecture used in ESRI ArcView IMS, Map-Objects IMS and MapInfo Map-Xtreme systems.

Major advantages of thin client model:

- Focal control.
- Update data easily.

- Commonly cheaper.
- Possible to Integrate.
- Saving the latest version.

Disadvantages**:**

- Not responsive to local requirements.
- Less interactive.
- Huge data volume.
- Vector data does not appear in client side.
- Time Response is slow: it takes long time to download new HTML frame.

4.9.3 Thick "Fat" client architecture (client side applications)

Generally, the web browser can manipulate HTML documents, and embedded raster images; otherwise, to handle other data formats such as vector data, music files, or video clips, the browser's functions have to be expanded. The client server communication in Thin Client architecture couldn't use vector files format, therefore, many browser applications present a technique that allows third tier programs to work together with the browser as a Plug-in. The function of user interface has advanced to more interactive applications, this progress is as follows: HTML, CGI, using HTML forms and CGI, Java script to increase user interface capabilities, java applets to provide client-side functionality (Figure 4.9) (Byong-Lyol, 1998).

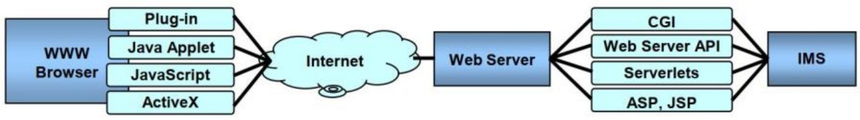

Figure 4.9: Client Side Applications (Alesheikh & Helali, 2001).

Major advantages of Thick client model:

- Standards for document or graphics are not required.
- Image quality not restricted only to GIF and JPEG.
- Using vector data.
- New interface is possible; and not restricted to single-click Operations.

Disadvantages:

- Users need to obtain additional software.
- Browser/Platformare incompatible.

4.9.4 Medium client architecture

To avoid vector data in client side and minimize the disadvantages of previous architectures, Medium Client is proposed, by using extensions in both client and server sides, clients may hold more functionally than thin client architecture. In (Figure 4.10) four components in interactive map are represented as services, each with interfaces.

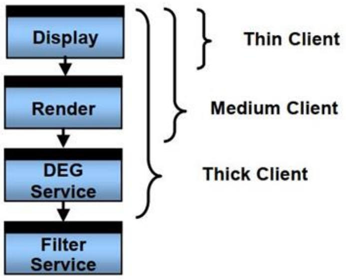

Figure 4.10: Medium Client position in Open GIS point of view (Alesheikh & Helali, 2001).

Finally, if the user's device includes only the display service, then a thin client is used. If the user’s device additionally includes a render service, then a medium client is used. Moreover, if the user’s device also includes the display element and generator service, then a thick client is used (Doyle, 1999).

4.9.5 Distributed architecture

The development of information technology leads to many distributed objects frameworks, which provide the structure required to establish distributed applications, hence, it supports a large number of servers and applications.

The most popular protocols are Distributed Component Object Model architecture in windows platform and Java Remote Method Invocation (RMI) in Java Virtual Machine (JVM), above architectures may be applied on GIS to develop the traditional client/server GIS model and improve scalable distributed GIS model. Some efforts made in the academic field (Zhang, 1998).

In the distributed GIS service model, a client program, in either web browser or distinct application, should be able to reach the resources (geo-data and geo-processing components) distributed in the whole network.

In this context, the client and the server do not refer to a specific device; any device requests the remote resources during the working, is a client or is a server, in particular program, a client may link to different servers and a particular device may be the client at one time and the server at another time.

The geo-data and geo-processing tools should be flexible and virtual anywhere in the network, and it should participate and integrate any time to complete a specified task (Yuan, 2000).

4.10 Web MappingTechnologies

There are unlimited technologies to implement web-mapping programs, and it can be implemented in any programming environment, programming language and server and client side framework. Next is a list of possible and famous server and client side technologies used in web mapping.

4.10.1 Server side technologies

- **Web server** The webserver uses web browsers and other user agents to handle http requests, and process authentication and content negotiation, in addition to, it serves static files as HTML pages or static image files. To enhance the functionality of webserver, modules or extensions must be used. Apache and Microsoft Internet Information Server and others are the most popular web server.
- **Web application servers** are middleware that link different software aspects with a programming language and the web server, also it benefits in developing complex real time web mapping applications or Web GIS.
- **Common Gateway Interface "CGI"** applications that are implemented on the webserver under the user's environment and permissions and written in any programming language or scripting language. A CGI application can execute several tasks such as: performing the common gateway interface protocol, processing data sent by the client, and resending the results in a web-readable format to the client. To enhance the performance of CGI applications, a Fast CGI can be installed that helps loading the application after starting the web server and keeps the work.

- **Alternatively,** scripting languages built into the webserver can be used as a module, like PHP, Python, Perl, Ruby, ASP.
- **Spatial databases** are relational databases enhanced with geographic data, it is very useful when web mapping application dealing with dynamic data or massive amount of geographic data. A widespread example for a spatial database is Post-GIS. MySQL also performs some spatial features. Trading alternatives are Oracle Spatial or spatial extensions of Microsoft SQL Server and IBM DB2.
- **WMS servers** are specialized web mapping servers carried out as a CGI application and Java Servlet. It can work as an independent web server or in cooperation with standing web servers and applications; they create maps on demand using parameters, such as map layer order, data format, projection, styling, symbolization and map extent. At last the image format of maps can be PNG, JPEG, GIF or SVG. Examples of WMS Servers are UMN Map server and Mapnik and the Commercial ones as Arc-GIS Server, ESRI Arc-IMS, Geo-Clip, Intergraph Geo-media Web-Map, and others.

4.10.2 Client side technologies

- **ECMA-Script** support ECMA-Script is the integrated version of JavaScript and part of any recent web browser, it implements client side interaction, performs network requests and refactor the DOM of a webpage.
- **Events** `support such as script execution events, SMIL animation events, UI events and SVG specific events.
- **Network requests** used to load further data and content in the web page. Most new browsers provide the XML-Http Request object and some feedback on the status of data loaded. The ECMA-Script processes data by that included into the current DOM tree of the web page. For network requests, SVG users provide the get-URL and post-URL methods in order to test if the network request method existed, otherwise it can provide alternatives. The term Ajax includes these network requests.
- **DOM** support The Document Object Model is included in any new web browser and offers an independent interface for the language to manipulate

the webpage document tree that allows adding new nodes, deleting nodes, reordering nodes and changing existing nodes. DOM support with scripting is also known as DHTML or Dynamic HTML. In addition to, Google Maps and different web mapping sites use a combination of DHTML, SVG, Ajax and VML.

- **SVG** support or SVG image support: SVG is for "Scalable Vector Graphics" that associates vector graphics, raster graphics and text, it also supports animation, interactivity, internationalization, scripting and XML based extension techniques, so it results in high quality and interactive maps. Mozilla/Firefox, version 1.5, Opera, version9 and Safari/Web-kit version support SVG.
- **Java support** some old versions of Java still used, the use of the Sun Java Plugin is the alternative, Java is a full featured programming language that creates a very complex and interactive web maps. The Java-2D and Java-3D libraries provide 2D and 3D vector graphics support.

4.11 Web Mapping for GIS

The internet maps are classified into two levels: the first level consists of static and dynamic maps and the second level contains non-interactive maps and interactive maps.

4.11.1 Definition and technical realization

Internet Maps: are every map accessible via Internet from ordinary scanned maps to such that offer different GIS functions.

Internet Mapping: is the creation, dissemination and use of maps via Internet.

Internet GIS are Internet based systems that do some tasks such as saving, analyzing and visualizing space related data. It has the same functions of ordinary GIS but the internet must be to access. The main differences between desktop GIS and Internet GIS are presented in the model of realization below (Figure 4.11).

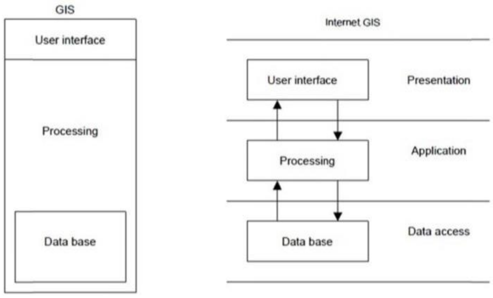

Figure 4.11 : Comparison between GIS and Internet GIS (Usun, 2011).

Usually, internet GIS have client-server structure in which GIS software, user client interface and communication protocol are used in the server. Also, it includes a separate map server, the map server is every server with installed software that handles and requests maps. Structcture of internet GIS is presented on (Figure 4.12).

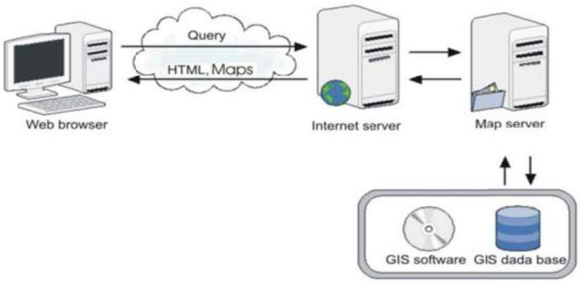

Figure 4.12: Traditional structure of internet GIS (Usun, 2011).

4.11.2 Interactive web maps

There are many technology means to publish maps on the Web, starting from sites that purely publish static maps to more complex sites that present dynamic maps, interactive maps and diverse computer schemes and operating systems. A Special Interest Group (SIG) for WWW Mapping is occupied to publish Web-based GIS, and has developed an base model of interactive portrayal (Figure 4.13).

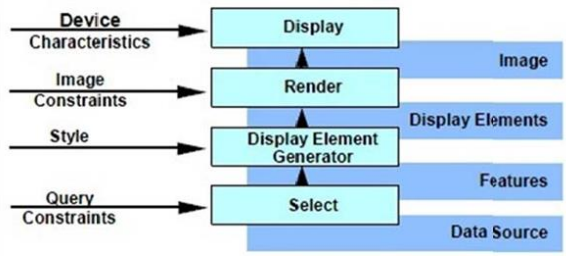

Figure 4.13 : Open GIS model of portrayal workflow (Doyle, 1999).

This model is advantageous because it analyzes and compares different structures for Internet Map Servers and other Internet based GIS applications, further, it is more accurate than the normal one. The interactive portrayal model has four classes (Alesheikh et al., 2016)as following:

- When a request is done, the selection process retrieves data from a geospatial data source such as search area or thematic selections.
- The Display Element Generator process switches the picked geospatial data to a series of display components; it links styles such as symbols, fill styles, line styles to spatial features, arranges the display components in a particular order and performs other graphical handling.
- The Render takes the display components and establishes a rendered map, such as In-memory display lists, postscript files, or GIF-files.
- Finally, the rendered map is visible to users on the display machine.

Between these four classes, there are three different types of data:

- Features and coverage's retrieved from the Selection process as raster data.
- Display components generated form the Display Element Generator
- Images produced by the Render

Another ability for interactive Web maps is to allow users adding new themes to the map from data sources available, which achieved by assigning the whole theme, or by requesting the spatial or attribute data (Strand, 1998).

4.11.3 Internet map servers

Internet Map Server (IMS) applications allow GIS database keeper's access easily to spatial data through a web browser interface to end-users. Any firm has a website can add an IMS without setting up additional security holes, so the data will be available to all users.

Software needs two elements to operate IMS: geospatial data processing engine and Common Gateway Interface (CGI) application. Also, IMS requires a downloadable plug-in that performs advanced buffer, labeling, query and sub setting operations, some IMS sites present both a plug-in and a simple HTML version.

4.11.3.1 Static and dynamic maps in internet

The digital maps are changing dynamically because of different interactive operations used; using suitable operations result in maps that are more expressive.

The first level of classification divides Internet maps into static and dynamic, the second level splits those maps to examination only (can't be changed) and interactive maps which show some chances for interaction and changes of the map.

4.11.3.2 Static maps

The static maps are constant maps, scanned in GIF or JPEG format and saved as static raster images or vector images; they aren't interactive but suitable to save and present such rare historical maps to public. Some functions may be used in static maps such as zoom function, but the scaling (Zoom) and moving (Pan) are non-interactive functions because a similar action can be done with the regular maps.

4.11.3.3 Static interactive maps

Similar to static maps but show a little interactivity, examples of static interactive maps are images with different active areas that linked to data given in several forms.

4.11.3.4 Dynamic maps for examination only

The dynamic maps differ from one another, they are created on the map server that handles the request and produces the needed map, which is displayed in a raster image format as GIF or JPEG, and then it sent to user.

Two advantages of these maps, the user always gains real maps and he can't find a clear software to examine it. Otherwise, the disadvantages are missing the interactivity in the dynamic maps for examination and some data will transfer to Internet when the view is changed (zoom or pan), so that, the user must connect to the map server every time he needs to generate a new map.

4.11.3.5 Dynamic interactive maps

They provide high level of GIS functionality regarding management and information analysis, they allow using, analyzing and searching any kind of information and help the user to determine the content and design the map elements.

4.12 Cyber Security in WEB GIS Environment

Web applications are and least protected and vulnerable because the standards often are not focused on security but more in the services (Charpentier, 2013).

The main o of objective Web-GIS is to serve clients in the geographic field, hence it is essential to protect information or data stored and transferred over the WebGIS environment (Rhodes, 2013). Information security is the procedures of safeguarding the availability, privacy, and integrity of data.

Cyber security guarantees the accomplishment and preservation of security features of the digital infrastructure and services against risks (Giribabu et al., 2018). von Solms and Van Niekerk 2013, reported in their article that the border lines of Cyber-security are wider than those of information security, and they defined the Cyber-security as a combination of policies, security concepts, security safeguards, guidelines, risk management methods, training, best practices, assurance and technologies used to save the cyber environment of organization (Von,2013).

Web-based GIS is open system and many hackers can penetrate port 80 if no security tools work out, if the hacker break through web server, it could result in disastrous problems and corrupt the information existed in GIS system. Rao & Pant 2011, proposed a framework to study the security and risk evaluation of GIS application, and address the security through the three interrelated classes (network, host and application). In addition to, their study brings a global model for vulnerability assessment, risk management of Geographical Weather Information System (GWIS)(Rao, 2009). Sankar & Sevugan 2016, advanced a hybrid model to make information more secured by storing and hiding the information with some techniques, which results in delivering information in an efficient way with minimum time through effective load balancing way (Sankar, 2016).

Cyber-security implementation depends on the software used in the structural components of Web-GIS system such as ESRI, ArcGIS Server, Geo-Server or Map-Server, ERDAS Apollo architecture (Mustakayev, 2017).

The security in Software Development Lifecycle divided into three steps as Secure Development, Secure Deployment and Secure Operations as shown in (Figure 4.14).

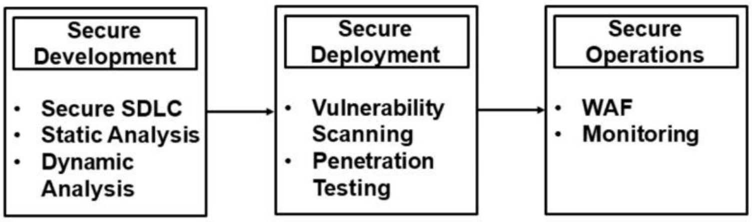

Figure 4.14 : Application Level Security (Adopted from (Securosis, 2009)).

Secure Development: involved in training people who develop web, this training includes education and supportive process modifications, secure development practices and software assurance.

Static analysis identifyes weak code using specific tools that scan the source code of an application to find the security errors, and called “white box” tools, and dynamic analysis to disclose irrigular application behaviour using tools that meet with running application and try to intrrupt it, often called “black box” tools.

This stage take into consideration the vulnerabilities such as Cross Site Scripting (XSS), SQL Injection, Cross Site Request Forgery, Hidden content, Debug code, Insecure Object References and Application logic vulnerabilities.

Secure Deployment: in this stage, it must be ensured that the application doesn’t suffer from any security faults, where vulnerability evaluation and penetration assessment will be done for configuration analysis, threat detection, patch levels, and operational consistency.

- Vulnerability evaluation: Remote scanning of a web application to find vulnerabilities, which focuses on the application itself, while standard vulnerability assessments focus on the host platform.

- Penetration assessment: is the process of entering an application to select security vulnerabilities and risks, while vulnerability evaluation finds security faults, penetration assessments explore those gaps to measure the effect.
- Secure Operations: detect capabilities to enhance policies, react rationally to events, and merge several services in a cooperative hybrid model.
- Web Application Firewalls: are network tools that control web application to screen requests for inappropriate activity and attempt to stop attacks, also, they own the ability to scan any application from undesirable uses.
- Network security is any activity created to safeguard the usability and integrity of network and data and manage access to the network, it includes both hardware and software technologies. Its targets is stopping threats and from entering or spreading the network. Network security includes multiple layers of defenses at the border and in the network, each layer carries out policies and controls.

The most important asset in Web-GIS is data and strong data storage and security process are fundamental element in the chain of Web-GIS setup. Data storage security is a wide field that protects everything from legal defenses, to preparedness for e-discovery requests to user access monitoring and security of data storage. Boundaries should be placed on the domain of web service requests to obviate web scraping, mass downloads, or massive data processing.

Web GIS managers must work closely with their IT management staff to ensure the security of web services, furthermore, Web GIS systems and apps have to integrate with current login infrastructure to manage control effectively and provide more convenience to users.

To raise the security of a GIS, standard web safety practices existed, such as giving users the minimum privileges needed to do their jobs, restricting access to servers, demanding strong passwords that are changed on a regular basis, also, all passwords and any sensitive data should be transformed in encrypted form via secure sockets layer (SSL) connections.

5. CASE STUDY: KÜÇÜKÇEKMECE REGION, ISTANBUL

This section is focused on the case study of Küçükçekmece region in Istanbul, Turkey for the implementation of Web GISbased MCDA method of AHP to determine earthquake hazard monitoring criteria as input into generation of earthquake hazard maps (EHMs) simulated on a Web GIS environment. The AHP technique is used to determine the weights of the parameters that have influence on earthquake effects, which are used as input for EHM online production.

5.1 Study Area

Turkey is situated within the Mediterranean portion of the Alpine-Himalayan orogenic system that extends from Europe to Asia, identified with high ranges of mountains and shallow, more or less uniform zones of seismicity, making it one of the most seismically active regions in the world as can be observed from (Figure 5.1). To this effect, Turkey has a long and well-documented record of earthquake events (Erdik et al, 1985).

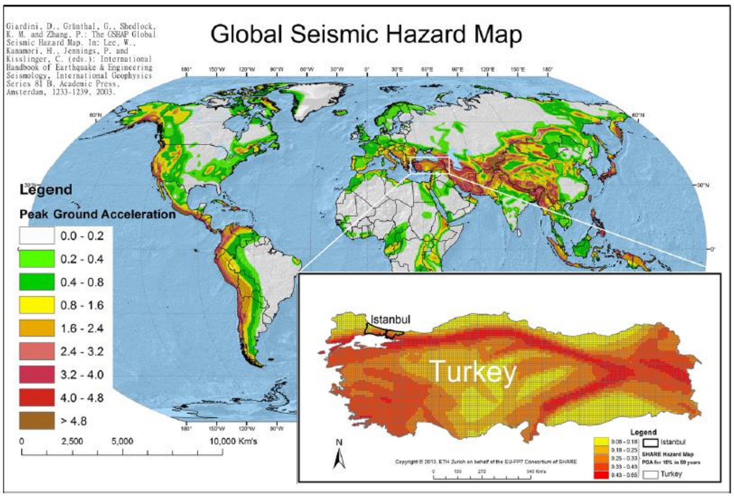

Figure 5.1 : Global seismic hazard map and study area location (Giardini et al, 2003).

Istanbul is the largest and most urbanized city, in Turkey with regard to population, industry, and infrastructure. Regrettably, it is also one of the most seismically active cities in Turkey. According to Parsons (2004), the probability of a M ≥ 7 earthquake rupturing beneath the Marmara Sea at the southern part of Istanbul is approximately 35-70% within the next 30 years. This has caused anxiety and roused communities, citizens and researchers into undertaking safeguards and precautions against likely earthquake occurrences. Extensive technical and scientific studies have been conducted in the region and all commend that the preparedness of Istanbul against earthquakes must be in accordance with the mitigation, response and recovery activities based on the DEM cycle (Karaman and Erden, 2014).

This study focuses on generation of EHMs online for the Küçükçekmece region in Istanbul, extending over an area of approximately, 36 km² (Figure 5.2), which are required for thorough hazard mapping and vulnerability risk/loss assessment as part of DEM.

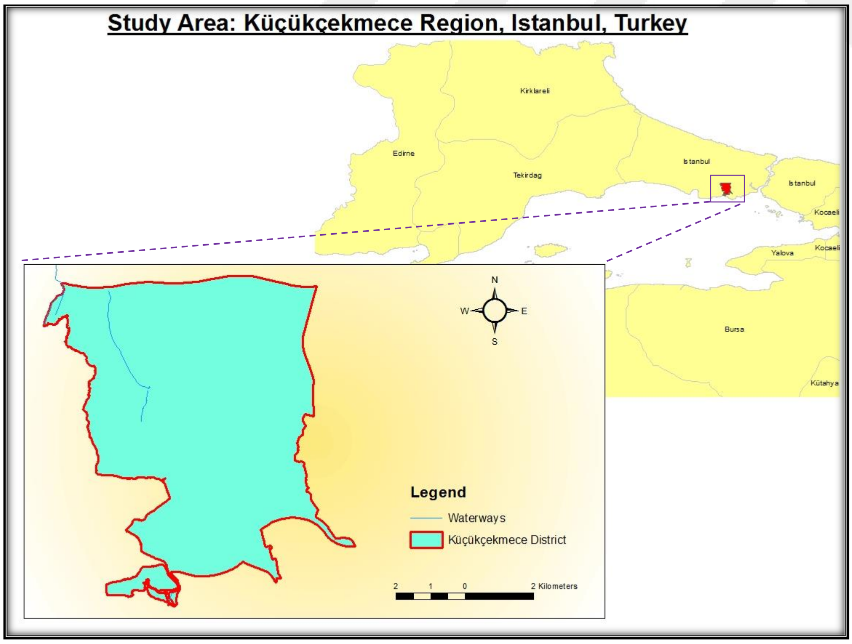

Figure 5.2 : Study area- Küçükçekmece region in Istanbul, Turkey (Nyimbili, 2017).

5.2 Framework for The Study

The proposed approach in the generation of earthquake hazard maps (EHMs) on the web for hazard and risk assessment is based MCDA method of AHP, integrated with Web GIS. This means that all operations will be do over the Internet to create interactive earthquake hazard map. The spatially referenced data as map layer (evaluation criterion) inputs into a Web GIS are combined and processed online into resultant hazard maps as outputs using AHP techniques.

The approach involves the procedures highlighted in Figure 5.3. The first step is identification of the evaluation criteria that include determination of the parameters that influence the effects of earthquakes to be simulated on a Web GIS environment.These criteria in form of input map layers are then standardized and appropriate factor weights assigned based on experts' opinions and preferences using the pairwise comparison technique of the AHP model.

By use ArcGIS API for JavaScript (online programming esri libraries), these attained weights for each of the criteria (map input layers) are combined using the spatial analyst tool's weighted sum function after relevant classifications are done for all the criteria generating the resultant earthquake hazard map.

The results of the generated earthquake hazard maps (EHMs) from AHP analyzed then integrate with building layer to conduct further analysis based on the behavior of the building layer with the hazard map.

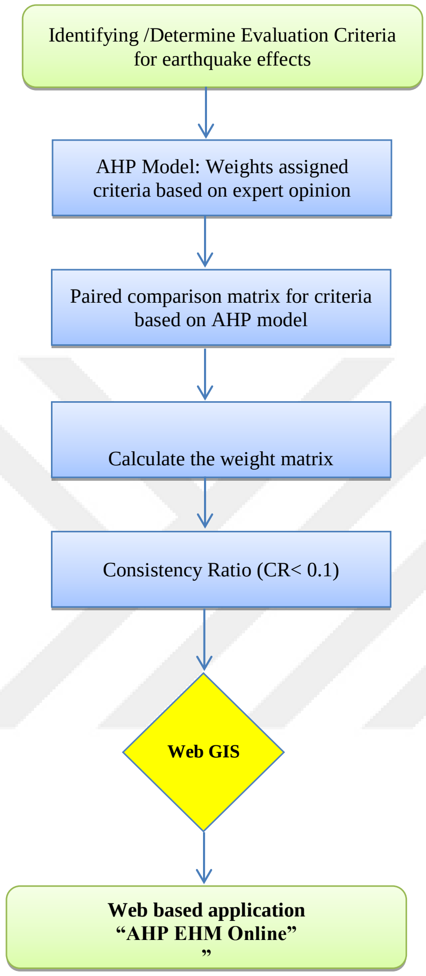

Figure 5.3 : Framework for the study.

5.3 Criteria Selection for Earthquake Hazard Mapping

Within the context of earthquake disasters, a hazard is characterized as an input ground motion parameter of an anticipated earthquake for the affected region. The other components of seismic loss assessment, besides hazard (exposure) are vulnerability (sensitivity), inventory (value) and integrated visualization (losses). When evaluating physical and economic impacts, translating damage resulting from disaster into loss of value, integrated visualization is a vital framework that utilizes hazard, vulnerability and inventory components (Karaman et al, 2008a).

For earthquake hazards, information about the attenuation models, earthquake scenario, soil classification, fault/focal mechanism, liquefaction potential and topography of area are required. These main parameters have significant influence on the impact and resultant effects of earthquakes on a study area and are thus broadly used as input for the attenuation models (Karaman and Erden, 2014). Attenuation model/relation or ground motion model is used to simulate the earthquake effects over a particular region and is described by seismologists as a mathematical expression relating specific strong motion parameter of ground shaking to one or more seismological earthquake parameters. The source of the earthquake, distance of wave propagation from source and site, fault type, soil and geological profile underneath the site and local site condition type, quantitatively describe these seismological parameters (Lee et al, 2002; Karaman et al, 2008a). Therefore, the criteria for this study were selected based on those required in attenuation relations. As there are over 300 attenuation relations worldwide applicable to particular regions, the most general form of the attenuation relation is structured as given in equation 5.1 (Boore and Atkinson, 2008).

$$\ln Y = F_M(M) + F_D(R_{JB,}M) + F_S\left(V_{s30}, R_{JB}, M\right) + \varepsilon\sigma_T \qquad (5.1)$$

where, (In) represents the natural logarithm, Y, is the strong motion parameter of interest, F_M, F_D, and $F_{S,}$ represent the magnitude scaling, distance function, and site amplification, respectively, while M is the moment magnitude, R_{JB} is the Joyner–Boore distance (nearest distance to the surface projection of the fault, which is almost equal to the distance to the epicentre distance for events of $M_w< 6$), and V_{S30} is the inverse of the time averaged shear-wave slowness from the surface to a depth of 30m, $\varepsilon_{\sigma T}$ is a random error expression(Boore and Atkinson, 2008).

From this equation, we can derive the five (5) basic criteria determined for earthquake hazard map generation which are magnitude and faulting type, soil type and source-to-site distance and use of two extra criteria of liquefaction potential and field topography, for a more realistic strong ground motion simulation in alignment with the next-generation attenuation models (NGA) (Atkinson and Boore, 2007; Campbell and Bozorgnia, 2007) and new codes such as Eurocode 8 (CEN, 2004).

The map layers representing these criteria were obtained from relevant authorities that included the Istanbul Municipality. The map layers were visualized using ArcGIS 10.3 software by classifying them into four (4) class representations for this study with reference to scientific codes and assumptions in conformity to the cartographic presentation rules of visualization of having less than seven (7) tone values (Schoppmeyer, 1978). This classification is done to assist decision-makers to quickly understand the situation and geographic distribution by a mere glance of the resulting hazard maps where class value of 4 represented major/highest risk cell areas while class value of 1 represented no/lowest risk cell areas (Karaman and Erden, 2014). Both manual and natural breaks (jenks) methods were used in this study for classifying the map layer data. The value ranges of the criteria/parameters and their matchingclass values were asdepictedin Table 5.1

Table 5.1 : Criteria class value ranges, corresponding class values and their hazard risk levels, adapted from (Erden and Karaman, 2012).

Criteria		Class Values			
		1	2	3	4
		No/Low Risk	⇢	⇢	Major Risk
1	FT (field topography) [degrees]	0-10	10-15	15-30	>30
2	DS (source-to-site distance) [km]	22.21-19.80	19.80-17.38	17.38-14.97	14.97-12.55
3	SC (soil classification) [m/s]	800-760	760-360	360-180	180-50
4	LP (liquefaction potential)	104-103	103-102	102-101	101
5	FM (fault/focal mechanism)	0.45-0.53	0.53-0.61	0.61-0.68	0.68-0.76

The following included the main spatial analyses in ArcGIS 10.4 and Web GIS an that were performed on the five (5) criteria map layer inputs: map data conversions (raster to vector), extract by mask for boundary study region delineation, near distance analysis, field calculator, overlay – spatial join, overlay – weighted sum for aggregation of map layers and application of weights, and classification into the 4 class values , resulting in the final AHP interactive earthquake hazard map.

5.3.1 Field topography (FT)

In earthquake hazards, the effect of topography is a vital factor that amplifies seismic energy, especially in highly seismic areas that are densely populated. The topography of the site has an amplification effect on the earthquake ground motion with respect to the height and slope angle (Erden and Karaman, 2012; Karaman and Erden, 2014). Further information can be obtained from the Eurocode 8 standards, part 5 (CEN, 2004).

5.3.2 Source-to-site distance (DS)

Earthquake effects attenuate (diminish) as the distance from the epicentre (source) of earthquake increases. Conversely, the effects of earthquakes increase as the distance from the source to the site of varied locations at region of interest reduces. Therefore, the effect of distance with regard to the magnitude of earthquake is a very important factor for simulation of the resulting hazard map. The source-to-site distance criteria was modelled by classifying the distance into 4 classes and involved several processes within Web GIS environment.

5.3.3 Soil classification (SC)

Model of how a site behaves in the event of an earthquake can be determined by the strength of the soil and geological conditions, hence the type of soil. For example, if a site has hard soil (rocky), the ground shaking effects of an earthquake is less than at site with softer soil. The classifications of soil were aggregated by using detailed soil maps of the study region obtained from the Istanbul Municipality. These soil maps were based on the classification scheme of the National Earthquake Hazards Reduction Program, U.S (NEHRP) (2004). The soil classes were determined using the shear velocity values (in m/s) at 30 metres in classification, where soil properties are detected for every metre for up to 30 metres depth beneath the ground surface. For higher velocities in hard soils, the ground shaking intensity is felt less and transfer rate is faster and vice versa for soft soils, where the velocities and transfer rates are slower, resulting in ground shaking effects being felt more.

5.3.4 Liquefaction potential (LP)

The liquefaction potential index (LPI) is relevant for spatial analysis of liquefaction hazard (Erden and Karaman, 2012) related to presence of water beneath the soil and site surface influencing earthquake effects.

5.3.5 Fault/Focal mechanism (FM)

Through an attenuation law, according to Ambraseys (1995) and Boore (1997), the level of hazard at a particular site can be acquired by an assessment of the effects of the seismic source zone, decribed by its geometry and relationship of recurrence.

During an earthquake occurrence, the resulting rupture (or break) involves just a portion of the fault (defined as the resulting fracture of the Earth's crust, Elnashai and Di Sarno, 2008). The 'focus' or 'hypocentre' is the point under the surface at which an earthquake originates and the intersection point of the projection of the focus to the surface of the Earth, is known as the 'epicentre' (Erden and Karaman, 2012; Karaman and Erden, 2014) as illustrated in (Figure 5.4).

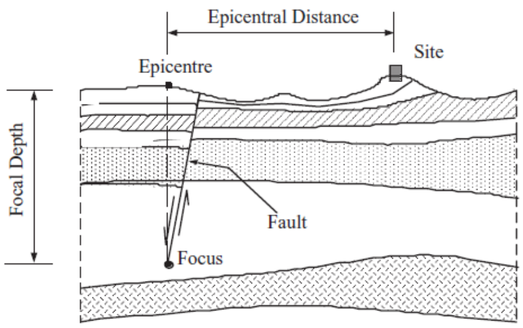

Figure 5.4: Definition of earthquake source parameters (Elnashai and Di Sarno, 2008).

The definition of the fault/focal geometry of earthquakes are characterized by the positions and orientation of the footand hanging wall. The focal mechanism of an earthquake is thus described by the three angles: strike (or azimuth), dip and rake (or slip) (Stein and Wysession, 2003) and can be visualized and determined as in (Figure 2.5) (Elnashai and Di Sarno, 2008).

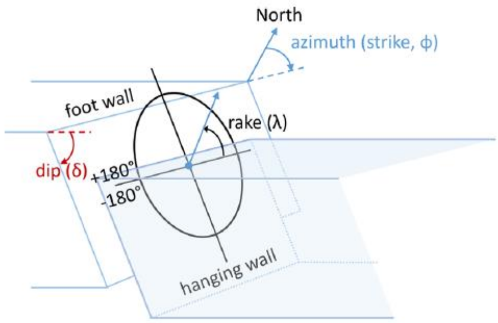

Figure 5.5 : Definition and visualization of fault/focal mechanism (Elnashai and Di Sarno, 2008).

The type of faults can be defined using these three angles. The type of fault is a very significant element in the simulation procedure of the earthquake hazard maps (EHM) because it influences the occurrence and effects of the earthquake. The main fault types and associated focal parameters are shown in Table 5.2.

Table 5.2 : Fault types by focal parameters, adapted from (Erden and Karaman, 2012).

Fault type	Dip angle(δ°)	Rake angle(λ°)
Normal	40 <δ > 70	Negative
Thrust	10 <δ> 40	Positive
Strike-slip	δ = 90	0 = sinistral/ 180 = dextral
Oblique-slip	0 <δ> 90	Negative = normal oblique Positive = reverse oblique

In the region of study, the fault line applied is known as the Main Marmara Fault (MMF) and is composed of various fault types. With reference to the focal parameters of the MMF, this fault line was modelled for various fault types and possible earthquake effects in ArcGIS by taking consideration of the measurements previously done on the fault itself under the Marmara Sea defining the strike, dip and rake angles in different locations. These focal parameters utilized were obtained from previous studies and measurements done for the MMF by Pulido et al. (2004), Sato et al. (2004), and Ansal et al. (2009). From all the three studies for the focal mechanism of the MMF, significant differences in the focal mechanism were shown in various locations at the fault line.

The geographic coordinates of the line segments and point locations and the focal parameters determined were inputted into ArcGIS and the MMF was displayed as a line feature for modelling earthquake effects for the study area as illustrated in (Figure 5.6).

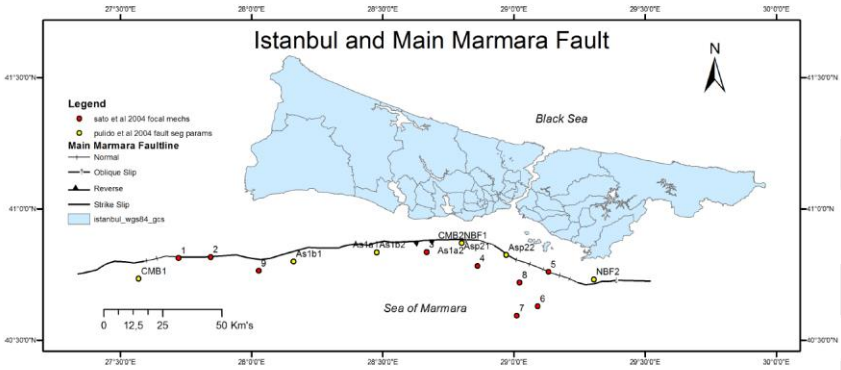

Figure 5.6: Visualization of Main Marmara Fault (MMF) and locations of focal parameters (Erden and Karaman, 2012).

The fault mechanism effect was determined and classified based on the fault type effect model of Boore and Atkinson (2008), which is one of the most recent and comprehensive relationships to be applied for this study region and has its main benefit over other models, of incorporating parameters for each relevant type of fault in modelling the earthquake effects (Erden and Karaman, 2012).

6. BUILDING WEB EARTHQUAKES HAZARD MAP SYSTEM

6.1 Introduction

This chapter aims to identify the new strategy and methodology used in building the interactive earthquake hazard map, the parameters of the EHM, topography, distance to epicenter, soil classification, liquefaction, and fault/focal mechanism, will be controllable and manageable through web based application. In addition to the weights of parameters produced by AHP tool, in which users can change these weights. The new strategy based on previously available data as a source to implement the new method in order to provide easier and simpler technique, and accurate for decision-making. Further, it will also achieve a good level of satisfaction among GIS Audience.

Many programming languages has been used to build system that provide speed, accuracy, security and handling to large sized data such as Node.js, ASP.net, C# and JQuery. The consistency between programming languages is available in system.

ArcGIS API for JavaScript is a key factor in the working of the proposed system, the API has created, which call the data from the GIS server and SQL Server display on the browser, it is responsible for handling the requests and response processes between the user environment and Web GIS server.

The proposed system working on the web so the users using Web browser to launching system and calling interactive map and doing analysis and decision making processes.

6.2 Installation and Configuration of The Software

Geographical Information Systems (GIS) are used increasingly in variety of application areas. The possibilities to increase the accuracy and to create combinations of all kinds of information sources are available through the GIS technology.

6.2.1 ArcGIS software

ESRI provides a package of spatial data management, mapping and analysis programs, and we have used many of these programs as appropriate with the methodology used to build an earthquake hazard management system.

ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web. It is developed by ESRI (Esri Support, 2018).

6.2.1.1 Download and install ArcGIS for desktop

ArcGIS Desktop is the key to realizing the advantage of location awareness. Collect and manage data, create professional maps, perform traditional and advanced spatial analysis, and solve real problems. We used 10.4 version of ArcMap to manage and customize the layers before publishing process.

Also by ArcMap we will create the map file (mxd) with the desired layers and symbology.

6.2.1.2 Download and install ArcGIS server and portal for ArcGIS

ArcGIS Server is the main component of the enterprise platform, it helps to create and manage the services of data. It also provides advanced analytics to the organization. Designed for interoperability, it publishes data from any major spatial data source using ESRI and open standards e.g. Mapping, WMS (Web Map service), WFS (Web Feature service), KML (Keyhole Markup Language) etc. Portal for ArcGIS allows users to share and secure the geospatial data and applications.

The Portal Sharing API, which exposes Portal for ArcGIS functionality as a REST endpoint and enables access to the ArcGIS Portal Directory.

Once we have web services “mxd” file running, we can use access to JSON code by ArcGIS REST framework that can communicate through HTTP. Therefore, we can call layers data to our API then perform the processes on it.

6.2.1.3 Steps followed installation

- Create a database server connection by Registered Folders option in ArcGIS Catalog that allows us to registered layers. This connection will be used to manage the desired layers in the database (Figure 6.1).
- Create a GIS Server connection with the ArcGIS Server using the GIS server’s IP address and login credentials in ArcGIS Catalog. This connection will be used to create a service in ArcGIS Server (Figure 6.2).

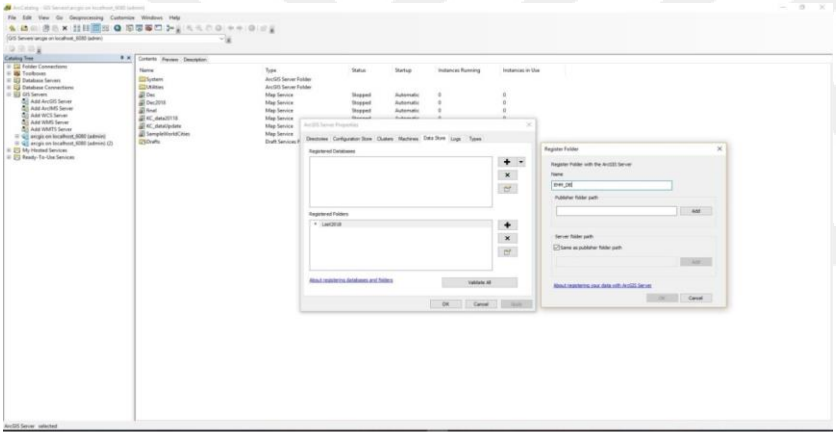

Figure 6.1: Create a database server connection by Registered Folders option in ArcGIS Catalog.

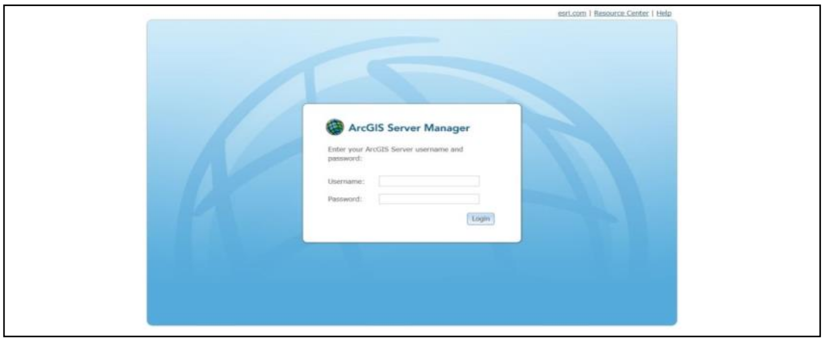

Figure 6.2 :GIS Server connections with the ArcGIS Server using the GIS server’s IP address and login credentials in ArcGIS Catalog.

6.2.2 Microsoft visual studio 2017

Microsoft Visual Studio is an integrated development environment (IDE) from Microsoft. We used this environmentto develop computer programs, as well as websites, web apps, web services and mobile apps. Visual Studio uses Microsoft software development platforms such as Windows API, Windows Forms, Windows Presentation Foundation, Windows Store and Microsoft Silverlight.

Visual Studio supports 36 different programming languages and allows the code editor and debugger to support (to varying degrees) nearly any programming language, provided a language-specific service exists. Built-in languages include C, C++, C++/CLI, Visual Basic .NET, C#, F#, JavaScript, TypeScript, XML, XSLT, HTML, Node.js, and CSS(Microsoft.com, 2019).

In our system Visual studio program will be the incubator for all the programming languages used in building the system, and by our code, we will able to called layer data from ArcGIS Server and SQL Server.

Programming Languages used to build Earthquakes hazard map system and within on Visual studio environment

6.2.2.1 ASP.net C#

ASP.NET is an open source server side web application framework designed for web development to produce dynamic web pages. It was developed by Microsoft to allow programmers to build dynamic web sites, web applications and web services.

It was first released in January 2002 with version 1.0 of the .NET Framework; ASP.NET is the successor to Microsoft's Active Server Pages (ASP) technology. Moreover, built on the Common Language Runtime (CLR), allowing programmers to write ASP.NET code using any supported .NET language. The ASP.NET SOAP extension framework allows ASP.NET components to process SOAP messages (dotnet.Microsoft.com, 2019).

Visual Studio has its own ASP.NET engine, which is responsible for running our web application so you don't have any problems running an ASP.NET application from the VS IDE. When we want to host your site for others to access, the concept of a "Web Server" comes into picture. A web server is responsible for providing a response to requests that come from clients. Therefore, when multiple users come in, multiple requests also come in and the web server will have a response for each of them. IIS (Internet Information Server) is one of the most powerful web servers from Microsoft that is used to host ASP.NET web applications. IIS has its own ASP.NET Process to handle ASP.NET requests as we see in (Figure 6.3).

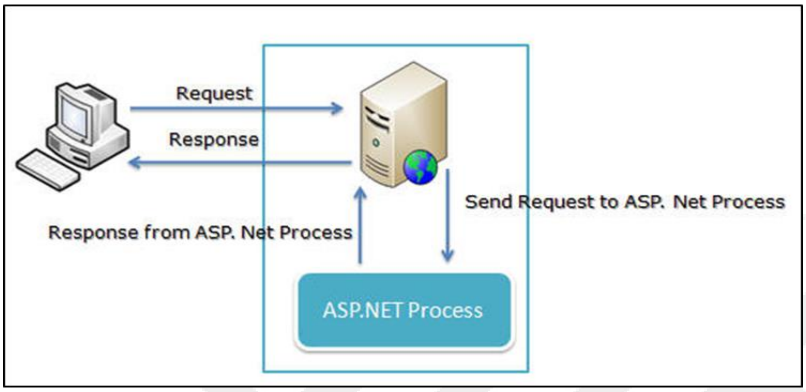

Figure 6.3 : IIS Server or ASP.Net server Architectures (Microsoft.com, 2019).

In our system the ASP server run the software components and programming languages such as C#, JavaScript, Node.js, Html, CSS. In addition, all requests received from the client are processed and responded to. It also receives requests from the client and responds directly to them.

ASP.Net supports a number of programming models for building web applications, we used ASP.NET MVC model during building system, this model using the model–view–controller design pattern for building web pages, and this model is more secure and addresses speed problems more than other models.

6.2.2.2 HTML5

HTML is the standard markup language for creating Web pages. HTML stands for Hyper Text Markup Language, it is describes the structure of Web pages using markup. The elements are the building blocks of HTML pages, and represented by tags.

HTML tags label pieces of content such as "heading", "paragraph", "table", and so on. Browsers do not display the HTML tags, but use them to render the content of the page. By this language, we have built system interfaces, then integrated with JQuery and CSS.

6.2.2.3 JQuery

JavaScript is the programming language of HTML and the Web, jQuery is JavaScript Library. JQuery has been used to design the system interfaces, perform some functions related to movements and handle the database. The 3.3.1version used to write code and call the functions of the JQuery.

6.2.2.4 CSS

Cascading Style Sheets (CSS) is a language that describes the style of HTML document. In addition, describes how HTML elements should be displayed on screen, paper, or in other media like on mobile, or tablet, CSS saves a lot of work. It can control the layout of multiple web pages all at once.

6.2.2.5 Node.js

Node.js is an open source server environment, uses JavaScript on the server side; by this language, we can run JavaScript on the server. Node.js has a high ability to handle large volumes of data and processing multiple requests and respond to them (w3schools.com, 2019).

In our system Node.js is used to build the API that integrate with ArcGIS API for JavaScript which hosted by Esri (Figure 6.4).

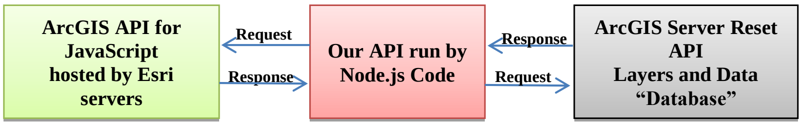

Figure 6.4: Integration our API with ArcGIS API for JavaScript and ArcGIS Server Reset API.

6.2.2.6 ArcGIS API for javaScript

ArcGIS API is designed to increase the productivity of developers in order to build attractive and beautiful web mapping applications. The API combines modern web technology with powerful geospatial capabilities that enable users to create high-performance applications and smarter data visualization.

We used Content Delivery Network (CDN) or hosting version to accessing ArcGIS API, the Benefits of using this approach (esri.com, 2019):

- CDN is a collection of geographically distributed web servers that deliver content efficiently.
- Balanced load servers and 24/7 monitoring.
- There is no need to download and install the API when new versions are released. You only need to modify the script tag in the application to point to the new version.
- After accessing to ArcGIS API we will be able to use the functions and the Classes to mapping and analyzing data on the web.

6.2.2.7 SQL server management studio

SQL Server Management Studio (SSMS) is an integrated environment for managing any SQL infrastructure. SSMS provides tools to configure, monitor, and administer instances of SQL Server and databases. Use SSMS to deploy, monitor, and upgrade the data-tier components used by applications, as well as build queries and scripts (W3School.com, 2019).

We have created a SQL Server database to storing user data (user name, password, etc.), and storing the results while working on the system. But the main database containing earthquake parameters data published on ArcGIS Server as mentioned in this chapter.

6.3 Preparing Layers to Publishing Phase

In our system, we have five main layers; these layers are the parameters on which the interactive earthquake hazard map is build. We have done several preparatory steps for publishing the layers to be able to use by API like the following:

6.3.1 Import layers in ArcMap

We loaded all parameter layers (Field topography, Source to site distance, Soil classification, Liquefaction potential, Fault/focal mechanism).

6.3.2 Spatial join operation

After loaded the layers in ArMap, We have done the spatial Join to all layers. The aim of this step is to unify the number of record in all layers so that the operations are easy to perform by API and get accurate results.

We selected the Field topography layer to be as master or target layer during spatial join process.The Layers after applying the previous steps:

6.3.3.1 Field topography

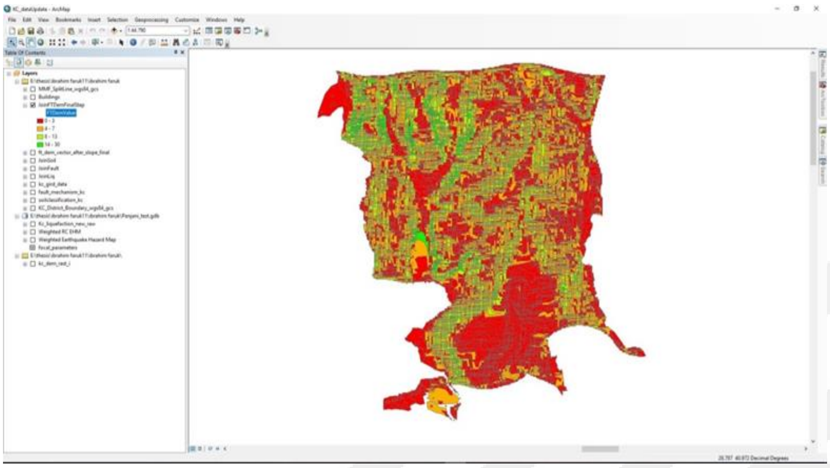

Figure 6.5 : Showing the Field topography Layer after performing the two steps.

6.3.3.2 Soil classification

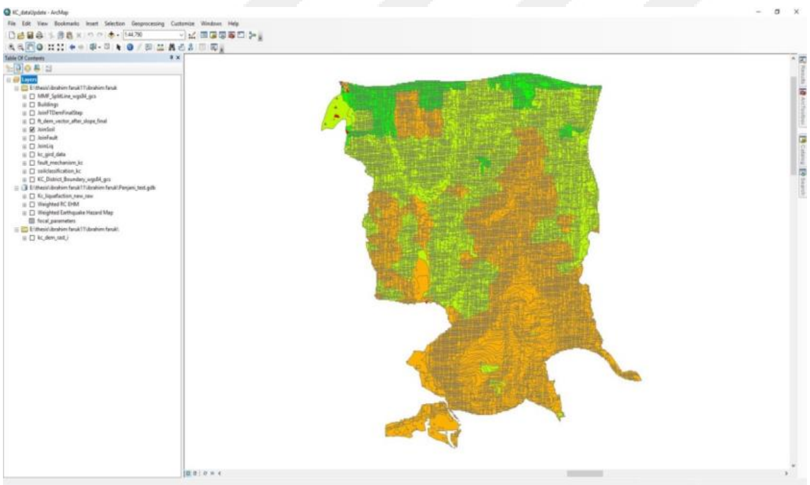

Figure 6.6 : Soil classification layer after performing the two steps.

6.3.3.3 Fault/Focal mechanism

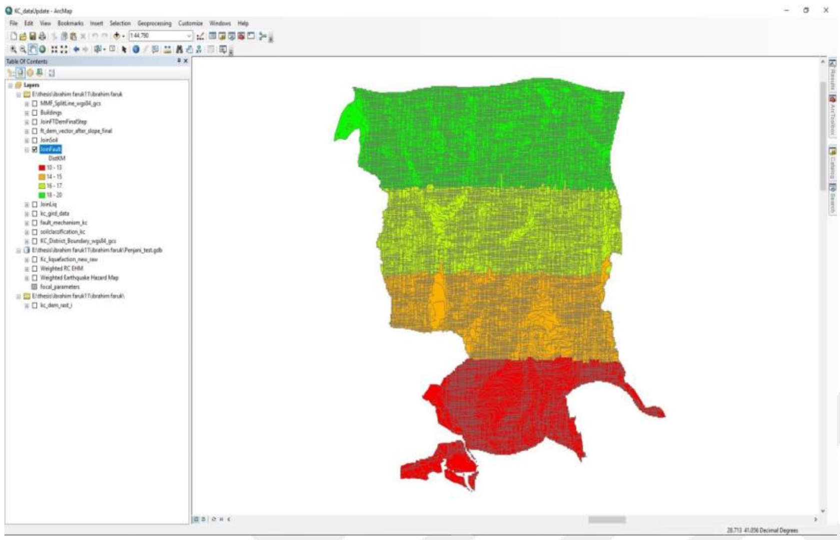

Figure 6.7: Fault/focal mechanism Layer after performing the two steps.

6.3.3.4 Liquefaction potential

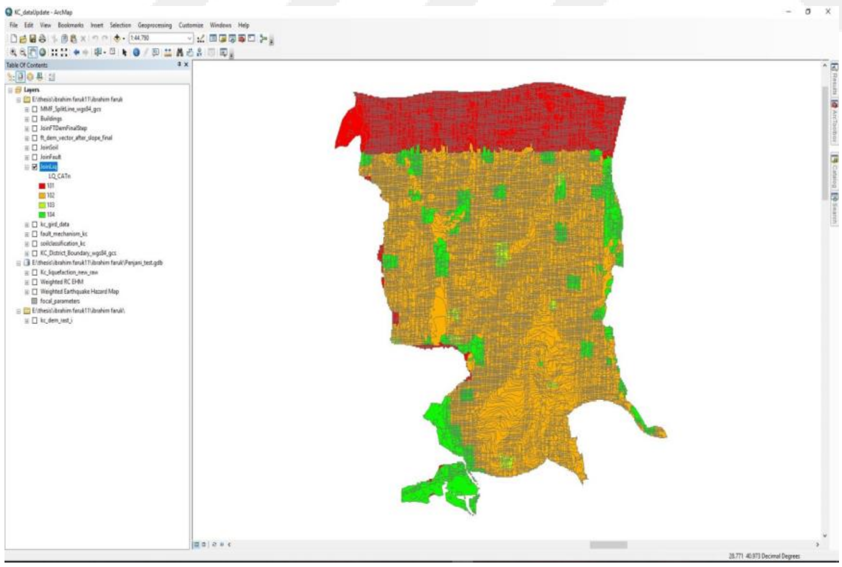

Figure 6.8: Liquefaction potential Layer after performing the two steps.

6.3.3.5 Source to site distance

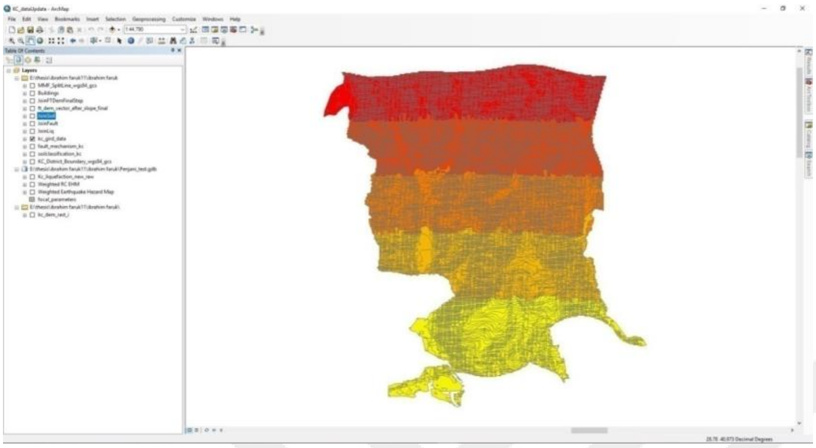

Figure 6.9 : Publishing service in ArcMap to our layers.

6.4 Publish Service in ArcGIS Server

After applying previous steps, the parameter layers ready to publishing in ArcGIS server to enabling our API accessing to layer data.

The output of the deployment, create map file (mxd), this file includes all layers data, and can be accessed and reviewed by ArcGis server manager.

Publish service steps:

- File > Share as > Service
- Adjust settings > capabilities (Mapping, KML etc.) in service editor.
- Analyze then publish service in ArcMap (Figure 6.10).

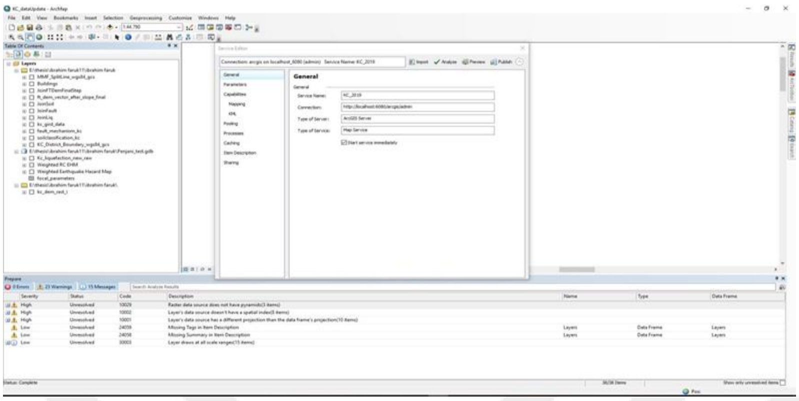

Figure 6.10 : Publishing service in ArcMap to our layers.

We can check the service that published by ArcGIS server manager and see all attribute tables from REST API (Figure 6.11) and (Figure 6.12).

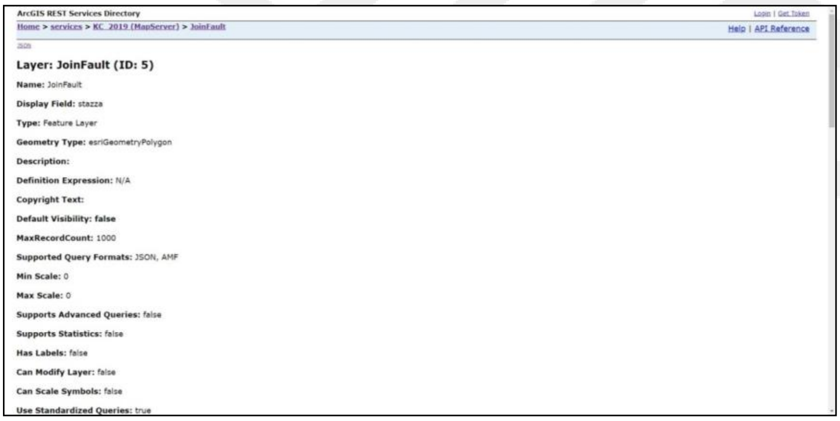

Figure 6.11: Fault layer details by ArcGIS REST services directory in ArcGIS server after publishing process.

Figure 6.12: Attribute table for fault mechanism layer on ArcGIS server manager.

6.5 Design System Interfaces

The principle on which designing the system interfaces is to use CSS and JQuery as well as Ajax technology and integration them with HTML5, also we used bootstrap V.4 technique. Bootstrap is the most popular HTML, CSS, and JavaScript framework for developing responsive, mobile-first websites. The system designed based on the data collected during system analysis process.

6.5.1 Login page

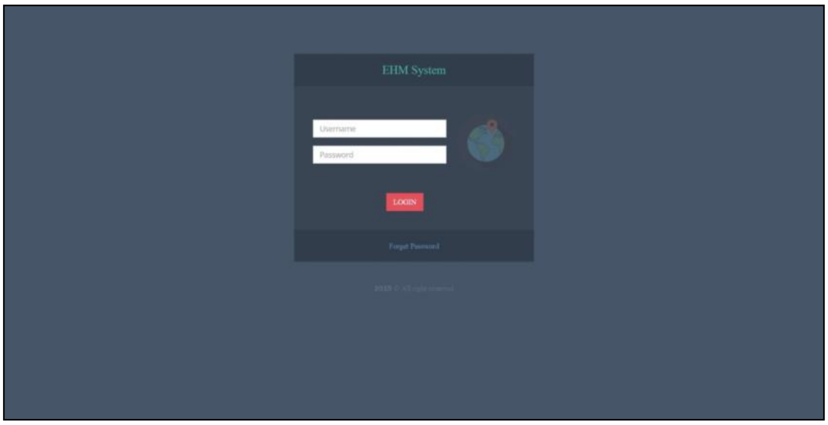

Figure 6.13: Login page for system users.

6.5.2 Main page

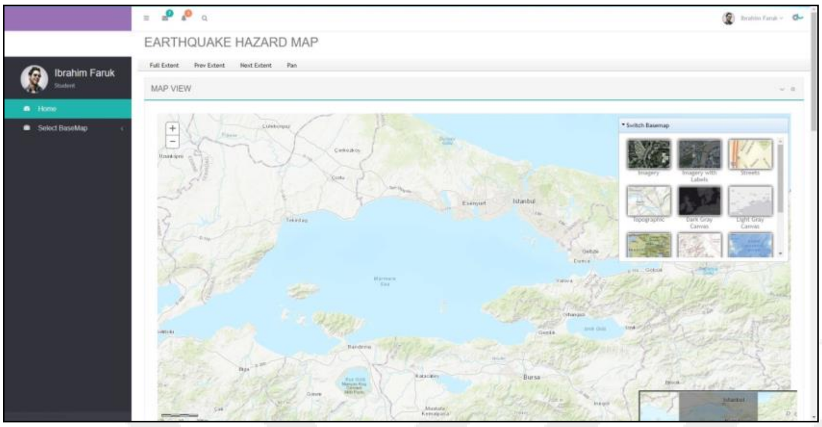

Figure 6.14 : Main page design.

6.5.3 Interactive map page

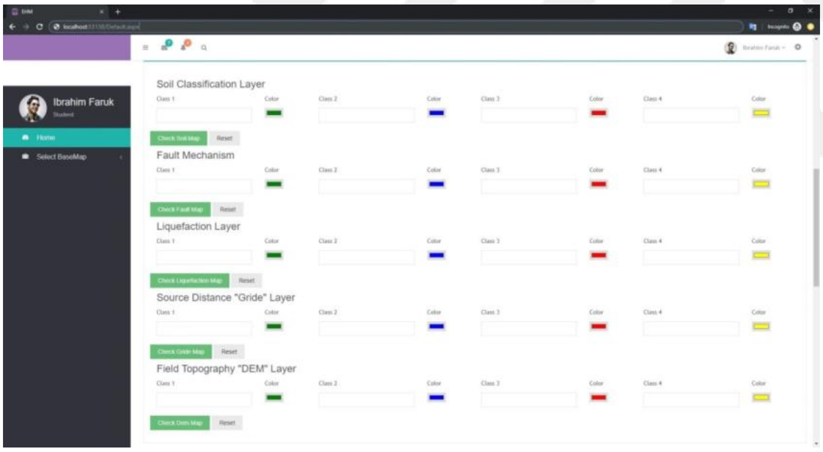

Figure 6.15: Interactive Map page deign.

6.5.4 Layers and its classes section in interactive map page

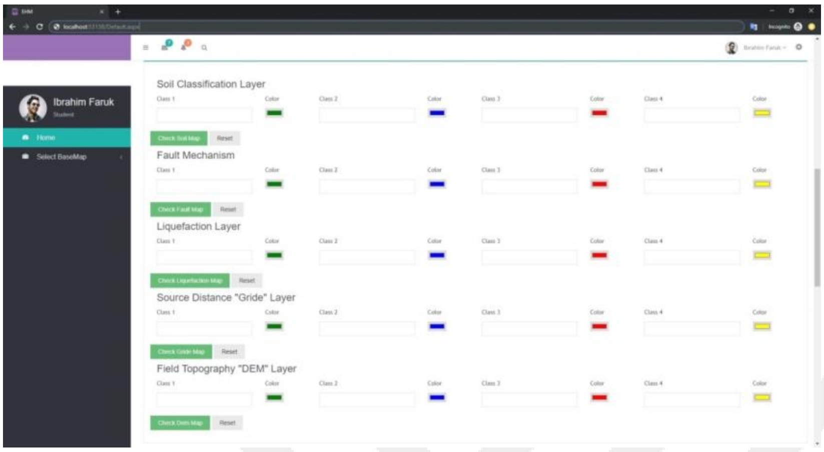

Figure 6.16: Classifican page design.

6.5.5 Layer weights section in interactive map page

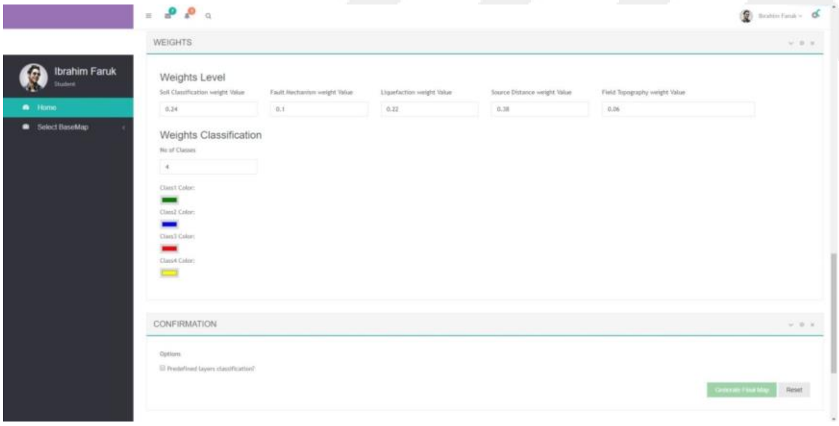

Figure 6.17 : Layer weights options section.

6.5.6 Add new user page

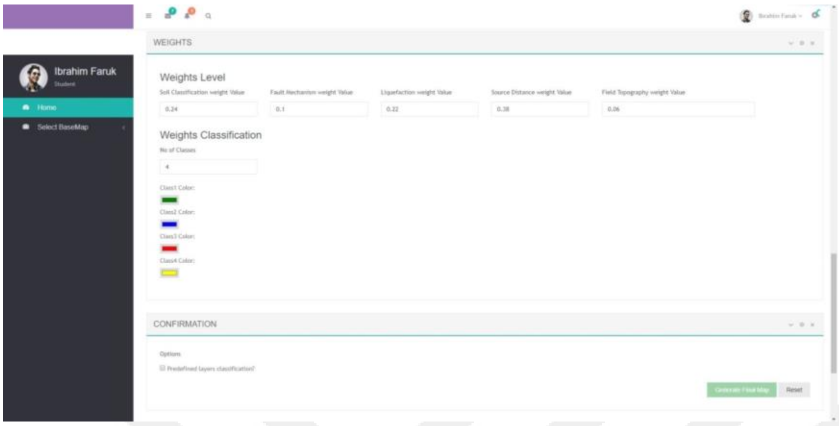

Figure 6.18 : Adding user page design.

6.5.7 Manage user

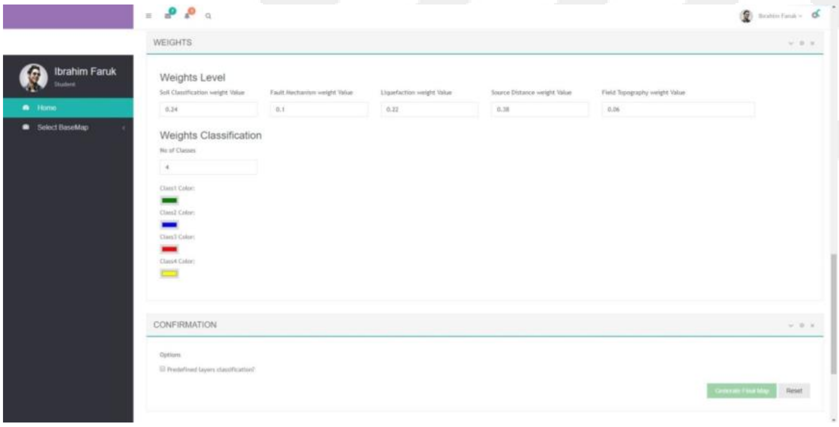

Figure 6.19: Manage users page design.

6.6 Creating API

As we mentioned previously in this chapter, API built on Node.js programming language, This API is the heart of system, it calling all functions and geographic libraries from the ArcGIS API for JavaScript such as geometry library, queries, zooming functions, measurement library, Gallery library and a lot of libraries that we can use it as a fit with our system.

ArcGIS API provides us with all the raw functions and libraries that enable us to create interactive web map, and dealing with these libraries requires special programming skills that must be available in the person who is working with ArcGIS API to create an effective, fast and secure web map application without relying on web publishing platforms.

The ArcGIS API calling process done by including special codes that allow using libraries and spatial functions that provided from ESRI to Programmers (Figure 6.20).

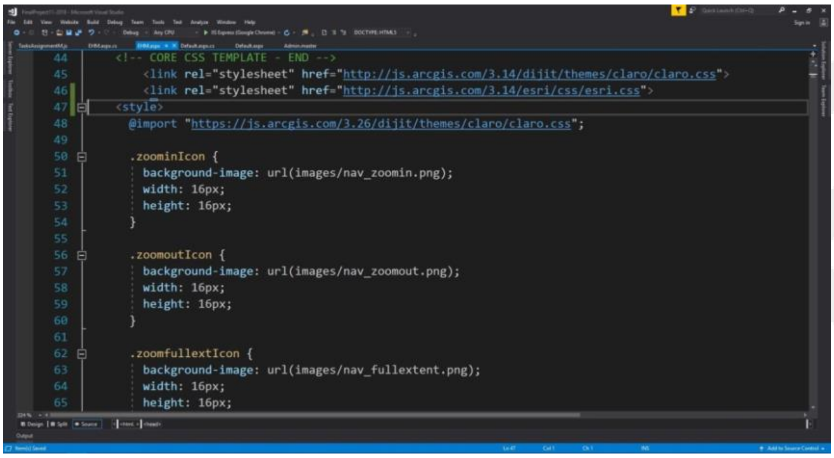

Figure 6.20: Screenshot from our coding showing the codes and links that calling ARCGIS API.

We can allocate the libraries and functions which coming from ARCGIS API to suit the functions of our system (Figure 6.21).

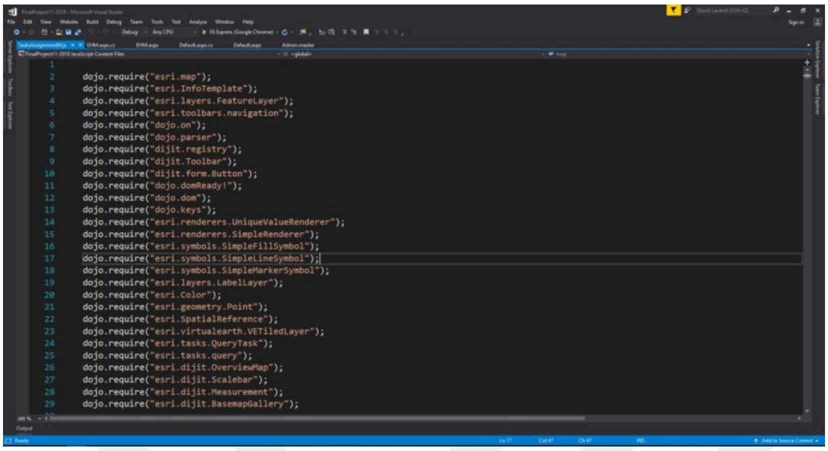

Figure 6.21: Libraries we will use to build the interactive map.

Also on the other side, which represents spatial information, our API calls the spatial data from ArcGis Server "Reset API" which was previously published, the various spatial processes using ARCGISAPI tools are performed on the spatial data coming from ArcGis Server, by this way the consistency and integration between APIs done (Figure 6.22).

Figure 6.23illustrates the consistency and harmony between API functionality within our system and its interaction with other parts of the system.

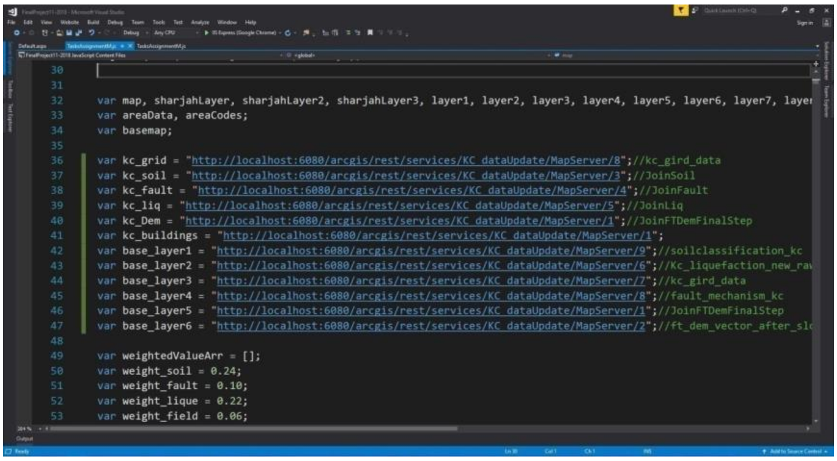

Figure 6.22 : Screenshot from our coding, showing how API calling the spatial data from arcgis server "Reset API".

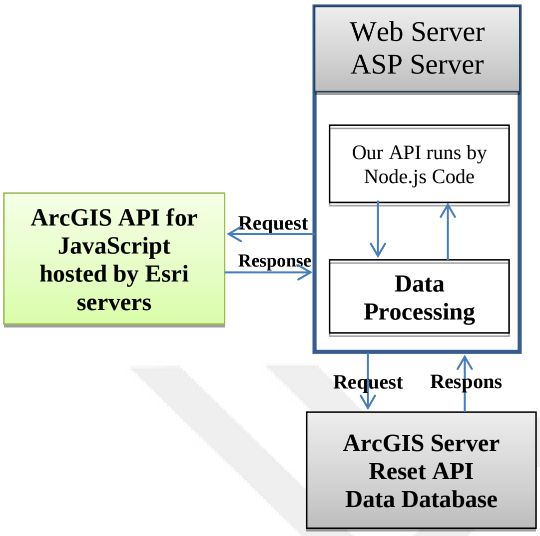

Figure 6.23 : Simple structure that explains the working mechanism of our API.

6.7 Client Scenario on EHM System

In order to the client able to use the EHM system, he/she must have a valid username and password, and then have the right to use the system, after the login process, the user has various options to use EHM.

6.7.1 Displaying the main maps

The user can view basic criteria maps on which the system is built (Figure 6.24) and (Figure 6.25).

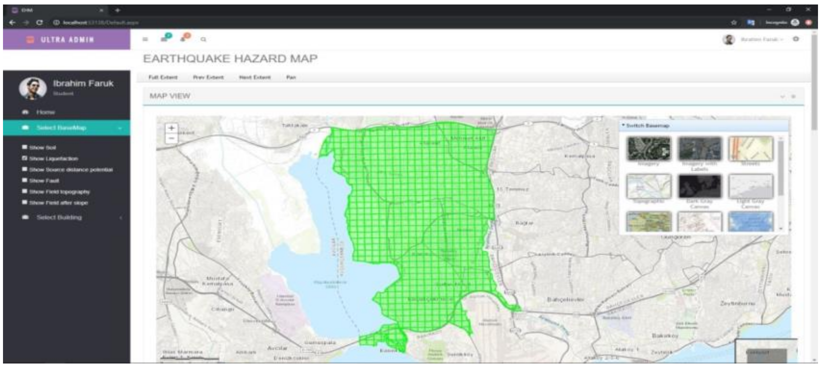

Figure 6.24 : Loading liquefaction layer on EHM system.

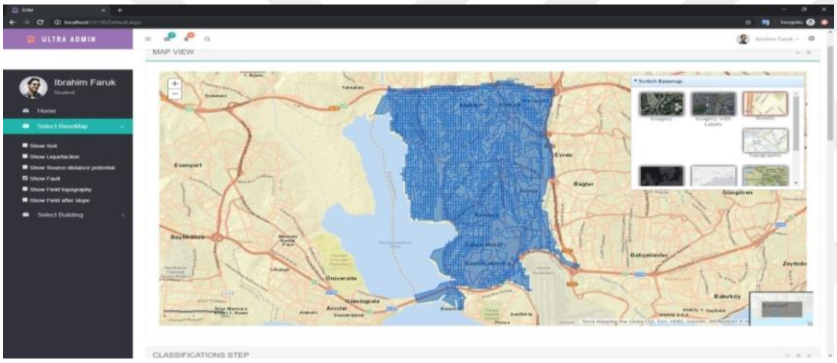

Figure 6.25 : Loading Fault mechanism layer on EHM system of street base map type.

6.7.2 Basemap gallery widget

The Basemap Gallery widget presents gallery of basemaps and allows user to select one from the gallery as the basemap for our app.

6.7.3 Create classification of layers

The system enabling user to create individual classification for each layer “criteria, map or parameter”, each layer classified into the 1 to 4 classes, each class have assign value range. Further the user have assigned special color for class.

When the system is loaded or opened through the browser, the API sets initial values, not random ones for each category and color, and the user can modify their data (Figure 6.26).

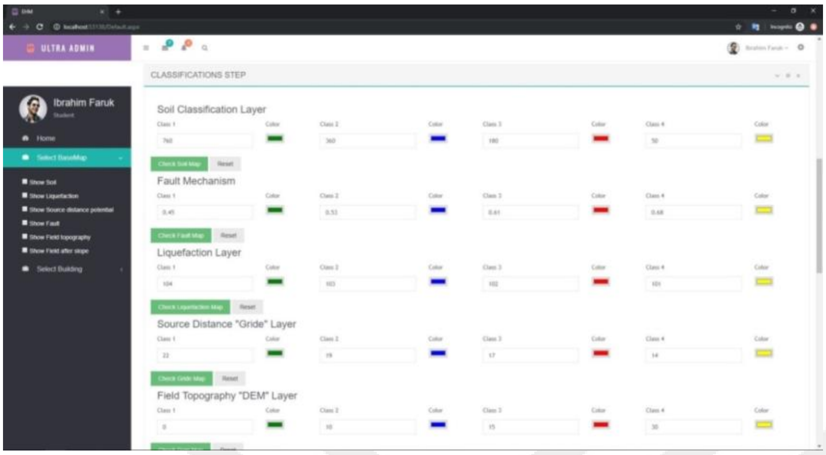

Figure 6.26: The initial values for classes' layers.

Then the user can show the results of classification on the map online (Figure 6.27).

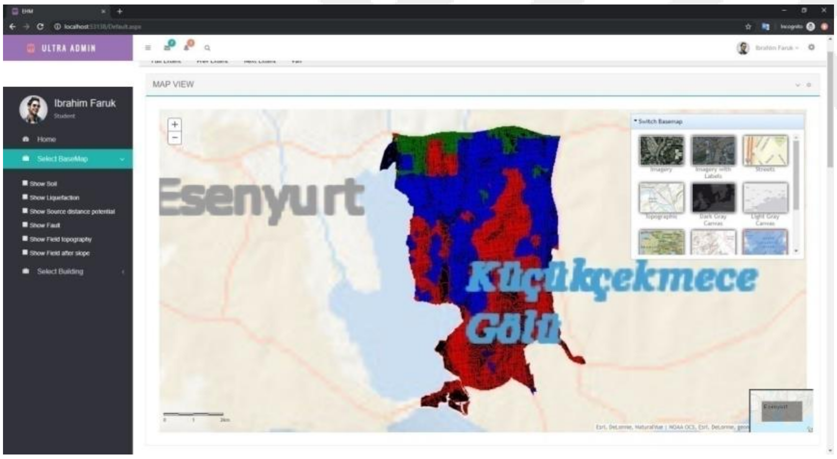

Figure 6.27: The Soil layer classified to four classes.

In addition, the user can see the legend for every layer have classified (Figure 6.28).

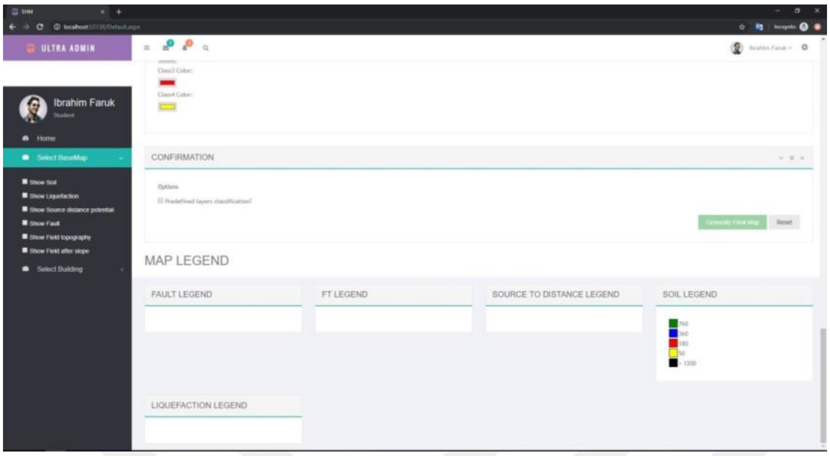

Figure 6.28: Legend for soil layer classified to four classes.

Another example Liquefaction classification layer to four classes each class has special color with changing the range value (Figure 6.29).

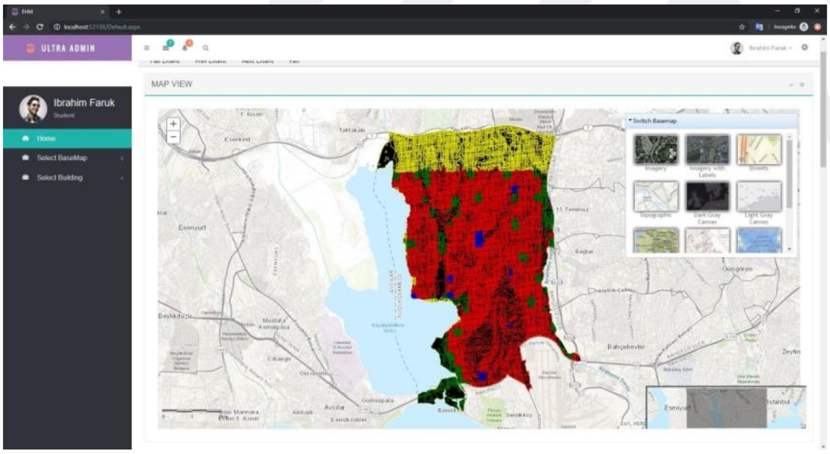

Figure 6.29: Soil layer classified to four classes.

6.7.4 Criteria priority/weight

In this study every earthquake parameter have weight/priority, when launched the system, the initial values and colors have been assign for every parameter depending on table 4.5 (Figure 6.30).

Figure 6.30: The initial values and colors of the earthquake parameters.

The user can check the result of final map, which has been loaded by initial values (Figure 6.31).

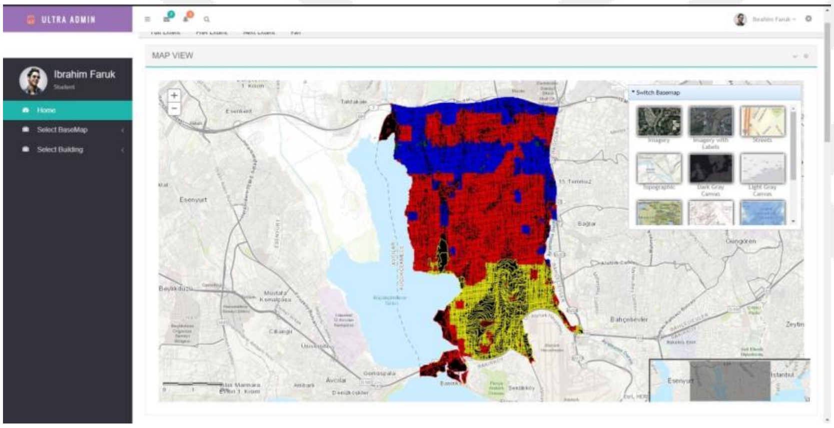

Figure 6.31: The final hazard online map with initial values.

In addition, the user has option to change the base map from Gallery basemap after or before producing EHM, for example producing map with Imagery with label basemap (Figure 6.32).

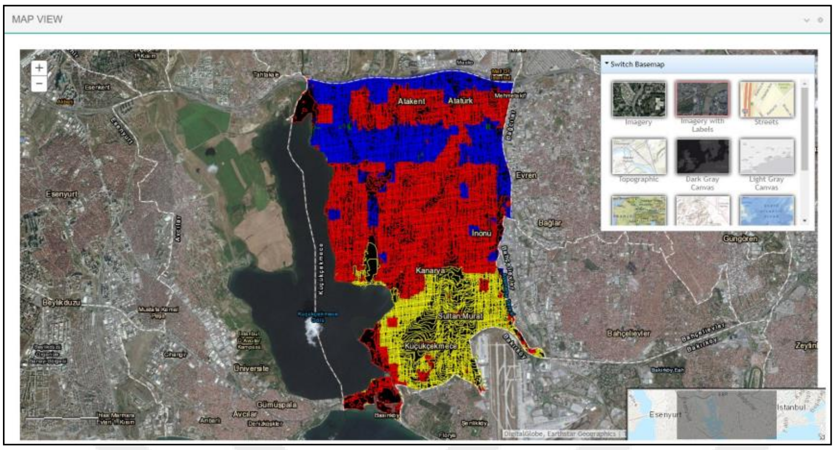

Figure 6.32: The final hazard online map of type (imagery with label basemap.

Also system enabling user to control in every weight of parameter and specify color for each weight, also the user have option to increase the number of classification for final map (Figure 6.33) and (Figure 6.34).

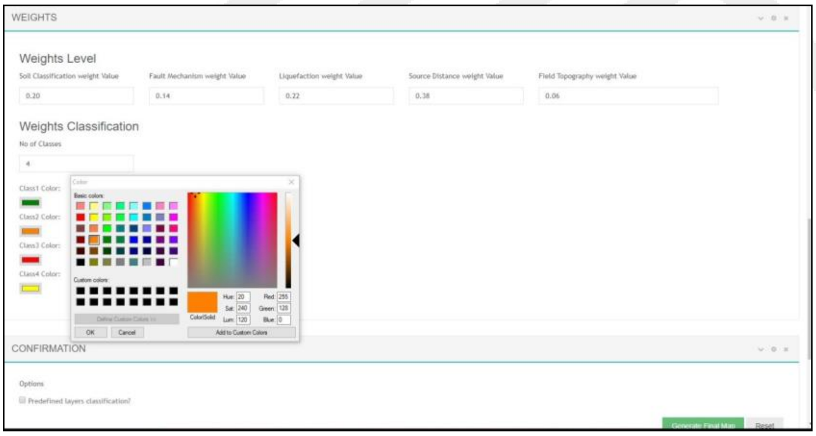

Figure 6.33: Shows how to control the weights and colors of parameters in the system.

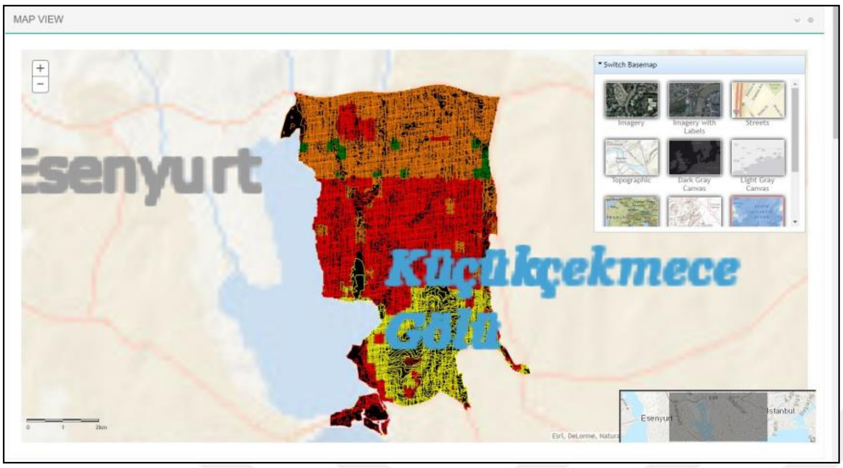

Figure 6.34: Shows EHM after changing the weights, colors and basemap by the user.

6.8 Applying AHP Technique Coding Phase

After process of classifying values of each parameter into four classes, in which each value have one class, the classes values of each parameter are multiplied by the weight of the parameter. Then we will get new values for each parameter, after that the system is applying symmetric combination to parameter values for producing earthquakes hazard map. All these processes and their variables are automated by the system, the results depend on the values entered by user.(Figure) 6.35illustrates the framework for producing earthqukes hazard map using AHP.

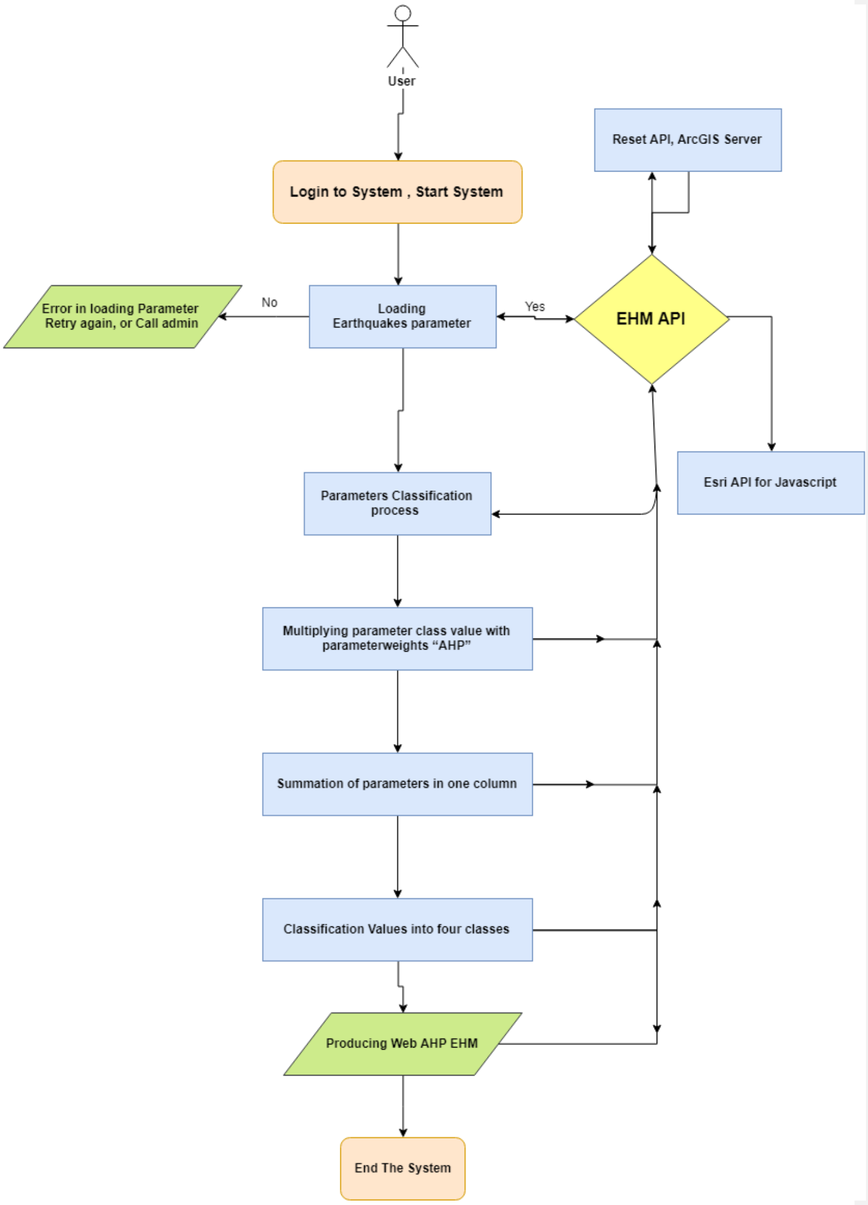

Figure 6.35: Web GIS framework for producing earthquakes hazard map.

We applied this framework by writing code for each phase to make our system work mechanism dynamic (Figure 6.35).

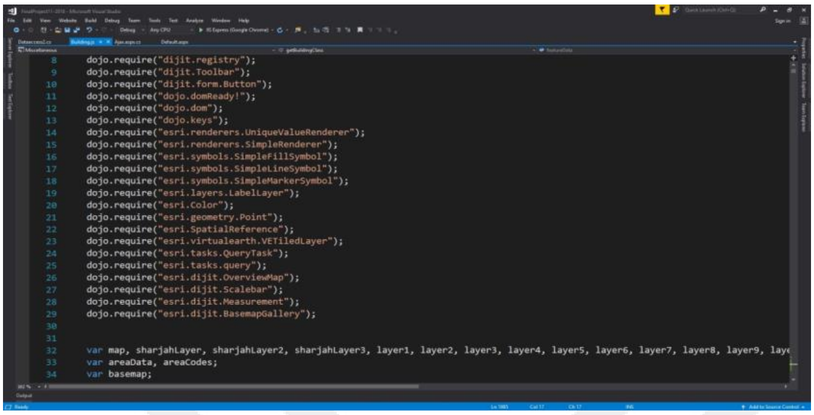

Figure 6.36: Shows the code that loading main layer.

6.8.1 Loading "Parameters" layers coding phase

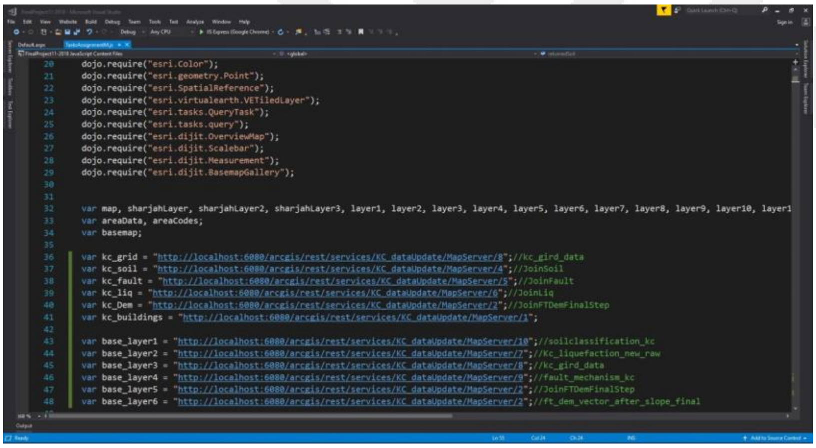

Figure 6.37 : Shows the code that loading main layer.

6.8.2 Colors and initial values for parameters layers code

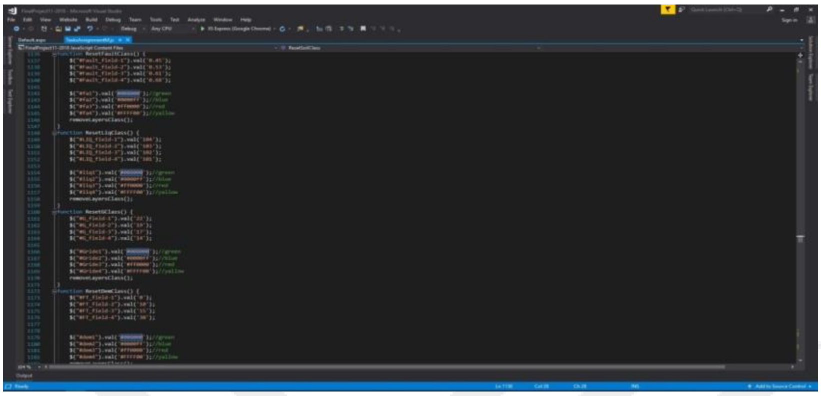

Figure 6.38 : Initial values and colors to classify layers code.

6.8.3 Classification code of layers into four classes

After applied the following code, all the five (5) processed and classified criteria map layers were subsequently used as input in AHP model for producing the final earthquake hazard map (EHM). Classification process means that each layer classified into the 1 to 4 classes depending on the values entered by user or by initial values (Figure 6.39).

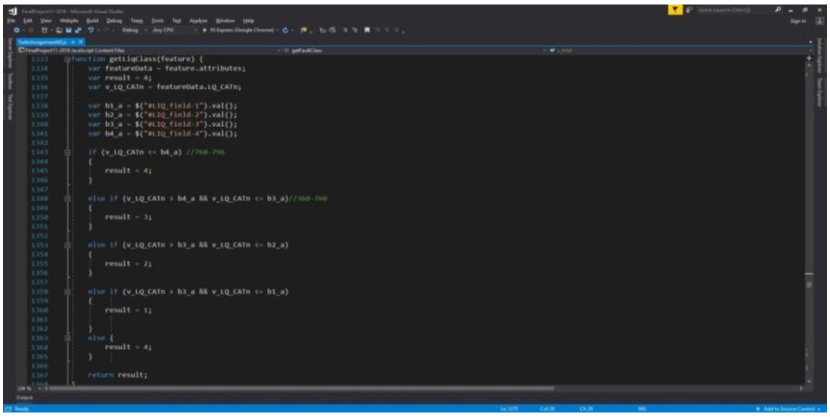

Figure 6.39 : Layers classification code into four classes.

6.8.4 Initial parameters weights code

Figure 6.40 illustrates the code that loading initial weights for performing weighted sum analysis process

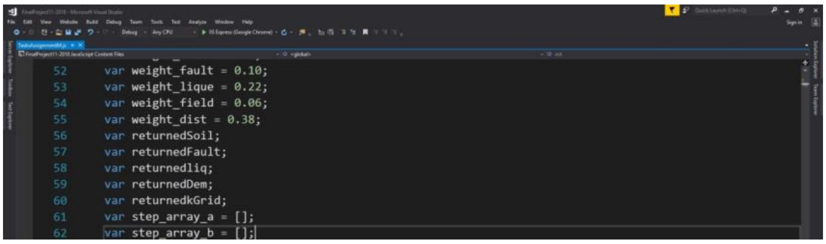

Figure 6.40: Initial weights of parameter code.

6.8.5 Coding of weighted sum process

The weights of the five (5) reclassified map layer derived from the AHP pairwise comparison technique were used as input to be applied to all the five (5) classified map layers and aggregated into one map layer creating the earthquake hazard map (EHM).

Figure 6.41 illustrates weighted sum process code execution in system.

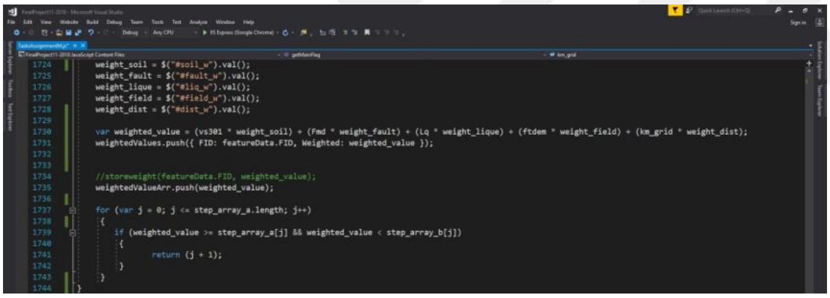

Figure 6.41: Weighted sum process code.

6.8.6 Classification EHM coding phase

After the weighted sum analysis process, the weighted sum EHM classified into the 1 to 4 equal interval method classification based on risk levels and class values based on Table 3.3 and the resulting AHP earthquake hazard map (EHM) coding and result execution were generated as in Figure 6.42 and Figure 6.43.

```
function addLayer1_1() {
    layer1 = new esri.layers.FeatureLayer(kc_grid,
      {
        id: 'idn1',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
      });
    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#wclass3").val()), new esri.Color.fromHex($("#wclass3").val())));//red
    var renderer = new esri.renderer.ClassBreaksRenderer(null, getMainFlag_1);
    var classes = $('#w_classes').val();
    for (var t = 0; t < classes; t++)
    {
        renderer.addBreak((t + 1), (t + 1), new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#wclass" + t).val()), new esri.Color.fromHex($("#wclass" + t).val()))));
    }

    renderer.addBreak(classes, classes, new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#wclass3").val()), new esri.Color.fromHex($("#wclass3").val()))));
    layer1.setRenderer(renderer);
    layer1.redraw();
    map.addLayer(layer1);
    layer1.show();
    layer1.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer1.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}
```

Figure 6.42: AHP earthquake hazard map (EHM) classification coding.

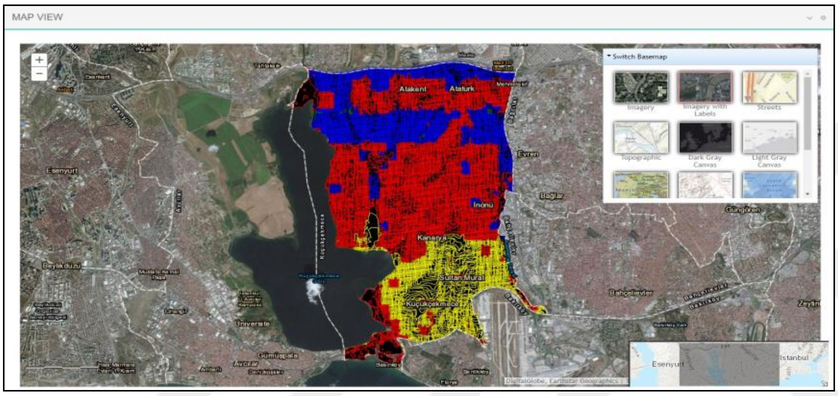

Figure 6.43: Earthquake hazard map (EHM).

6.9 Integration EHM With Building Layer

The combining EHM with building layer allows us to increase analysis process, leading to increase in better decision-making, as this provides us with future information on the buildings most at risk of future earthquakes, and make early decisions to reduce the losses caused by earthquakes.

After the final map is generated, the system merges it with building layer that is giving the user many options

- Find out each building in which class is located on the map
- Number of Buildings in each class.
- Know the most hazard buildings.
- Search for a particular building.
- Filter buildings by regions.

Figure 6.44 and Figure 6.45 shows how the layer works with the EHM and options available to the user and after integration process the user will have statistics that show the buildings districuted on the four classes Figure 46.

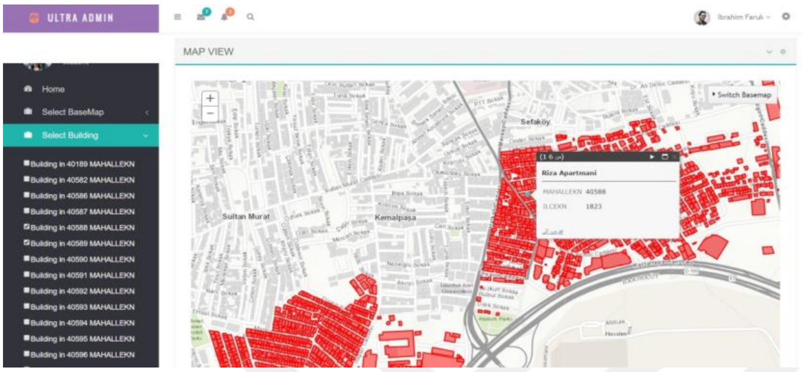

Figure 6.44: The combining EHM with building layer**.**

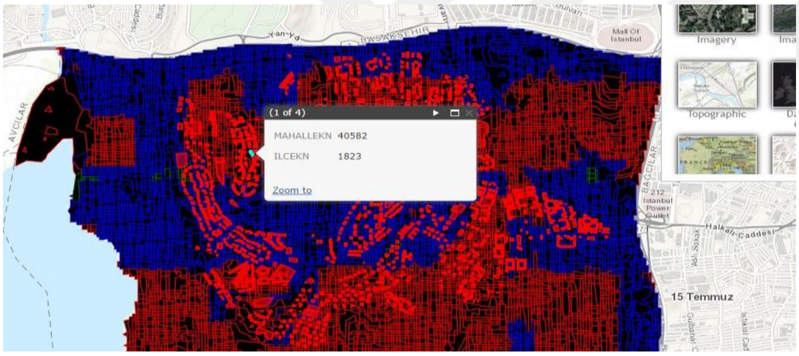

Figure 6.45: Integration Buildings layer with EHM.

BUILDING STATISTICS

#	Building Count	Class
1	62029	0
2	49	1
3	5057	2
4	14299	3
5	3477	4

Figure 6.46 : Building statistics after integrating them with the EHM.

7. CONCLUSION AND RECOMMENDATIONS

The aim of this study was to develop and implement Web GIS framework to generate online earthquake hazard maps integrating AHP technique for Kucukcekmece region in Turkey. This framework is more like to web based GIS application that allows the end-user to view geographical data using a web browser.

This study based on a server side web architecture that provides map visualization, query and analyzing operations. Web GIS helps users to use GIS more easily than desktop complex system. Web-based applications can be utilized by multiple users at the same time. The clients using the browsers do not install any additional plug-in. Web-based system is also cost-efficient. The advantage for the user is using the functionality of the application without need to purchase or learn any GIS software,thus, the decision-making process will be more effective. The availability of these features is required in our study, which is part of the concept of natural disaster management.

The building of interactive map included the using of modern programming language such as Node.js, which has the ability to handle large amounts of spatial data and making the analysis process more effective and drawing the results on the map.This language has been used to build APIs to connect with API ArcGIS for javascript and ArcGIS server.

The components of this system operating underthe ASP server or platform to give additional power advantage in spatial information security and speed of implementation of spatial analysis and mapping, in addition to encapsulation process for requests done between the client and the server.

The presented web application not only includes the analysis of earthquake parameters but also performs much deep analysis by connecting the EHM with buildings that are located in the study area, thus obtaining future details about the relationship of buildings withpotential earthquakes, which making prior decisions to ensure public safety.This is in addition to connecting the earthquake hazard map with land uses, which in turn describes the future of the land and the selection of sites and make a sound decision before using it to create vital centers and even behavior of populationsduring earthquakes expected to occur in the near future.

Moreover, it was discovered that the Analytic Hierarchy Process is one of the most commonly used decision-making tools that are easy to use. At the same time, the AHP tool can be applied on the internet, as done in the presented study in which the user can change the weights value for each criteria then check the resultant by online map.

The key functions of the web based system are online reclassificationof each criterion into four classes, change the value of each class manually and view the classification on the interactive map, change criterion weights, weighting sum process, change colors, Gallery map “Basemap” services, Building queries, Land use queries for future analyses.

Generally, an interactive Web GIS is an ideal tool to facilitate and encourage public participation in the Distaster management process. In addition, the technique presented in this study could be used as an efficient method for more effective monitoring and managementthus making convenient decision in real time. The approach of the presented application has a flexible environment that can be adapted and applied to any other cities.

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APPENDICES

APPENDIX A: API Code “Node.js and API ArcGis for javascript

APPENDIXA

Açıklamalı [İTÜ1]: Titles of appendices must be listed under the main title "APPENDICES", but must not be indicated in Table of Contents.

```
dojo.require("esri.map");
dojo.require("esri.InfoTemplate");
dojo.require("esri.layers.FeatureLayer");
dojo.require("esri.toolbars.navigation");
dojo.require("dojo.on");
dojo.require("dojo.parser");
dojo.require("dijit.registry");
dojo.require("dijit.Toolbar");
dojo.require("dijit.form.Button");
dojo.require("dojo.domReady!");
dojo.require("dojo.dom");
dojo.require("dojo.keys");
dojo.require("esri.renderers.UniqueValueRenderer");
dojo.require("esri.renderers.SimpleRenderer");
dojo.require("esri.symbols.SimpleFillSymbol");
dojo.require("esri.symbols.SimpleLineSymbol");
dojo.require("esri.symbols.SimpleMarkerSymbol");
dojo.require("esri.layers.LabelLayer");
dojo.require("esri.Color");
dojo.require("esri.geometry.Point");
dojo.require("esri.SpatialReference");
dojo.require("esri.virtualearth.VETiledLayer");
dojo.require("esri.tasks.QueryTask");
dojo.require("esri.tasks.query");
dojo.require("esri.dijit.OverviewMap");
dojo.require("esri.dijit.Scalebar");
dojo.require("esri.dijit.Measurement");
dojo.require("esri.dijit.BasemapGallery");
var map, sharjahLayer, sharjahLayer2, sharjahLayer3, layer1, layer2, layer3, layer4,
layer5, layer6, layer7, layer8, layer9, layer10, layer11, layer1Select, layer6_6,
layerBuilding;
var areaData, areaCodes;
var basemap;
```

```
var kc_grid =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/8";//kc_gird_data
var kc_soil =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/4";//JoinSoil
var kc_fault =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/5";//JoinFault
var kc_liq =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/6";//JoinLiq
var kc_Dem =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/2";//JoinFTDemFinalStep
var kc_buildings =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/1";


var base_layer1 =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/10";//soilclassification_kc
var base_layer2 =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/7";//Kc_liquefaction_new_raw
var base_layer3 =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/8";//kc_gird_data
var base_layer4 =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/9";//fault_mechanism_kc
var base_layer5 =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/2";//JoinFTDemFinalStep
var base_layer6 =
"http://localhost:6080/arcgis/rest/services/KC_dataUpdate/MapServer/2";//ft_dem_vector_after_slope_final
var weightedValueArr = [];
var weight_soil = 0.24;
var weight_fault = 0.10;
var weight_lique = 0.22;
var weight_field = 0.06;
var weight_dist = 0.38;
var returnedSoil;
var returnedFault;
```

```
var returnedliq;
var returnedDem;
var returnedkGrid;
var step_array_a = [];
var step_array_b = [];
//(vs301 * 0.24) + (Fmd * 0.10) + (Lq * 0.22) + (ftdem * 0.06) + (km_grid * 0.38)
function init() {
    $("#G_btn").prop('disabled', true);
       // prevent cashing to update the areas status after saving
    esri.setRequestPreCallback(function (ioArgs)
    {
        ioArgs.preventCache = true;
        return ioArgs;
    });
    var base_map_type=$('[name="Base_type"]:checked').val();

    map = new esri.Map("mapDiv", {
        //basemap: "hybrid",
        basemap: "topo",
        center: [28.74001734107564, 41.064427787355704],
        zoom: 9,
        //scale: 50000000,
        sliderStyle: "small",
        logo: true
    });
    weightedValueArr = [];
    weightedValues = [];

    ResetSoilClass();
    ResetFaultClass();
    ResetLiqClass();
    ResetGClass();
    ResetDemClass();

    ResetFMap();
```

```
    getAllData();

    setTimeout(function () {

        addBlockLayer1();
        addBlockLayer2();
        addBlockLayer3();
        addBlockLayer4();
        addBlockLayer5();
        addBlockLayer6_6();

    }, 1000);

    //add the basemap gallery, in this case we'll display maps from ArcGIS.com
including bing maps
    var basemapGallery = new esri.dijit.BasemapGallery({
        showArcGISBasemaps: true,
        map: map
    }, "basemapGallery");
    basemapGallery.startup();

    basemapGallery.on("error", function (msg) {
        console.log("basemap gallery error:  ", msg);
    });
    //addSharjahEmaraLayer();
    var overviewMapDijit = new esri.dijit.OverviewMap({
        map: map,
        attachTo: "bottom-right",
        opacity: .40,
        expandFactor: 1,
        visible: true
    });
    overviewMapDijit.startup();
    var scalebar = new esri.dijit.Scalebar({
        map: map,
```

```
    scalebarUnit: "metric",
    attachTo: "bottom-left"
});
require([
    "esri/map",
    "esri/toolbars/navigation",
    "dojo/on",
    "dojo/parser",
    "dijit/registry",
    "dijit/Toolbar",
    "dijit/form/Button",
    "dojo/domReady!"
],
    function (Map, Navigation, on, parser, registry) {

        parser.parse();

        var navToolbar;


        navToolbar = new esri.toolbars.Navigation(map);
        on(navToolbar, "onExtentHistoryChange", extentHistoryChangeHandler);


        registry.byId("zoomfullext").on("click", function () {
            navToolbar.zoomToFullExtent();
        });

        registry.byId("zoomprev").on("click", function () {
            navToolbar.zoomToPrevExtent();
        });

        registry.byId("zoomnext").on("click", function () {
            navToolbar.zoomToNextExtent();
```

```
        });

        registry.byId("pan").on("click", function () {
          navToolbar.activate(esri.toolbars.Navigation.PAN);
        });


        function extentHistoryChangeHandler() {
          registry.byId("zoomprev").disabled = navToolbar.isFirstExtent();
          registry.byId("zoomnext").disabled = navToolbar.isLastExtent();
        }
      });
  var measurement = new esri.dijit.Measurement({
      map: map
  }, dojo.dom.byId("measurementDiv"));
  measurement.startup();
  return;
}
///add the generated map///////////////////////////////////////////////////////////////////

//draw class reday
function addLayer1() {
  //7
  layer1 = new esri.layers.FeatureLayer(kc_grid, {
      id: 'idn1',
      outFields: ["*"],
      returnGeometry: true,
      mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
  });




  var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val())));//red
```

```
    var renderer = new esri.renderer.ClassBreaksRenderer(null, getMainFlag);
    //renderer.addBreak(0, 1, symbol0);//red
    var classes = $('#w_classes').val();

    for (var t = 0; t < classes; t++)
     {
        renderer.addBreak((t + 1), (t + 1), new esri.symbol.SimpleFillSymbol("solid",
new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#wclass" +
t).val()), new esri.Color.fromHex($("#wclass" + t).val()))));
     }
    renderer.addBreak(classes, classes, new esri.symbol.SimpleFillSymbol("solid",
new esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val()))));

    layer1.setRenderer(renderer);
    layer1.redraw();
    map.addLayer(layer1);


    layer1.show();
    layer1.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer1.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}
//Class Custamize
//function addLayer1_1() {
//    layer1 = new esri.layers.FeatureLayer(kc_grid, {
//        id: 'idn1',
//        outFields: ["*"],
//        returnGeometry: true,
//        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
//    });
```

```
//    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val())));//red

//    var renderer = new esri.renderer.ClassBreaksRenderer(null, getMainFlag_1);

//    var classes = $('#w_classes').val();//4


//   // renderer.addBreak(1.72117651, 3.85, new
esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid",
new esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val())));

//   // renderer.addBreak(3.85, 3.85, new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass2").val()), new
esri.Color.fromHex($("#wclass2").val())));

//    var realcounter = 1;

//    //for (var t = 0; t < classes; t++)

//    //{

//        renderer.addBreak(1, 1,esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass0").val()), new
esri.Color.fromHex($("#wclass0").val())));

//        renderer.addBreak(2, 2,esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass1").val()), new
esri.Color.fromHex($("#wclass1").val())));

//        renderer.addBreak(3, 3,esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass2").val()), new
esri.Color.fromHex($("#wclass2").val())));

//        renderer.addBreak(4, 4,esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val())));


esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid",
new esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val())));


function addLayer1_1() {
   layer1 = new esri.layers.FeatureLayer(kc_grid,
     {
```

```
        id: 'idn1',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
       });
    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val())));//red
    var renderer = new esri.renderer.ClassBreaksRenderer(null, getMainFlag_1);
    var classes = $('#w_classes').val();
    for (var t = 0; t < classes; t++)
    {
        renderer.addBreak((t + 1), (t + 1), new esri.symbol.SimpleFillSymbol("solid",
new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#wclass" +
t).val()), new esri.Color.fromHex($("#wclass" + t).val()))));
    }


    renderer.addBreak(classes, classes, new esri.symbol.SimpleFillSymbol("solid",
new esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#wclass3").val()), new
esri.Color.fromHex($("#wclass3").val()))));
    layer1.setRenderer(renderer);
    layer1.redraw();
    map.addLayer(layer1);
    layer1.show();
    layer1.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer1.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}

function getAllData() {

    var _query = new esri.tasks.Query();
    _query.where = "1=1";
```

```
_query.returnGeometry = true;
_query.outFields = ['FID,vs301,SolidClass'];

var _queryTask = new esri.tasks.QueryTask(kc_soil);
var result;

_queryTask.execute(_query, function (response) {
    returnedSoil = response.features;
    console.log(returnedSoil);
    var _query = new esri.tasks.Query();
    _query.where = "1=1";
    _query.returnGeometry = true;
    _query.outFields = ['FID,Fmd,FaultClass'];

    var _queryTask = new esri.tasks.QueryTask(kc_fault);
    var result;

    _queryTask.execute(_query, function (response) {
        returnedFault = response.features;
        console.log(returnedFault);
        var _query = new esri.tasks.Query();
        _query.where = "1=1";
        _query.returnGeometry = true;
        _query.outFields = ['FID,LQ_CATn,LiqClass'];

        var _queryTask = new esri.tasks.QueryTask(kc_liq);
        var result;

        _queryTask.execute(_query, function (response) {
            returnedliq = response.features;
            console.log(returnedliq);
            var _query = new esri.tasks.Query();
            _query.where = "1=1";
            _query.returnGeometry = true;
            _query.outFields = ['FID,FTDemValue,FTClass'];
```

```
var _queryTask = new esri.tasks.QueryTask(kc_Dem);
var result;

_queryTask.execute(_query, function (response) {
    returnedDem = response.features;
    console.log(returnedDem);
    setTimeout(function () {
        // addLayer1();
        //alert('Data Loaded Ready');
        $("#G_btn").prop('disabled', false);
    }, 1000);

    //var _query = new esri.tasks.Query();
    //_query.where = "1=1";
    //_query.returnGeometry = true;
    //_query.outFields = ['FID,DistKM,GrideClass'];

    //var _queryTask = new esri.tasks.QueryTask(kc_grid);
    //var result;

    //_queryTask.execute(_query, function (response) {
    //    returnedkGrid = response.features;
    //    console.log(returnedkGrid);

    //    setTimeout(function () {
    //        addLayer1();

    //    }, 1000);


    //});

});
```

```
        });


      });
      // return returnedSoil;

    });

}
function GenerateFMap() {
    calcuateClassSett();
    removeLayersClass();
    if (map._layers["idn1"] != undefined) {
        map.removeLayer(map._layers["idn1"]);
    }
    if ($('#OptionsCk').is(":checked")) {
        addLayer1();
    } else {
        addLayer1_1();
    }

    if (map._layers["idn1"] != undefined) {
        map._layers["idn1"].setVisibility(true);
    }

}
/////////////////////////////////////////////////////////////////////////////////////////
///add the fifth layer base map ////////////////////////////////////////////////////////////
function addBlockLayer1() {

    layer1 = new esri.layers.FeatureLayer(base_layer1,
    {
        id: 'id1',
        outFields: ["*"],
        returnGeometry: true,
```

```
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });




//   map.on("load", function () {

        // map.addLayer(layer2);
        //console.log(layer1)
        var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([255, 0, 0, 1]), 1), new
esri.Color([255, 0, 0, 0.2]));
        var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 255, 0, 1]), 2), new
esri.Color([0, 255, 0, 0.3]));
        var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 255, 1]), 1), new
esri.Color([0, 0, 255, 0.2]));
        var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([195, 229, 0, 1]), 1), new
esri.Color([195, 229, 0, 0.5]));
        var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([210, 135, 0, 1]), 2), new
esri.Color([210, 135, 0, 0.5]));
        var symbol5 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 89, 198, 1]), 1), new
esri.Color([0, 89, 198, 0.5]));


        //var renderer = new esri.renderer.ClassBreaksRenderer(symbol0,
1);//AREA_STATUS



        var renderer = new esri.renderer.ClassBreaksRenderer(symbol3,
getBlockFlag1);
        renderer.addBreak(0, 1, symbol0);//red
        renderer.addBreak(1, 2, symbol1);//green
        renderer.addBreak(2, 3, symbol2);//blue
        renderer.addBreak(3, 4, symbol5);//yellow
        renderer.addBreak(4, 5, symbol5);
```

```
        ////renderer.addBreak(5, 6, symbol5);
        layer1.setRenderer(renderer);
        layer1.redraw();
        map.addLayer(layer1);

    //})

    //// create a text symbol to define the style of labels
    var statesColor = new esri.Color("#000000");
    var statesLabel = new esri.symbol.TextSymbol().setColor(statesColor);
    statesLabel.font.setSize("10pt");
    statesLabel.font.setFamily("arial");
    statesLabelRenderer = new esri.renderer.SimpleRenderer(statesLabel);

    //var labels = new esri.layers.LabelLayer({ id: "FID" });
    //labels.addFeatureLayer(layer1, statesLabelRenderer, "{FID}");//
    //map.addLayer(labels);

    layer1.hide();
}
function addBlockLayer2() {

    layer2 = new esri.layers.FeatureLayer(base_layer2, {
        id: 'id2',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });



   // map.on("load", function () {

        // map.addLayer(layer2);
        //console.log(layer1)
```

```
var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([255, 0, 0, 1]), 1), new esri.Color([255, 0, 0, 0.2]));

var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 255, 0, 1]), 2), new esri.Color([0, 255, 0, 0.3]));

var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 255, 1]), 1), new esri.Color([0, 0, 255, 0.2]));

var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([195, 229, 0, 1]), 1), new esri.Color([195, 229, 0, 0.5]));

var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([210, 135, 0, 1]), 2), new esri.Color([210, 135, 0, 0.5]));

var symbol5 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 89, 198, 1]), 1), new esri.Color([0, 89, 198, 0.5]));


///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen, 1);//AREA_STATUS



var renderer = new esri.renderer.ClassBreaksRenderer(symbol3, getBlockFlag2);
renderer.addBreak(0, 1, symbol0);//red
renderer.addBreak(1, 2, symbol1);//green
renderer.addBreak(2, 3, symbol2);//blue
renderer.addBreak(3, 4, symbol5);//yellow
renderer.addBreak(4, 5, symbol5);
////renderer.addBreak(5, 6, symbol5);
layer2.setRenderer(renderer);
layer2.redraw();
map.addLayer(layer2);


layer2.hide();
//layer2.on("update-end", function () {
//    require(["esri/graphicsUtils"], function (graphicsUtils) {
```

```
    //        var zoomExtent = graphicsUtils.graphicsExtent(layer2.graphics);
    //        map.setExtent(zoomExtent.expand(2));
    //    });
    //})
}
function addBlockLayer3() {



    layer3 = new esri.layers.FeatureLayer(base_layer3, {
        id: 'id3',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });



   // map.on("load", function () {

        // map.addLayer(layer2);
        //console.log(layer1)
        var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([255, 0, 0, 1]), 1), new esri.Color([255, 0, 0, 0.2]));
        var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 255, 0, 1]), 2), new esri.Color([0, 255, 0, 0.3]));
        var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 255, 1]), 1), new esri.Color([0, 0, 255, 0.2]));
        var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([195, 229, 0, 1]), 1), new esri.Color([195, 229, 0, 0.5]));
        var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([210, 135, 0, 1]), 2), new esri.Color([210, 135, 0, 0.5]));
```

```
        var symbol5 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 89, 198, 1]), 1), new
esri.Color([0, 89, 198, 0.5]));


        ///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen,
1);//AREA_STATUS


        var renderer = new esri.renderer.ClassBreaksRenderer(symbol3,
getBlockFlag3);
        renderer.addBreak(0, 1, symbol0);//red
        renderer.addBreak(1, 2, symbol1);//green
        renderer.addBreak(2, 3, symbol2);//blue
        renderer.addBreak(3, 4, symbol5);//yellow
        renderer.addBreak(4, 5, symbol5);
        ////renderer.addBreak(5, 6, symbol5);
        layer3.setRenderer(renderer);
        layer3.redraw();
        map.addLayer(layer3);


    layer3.hide();
    //layer3.on("update-end", function () {
    //    require(["esri/graphicsUtils"], function (graphicsUtils) {
    //        var zoomExtent = graphicsUtils.graphicsExtent(layer3.graphics);
    //        map.setExtent(zoomExtent.expand(2));
    //    });
    //})
}
function addBlockLayer4() {


    layer4 = new esri.layers.FeatureLayer(base_layer4, {
        id: 'id4',
        outFields: ["*"],
```

```
    returnGeometry: true,
    mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
  });



  //map.on("load", function () {

    // map.addLayer(layer2);
    //console.log(layer1)
    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([255, 0, 0, 1]), 1), new
esri.Color([255, 0, 0, 0.2]));
    var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 255, 0, 1]), 2), new
esri.Color([0, 255, 0, 0.3]));
    var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 255, 1]), 1), new
esri.Color([0, 0, 255, 0.2]));
    var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([195, 229, 0, 1]), 1), new
esri.Color([195, 229, 0, 0.5]));
    var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([210, 135, 0, 1]), 2), new
esri.Color([210, 135, 0, 0.5]));
    var symbol5 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 89, 198, 1]), 1), new
esri.Color([0, 89, 198, 0.5]));

    ///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen,
1);//AREA_STATUS



    var renderer = new esri.renderer.ClassBreaksRenderer(symbol3,
getBlockFlag4);
    renderer.addBreak(0, 1, symbol0);//red
    renderer.addBreak(1, 2, symbol1);//green
    renderer.addBreak(2, 3, symbol2);//blue
    renderer.addBreak(3, 4, symbol5);//yellow
```

```
        renderer.addBreak(4, 5, symbol5);
        ////renderer.addBreak(5, 6, symbol5);
        layer4.setRenderer(renderer);
        layer4.redraw();
        map.addLayer(layer4);



    layer4.hide();

}
function addBlockLayer5() {



    layer5 = new esri.layers.FeatureLayer(base_layer5, {
        id: 'id1',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });




        var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([255, 0, 0, 1]), 1), new
esri.Color([255, 0, 0, 0.2]));
        var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 255, 0, 1]), 2), new
esri.Color([0, 255, 0, 0.3]));
        var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 255, 1]), 1), new
esri.Color([0, 0, 255, 0.2]));
        var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([195, 229, 0, 1]), 1), new
esri.Color([195, 229, 0, 0.5]));
```

```
        var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([210, 135, 0, 1]), 2), new
esri.Color([210, 135, 0, 0.5]));
        var symbol5 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 89, 198, 1]), 1), new
esri.Color([0, 89, 198, 0.5]));

        ///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen,
1);//AREA_STATUS


        var renderer = new esri.renderer.ClassBreaksRenderer(null,
getBlockFlag5);//joinfault
        renderer.addBreak(0, 1, symbol0);//red
        renderer.addBreak(1, 1, symbol1);//green
        renderer.addBreak(2, 2, symbol2);//blue
        renderer.addBreak(3, 3, symbol5);//yellow
        renderer.addBreak(4, 4, symbol5);
        ////renderer.addBreak(5, 6, symbol5);
        layer5.setRenderer(renderer);
        layer5.redraw();
        map.addLayer(layer5);




    layer5.hide();
    //layer2.on("update-end", function () {
    //    require(["esri/graphicsUtils"], function (graphicsUtils) {
    //        var zoomExtent = graphicsUtils.graphicsExtent(layer2.graphics);
    //        map.setExtent(zoomExtent.expand(2));
    //    });
    //})
}
function addBlockLayer6_6() {
```

```
layer6_6 = new esri.layers.FeatureLayer(base_layer5, {
    id: 'id6_6',
    outFields: ["*"],
    returnGeometry: true,
    mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
});

    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([255, 0, 0, 1]), 1), new
esri.Color([255, 0, 0, 0.2]));
    var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 255, 0, 1]), 2), new
esri.Color([0, 255, 0, 0.3]));
    var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 255, 1]), 1), new
esri.Color([0, 0, 255, 0.2]));
    var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([195, 229, 0, 1]), 1), new
esri.Color([195, 229, 0, 0.5]));
    var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([210, 135, 0, 1]), 2), new
esri.Color([210, 135, 0, 0.5]));
    var symbol5 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 89, 198, 1]), 1), new
esri.Color([0, 89, 198, 0.5]));

    ///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen,
1);//AREA_STATUS



    var renderer = new esri.renderer.ClassBreaksRenderer(symbol3,
getBlockFlag6_6);
    renderer.addBreak(0, 1, symbol0);//red
    renderer.addBreak(1, 2, symbol1);//green
    renderer.addBreak(2, 3, symbol2);//blue
    renderer.addBreak(3, 4, symbol5);//yellow
    renderer.addBreak(4, 5, symbol5);
    ////renderer.addBreak(5, 6, symbol5);
```

```
        layer6_6.setRenderer(renderer);
        layer6_6.redraw();
        map.addLayer(layer6_6);

    layer6_6.hide();
    //layer2.on("update-end", function () {
    //    require(["esri/graphicsUtils"], function (graphicsUtils) {
    //        var zoomExtent = graphicsUtils.graphicsExtent(layer2.graphics);
    //        map.setExtent(zoomExtent.expand(2));
    //    });
    //})
}
function getBlockFlag1(feature) {
    var featureData = feature.attributes;
    var result = 1;

    return result;

}
function getBlockFlag2(feature) {
    var featureData = feature.attributes;
    var result = 2;
    return result;
}
function getBlockFlag3(feature) {
    var featureData = feature.attributes;
    var result = 3;

    return result;
}
function getBlockFlag4(feature) {
    var featureData = feature.attributes;
    var result = 4;

    return result;
```

```
}
function getBlockFlag5(feature) {
   var featureData = feature.attributes;
   var result = 4;

   return result;
}
function getBlockFlag6_6(feature) {
   var featureData = feature.attributes;
   var result = 4;

   return result;
}
///add the 5 layers classification//////////////////////////////////////////////////////////
function addBlockLayer6() {
   layer6 = new esri.layers.FeatureLayer(kc_fault, {
      id: 'id6',
      outFields: ["*"],
      returnGeometry: true,
      mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
   });

  // map.on("load", function () {

      // map.addLayer(layer2);
      //console.log(layer1)
   var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa1").val()),
new esri.Color.fromHex($("#fa1").val())));
   var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa2").val()),
new esri.Color.fromHex($("#fa2").val())));
   var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa3").val()),
new esri.Color.fromHex($("#fa3").val())));
   var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa4").val()),
new esri.Color.fromHex($("#fa4").val())));
```

```
    var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 0, 1]), 2), new
esri.Color([0, 0, 0, 0.5]));

    var sybmol0_hex = $("#fa1").val();
    var sybmol1_hex = $("#fa2").val();
    var sybmol2_hex = $("#fa3").val();
    var sybmol3_hex = $("#fa4").val();
    var sybmol4_hex = '#000';

    var b1_a = $("#Fault_field-1").val();
    var b2_a = $("#Fault_field-2").val();
    var b3_a = $("#Fault_field-3").val();
    var b4_a = $("#Fault_field-4").val();

        var renderer = new esri.renderer.ClassBreaksRenderer(null, getFaultClass);//
        renderer.addBreak(1, 1, symbol0);//red
        renderer.addBreak(2, 2, symbol1);//green
        renderer.addBreak(3, 3, symbol2);//blue
        renderer.addBreak(4, 4, symbol3);//yellow
        //renderer.addBreak(b5_a, b5_b, symbol4);

        var f_temp = '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol0_hex + ' !important
"></div>' + b1_a + '<BR />';
        f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol1_hex + ' !important
"></div>' + b2_a + '<BR />';
        f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol2_hex + ' !important
"></div>' + b3_a + '<BR />';
        f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol3_hex + ' !important
"></div>' + b4_a + '<BR />';
        //f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important
"></div>' + b5_a + '<BR />';

        $("#FaultLegend").html('');
```

```
        $("#FaultLegend").append(f_temp);

        ////renderer.addBreak(5, 6, symbol5);
        layer6.setRenderer(renderer);
        layer6.redraw();
        map.addLayer(layer6);

    layer6.hide();
    layer6.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer6.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}
function removeBlockLayer6() {
    if (map._layers["id6"] != undefined)
        map.removeLayer(map._layers["id6"]);

    addBlockLayer6();

    if (map._layers["id6"] != undefined)
         map._layers["id6"].setVisibility(true);

}
function addBlockLayer7() {
    layer7 = new esri.layers.FeatureLayer(kc_Dem, {
        id: 'id7',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });

    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#dem1").val()),
new esri.Color.fromHex($("#dem1").val())));
```

```
var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#dem2").val()), new esri.Color.fromHex($("#dem2").val())));

var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#dem3").val()), new esri.Color.fromHex($("#dem3").val())));

var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#dem4").val()), new esri.Color.fromHex($("#dem4").val())));

var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 0, 1]), 2), new esri.Color([0, 0, 0, 0.5]));

var sybmol0_hex = $("#dem1").val();

var sybmol1_hex = $("#dem2").val();

var sybmol2_hex = $("#dem3").val();

var sybmol3_hex = $("#dem4").val();

var sybmol4_hex = '#000';

var b1_a = parseInt("" + $("#FT_field-1").val());

var b2_a = parseInt("" + $("#FT_field-2").val());

var b3_a = parseInt("" + $("#FT_field-3").val());

var b4_a = parseInt("" + $("#FT_field-4").val());

var renderer = new esri.renderer.ClassBreaksRenderer(null, getDimClass);

renderer.addBreak(1, 1, symbol0);//red

renderer.addBreak(2, 2, symbol1);//green

renderer.addBreak(3, 3, symbol2);//blue

renderer.addBreak(4, 4, symbol3);//yellow

//renderer.addBreak(b4_a, 5, symbol4);

////renderer.addBreak(5, 6, symbol5);


var f_temp = '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol0_hex + ' !important "></div>' + b1_a + '-' + b2_a + '<BR />';

f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol1_hex + ' !important "></div>' + b2_a + '-' + b3_a + '<BR />';

f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol2_hex + ' !important "></div>' + b3_a + '-' + b4_a + '<BR />';
```

```
    f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol3_hex + ' !important
"></div>' + b4_a + '<' + '<BR />';
    //f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important
"></div>' + b5_a + '<BR />';


    $("#FTLegend").html('');
    $("#FTLegend").append(f_temp);

    layer7.setRenderer(renderer);
    layer7.redraw();
    map.addLayer(layer7);
    //})
    layer7.hide();
    layer7.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer7.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}
function removeBlockLayer7() {
    if (map._layers["id7"] != undefined)
        map.removeLayer(map._layers["id7"]);

    addBlockLayer7();

    if (map._layers["id7"] != undefined)
        map._layers["id7"].setVisibility(true);

}
function addBlockLayer8()
{
    layer8 = new esri.layers.FeatureLayer(kc_grid, {
```

```
      id: 'id8',
      outFields: ["*"],
      returnGeometry: true,
      mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });



    var b1_a = parseInt("" + $("#G_field-1").val());
   // var b1_b = parseInt("" + $("#G_field-1").val()) + 1;

    var b2_a = parseInt("" + $("#G_field-2").val());
    //var b2_b = parseInt("" + $("#G_field-2").val()) + 1;

    var b3_a = parseInt("" + $("#G_field-3").val());
    //var b3_b = parseInt("" + $("#G_field-3").val()) + 1;

    var b4_a = parseInt("" + $("#G_field-4").val());
    //var b4_b = parseInt("" + $("#G_field-4").val()) + 1;
    // map.on("load", function () {

    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#Gride1").val()), new
esri.Color.fromHex($("#Gride1").val())));
    var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#Gride2").val()), new
esri.Color.fromHex($("#Gride2").val())));
    var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#Gride3").val()), new
esri.Color.fromHex($("#Gride3").val())));
    var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new
esri.Color.fromHex($("#Gride4").val()), new
esri.Color.fromHex($("#Gride4").val())));
```

```
var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 0, 1]), 2), new
esri.Color([0, 0, 0, 0.5]));

var sybmol0_hex = $("#Gride1").val();
var sybmol1_hex = $("#Gride2").val();
var sybmol2_hex = $("#Gride3").val();
var sybmol3_hex = $("#Gride4").val();
var sybmol4_hex = '#000';


var renderer = new esri.renderer.ClassBreaksRenderer(null, getDistClass);
renderer.addBreak(1, 1, symbol0);//red
renderer.addBreak(2, 2, symbol1);//green
renderer.addBreak(3, 3, symbol2);//blue
renderer.addBreak(4, 4, symbol3);//yellow

var f_temp = '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol0_hex + ' !important
"></div>' + b1_a + "+ b2_a +'<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol1_hex + ' !important
"></div>' + b2_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol2_hex + ' !important
"></div>' + b3_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol3_hex + ' !important
"></div>' + b4_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important
"></div>> ' + b4_a + '<BR />';
//f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important
"></div>' + b5_a + '<BR />';


$("#GridLegend").html('');
$("#GridLegend").append(f_temp);
```

```
    layer8.setRenderer(renderer);
    layer8.redraw();
    map.addLayer(layer8);

    //})
    layer8.hide();
    layer8.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer8.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}
function removeBlockLayer8() {
    if (map._layers["id8"] != undefined)
        map.removeLayer(map._layers["id8"]);

    addBlockLayer8();

    if (map._layers["id8"] != undefined)
        map._layers["id8"].setVisibility(true);

}
function addBlockLayer9() {
    layer9 = new esri.layers.FeatureLayer(kc_soil, {
        id: 'id9',
        outFields: ["*"],
        returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });

    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa1").val()),
new esri.Color.fromHex($("#fa1").val())));
```

```
var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa2").val()), new esri.Color.fromHex($("#fa2").val())));

var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa3").val()), new esri.Color.fromHex($("#fa3").val())));

var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#fa4").val()), new esri.Color.fromHex($("#fa4").val())));

var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 0, 1]), 2), new esri.Color([0, 0, 0, 0.5]));



///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen, 1);//AREA_STATUS
var sybmol0_hex = $("#fa1").val();
var sybmol1_hex = $("#fa2").val();
var sybmol2_hex = $("#fa3").val();
var sybmol3_hex = $("#fa4").val();
var sybmol4_hex = '#000';

///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen, 1);//AREA_STATUS

var b1_a = parseInt("" + $("#soil_field-1").val());
//var b1_b = parseInt("" + $("#soil_field-1").val()) + 1;

var b2_a = parseInt("" + $("#soil_field-2").val());
//var b2_b = parseInt("" + $("#soil_field-2").val()) + 1;

var b3_a = parseInt("" + $("#soil_field-3").val());
//var b3_b = parseInt("" + $("#soil_field-3").val()) + 1;

var b4_a = parseInt("" + $("#soil_field-4").val());
//var b4_b = parseInt("" + $("#soil_field-4").val()) + 1;

var renderer = new esri.renderer.ClassBreaksRenderer(null, getSoilClass);
```

```
///////
renderer.addBreak(1, 1, symbol0);//red
renderer.addBreak(2, 2, symbol1);//green
renderer.addBreak(3, 3, symbol2);//blue
renderer.addBreak(4, 4, symbol3);//blue

var f_temp = '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol0_hex + ' !important "></div>' + b1_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol1_hex + ' !important "></div>' + b2_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol2_hex + ' !important "></div>' + b3_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol3_hex + ' !important "></div>' + b4_a + '<BR />';
f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important "></div>> 1200 <BR />';
//f_temp += '<div style="width:20px;height:20px;float:left;    margin-right: 2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important "></div>' + b5_a + '<BR />';

$("#SoilLegend").html('');
$("#SoilLegend").append(f_temp);
layer9.setRenderer(renderer);
layer9.redraw();
map.addLayer(layer9);

layer9.hide();
layer9.on("update-end", function () {
    require(["esri/graphicsUtils"], function (graphicsUtils) {
        var zoomExtent = graphicsUtils.graphicsExtent(layer9.graphics);
        map.setExtent(zoomExtent.expand(1));
    });
})
```

```
}
function removeBlockLayer9()
{
    if (map._layers["id9"] != undefined)
        map.removeLayer(map._layers["id9"]);

        addBlockLayer9();

    if (map._layers["id9"] != undefined)
        map._layers["id9"].setVisibility(true);

}
function addBlockLayer10() {



    layer10 = new esri.layers.FeatureLayer(kc_liq, {
        id: 'id10',
        outFields: ["*"],
        //strWhere:"FID<200",
        // returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });



    // map.on("load", function () {


    // map.addLayer(layer2);
    //console.log(layer1)
    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#liq1").val()),
new esri.Color.fromHex($("#liq1").val())));
    var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#liq2").val()),
new esri.Color.fromHex($("#liq2").val())));
```

```
var symbol2 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#liq3").val()), new esri.Color.fromHex($("#liq3").val())));

var symbol3 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color.fromHex($("#liq4").val()), new esri.Color.fromHex($("#liq4").val())));

var symbol4 = new esri.symbol.SimpleFillSymbol("solid", new esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 0, 1]), 2), new esri.Color([0, 0, 0, 0.5]));


var sybmol0_hex = $("#liq1").val();
var sybmol1_hex = $("#liq2").val();
var sybmol2_hex = $("#liq3").val();
var sybmol3_hex = $("#liq4").val();
var sybmol4_hex = '#000';


///var renderer = new esri.renderer.ClassBreaksRenderer(symbolGreen, 1);//AREA_STATUS
var b1_a = parseInt("" + $("#LIQ_field-1").val());
//var b1_b = parseInt("" + $("#soil_field-1").val()) + 1;

var b2_a = parseInt("" + $("#LIQ_field-2").val());
//var b2_b = parseInt("" + $("#soil_field-2").val()) + 1;

var b3_a = parseInt("" + $("#LIQ_field-3").val());
//var b3_b = parseInt("" + $("#soil_field-3").val()) + 1;

var b4_a = parseInt("" + $("#LIQ_field-4").val());
//var b4_b = parseInt("" + $("#soil_field-4").val()) + 1;

var renderer = new esri.renderer.ClassBreaksRenderer(null, getLiqClass);
renderer.addBreak(1, 1, symbol0);//red
renderer.addBreak(2, 2, symbol1);//red
renderer.addBreak(3, 3, symbol2);//red
renderer.addBreak(4, 4, symbol3);//red
//renderer.addBreak(4, 5, symbol4);
////renderer.addBreak(5, 6, symbol5);
```

```
    var f_temp = '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol0_hex + ' !important
"></div>' + b1_a + '<BR />';

    f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol1_hex + ' !important
"></div>' + b2_a + '<BR />';

    f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol2_hex + ' !important
"></div>' + b3_a + '<BR />';

    f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol3_hex + ' !important
"></div>' + b4_a + '<BR />';

    //f_temp += '<div style="width:20px;height:20px;float:left;    margin-right:
2px;border:1px solid #000; background-color:' + sybmol4_hex + ' !important
"></div>' + b5_a + '<BR />';



    $("#liquefactionLegend").html('');
    $("#liquefactionLegend").append(f_temp);
    layer10.setDefinitionExpression("FID<20000");
    layer10.setRenderer(renderer);
    //layer10.redraw();

    // setTimeout(function () {
    //  console.log("pausing a few seconds");
    map.addLayer(layer10);
    // }, 1000);



    //})



    //layer10.hide();
    layer10.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layer10.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
```

```
    })
}
function removeBlockLayer10() {

    if (map._layers["id10"] != undefined)
        map.removeLayer(map._layers["id10"]);

    addBlockLayer10();

    if (map._layers["id10"] != undefined)
        map._layers["id10"].setVisibility(true);

}
///////////////////////////////////////////////////////////////////////////////////////////////
///Reset function for each layer////////////////////////////////////////////////////////////////
function ResetSoilClass() {

    $("#soil_field-1").val('760');
    $("#soil_field-2").val('360');
    $("#soil_field-3").val('180');
    $("#soil_field-4").val('50');


    $("#sc1").val('#008000');//green
    $("#sc2").val('#0000ff');//blue
    $("#sc3").val('#ff0000');//red
    $("#sc4").val('#FFFF00');//yellow
    removeLayersClass();
}
function ResetFaultClass() {
    $("#Fault_field-1").val('0.45');
    $("#Fault_field-2").val('0.53');
    $("#Fault_field-3").val('0.61');
    $("#Fault_field-4").val('0.68');
```

```
    $("#fa1").val('#008000');//green
    $("#fa2").val('#0000ff');//blue
    $("#fa3").val('#ff0000');//red
    $("#fa4").val('#FFFF00');//yellow
    removeLayersClass();
}
function ResetLiqClass() {
    $("#LIQ_field-1").val('104');
    $("#LIQ_field-2").val('103');
    $("#LIQ_field-3").val('102');
    $("#LIQ_field-4").val('101');

    $("#liq1").val('#008000');//green
    $("#liq2").val('#0000ff');//blue
    $("#liq3").val('#ff0000');//red
    $("#liq4").val('#FFFF00');//yellow
    removeLayersClass();
}
function ResetGClass() {
    $("#G_field-1").val('22');
    $("#G_field-2").val('19');
    $("#G_field-3").val('17');
    $("#G_field-4").val('14');

    $("#Gride1").val('#008000');//green
    $("#Gride2").val('#0000ff');//blue
    $("#Gride3").val('#ff0000');//red
    $("#Gride4").val('#FFFF00');//yellow
    removeLayersClass();
}
function ResetDemClass() {
    $("#FT_field-1").val('0');
    $("#FT_field-2").val('10');
    $("#FT_field-3").val('15');
    $("#FT_field-4").val('30');
```

```
    $("#dem1").val('#008000');//green
    $("#dem2").val('#0000ff');//blue
    $("#dem3").val('#ff0000');//red
    $("#dem4").val('#FFFF00');//yellow
    removeLayersClass();
}
function removeLayersClass() {
    if (map._layers["id10"] != undefined)
        map.removeLayer(map._layers["id10"]);
    if (map._layers["id9"] != undefined)
        map.removeLayer(map._layers["id9"]);
    if (map._layers["id8"] != undefined)
        map.removeLayer(map._layers["id8"]);
    if (map._layers["id7"] != undefined)
        map.removeLayer(map._layers["id7"]);
    if (map._layers["id6"] != undefined)
        map.removeLayer(map._layers["id6"]);

}
///reset function for the generated map/////////////////////////////////////////////////////////
function ResetFMap() {
    removeLayersClass();
      weight_soil = 0.24;
      weight_fault = 0.10;
      weight_lique = 0.22;
      weight_field = 0.06;
      weight_dist = 0.38;
    $("#w_classes").val(4);
    $("#soil_w").val(weight_soil);
    $("#fault_w").val(weight_fault);
    $("#field_w").val(weight_field);
    $("#liq_w").val(weight_lique);
    $("#dist_w").val(weight_dist);
```

```
    ChangeNoClass();



}
///calculate the classes set for the generated map/////////////////////////////////////////
function calcuateClassSett() {

    var class_weight = $('#w_classes').val();
    var min = 1.1;
    var max = 3.76;
    var range = max - min;
   // console.log("range" + range);
   // console.log("class_weight" + class_weight);

    var segment = range / class_weight;
   // console.log("segment" + segment);

    for (var tt = 0; tt < class_weight ; tt++) {
        var padding_a = tt * segment;
        var padding_b = (tt + 1) * segment;

        step_array_a.push(min + padding_a);
        step_array_b.push(min + padding_b);

        console.log("range " + tt +": " + step_array_a[tt] + "  -  " + step_array_b[tt]);
    }

}
///classification for each layer///// ///////////////////////////////////////////////////////
function getFaultClass(feature) {
    var featureData = feature.attributes;
    var result = 4;
    var v_fmd = featureData.Fmd_1;
```

```
    var b1_a = $("#Fault_field-1").val();//0.45
    var b2_a = $("#Fault_field-2").val();//0.53
    var b3_a = $("#Fault_field-3").val();//0.61
    var b4_a = $("#Fault_field-4").val();//0.68


    if (v_fmd < b1_a) {
        result = 1;
    }
    else if (v_fmd >= b1_a && v_fmd < b2_a) {
        result = 1;
    }

    else if (v_fmd >= b2_a && v_fmd < b3_a) {
        result = 2;
    }

    else if (v_fmd >= b3_a && v_fmd < b4_a) {
        result = 3;
    }

    else if (v_fmd >= b4_a && v_fmd <= 0.757875) {
        result = 4;
    }
    else {
        result = 4;
    }
    return result;
}
function getDistClass(feature) {
    var featureData = feature.attributes;
    var result = 1;
    var v_DistKm = featureData.DistKM;
```

```
    var b1_a = $("#G_field-1").val();
    var b2_a = $("#G_field-2").val();
    var b3_a = $("#G_field-3").val();
    var b4_a = $("#G_field-4").val();

    if (v_DistKm > b2_a && v_DistKm <= b1_a)
    {
        result = 1;
    }
    else if (v_DistKm > b3_a && v_DistKm <= b2_a) {
        result = 2;
    }
    else if (v_DistKm > b4_a && v_DistKm <= b3_a) {
        result = 3;
    }

    else if (v_DistKm <= b4_a) {
        result = 4;
    }

    return result;
}
function getDimClass(feature) {
    var featureData = feature.attributes;
    var result = 4;
    var v_GRIDCODE = featureData.FTDemValue;

    var b1_a = $("#FT_field-1").val();
    var b2_a = $("#FT_field-2").val();
    var b3_a = $("#FT_field-3").val();
    var b4_a = $("#FT_field-4").val();

    if (v_GRIDCODE >= b1_a && v_GRIDCODE < b2_a)
        result = 1;
    else if (v_GRIDCODE >= b2_a && v_GRIDCODE < b3_a)
```

```
        result = 2;
    else if (v_GRIDCODE > b3_a && v_GRIDCODE < b4_a)
        result = 3;
    else if (v_GRIDCODE >= b4_a)
        result = 4;
    else {
        result = 4;
    }
    return result;

}
function getLiqClass(feature) {
    var featureData = feature.attributes;
    var result = 4;
    var v_LQ_CATn = featureData.LQ_CATn;

    var b1_a = $("#LIQ_field-1").val();
    var b2_a = $("#LIQ_field-2").val();
    var b3_a = $("#LIQ_field-3").val();
    var b4_a = $("#LIQ_field-4").val();

    if (v_LQ_CATn <= b4_a) //760-796
    {
        result = 4;
    }

    else if (v_LQ_CATn > b4_a && v_LQ_CATn <= b3_a)//360-760
    {
        result = 3;
    }

    else if (v_LQ_CATn > b3_a && v_LQ_CATn <= b2_a)
```

```
    {
        result = 2;
    }

    else if (v_LQ_CATn > b3_a && v_LQ_CATn <= b1_a)
    {
        result = 1;

    }
    else {
        result = 4;
    }

    return result;
}
function getSoilClass(feature) {
    var featureData = feature.attributes;
    var result = 4;
    var v_vs301 = featureData.vs301;

    var b1_a = $("#soil_field-1").val();//760
    var b2_a = $("#soil_field-2").val();//360
    var b3_a = $("#soil_field-3").val();//180
    var b4_a = $("#soil_field-4").val();//50

    if (v_vs301 >= b1_a && v_vs301 <= 800) //760-796
    {
        result = 1;
    }

    else if (v_vs301 >= b2_a && v_vs301 < b1_a)//360-760
    {
        result = 2;
    }
```

```
    else if (v_vs301 >= b3_a && v_vs301 < b2_a)//180-360
    {
        result = 3;
    }

    else if (v_vs301 >= b4_a && v_vs301 < b3_a )//50-180
    {
        result = 4;


    }


    else if (v_vs301 < 50)//50-180
    {
        result = 4;
    }
    else //
    {
        result = 4;
    }

    return result;
    ///////
}
///classifications of 4 layers for final generated map (used by getMainFlag_1 &&
addlayer1_1)
function getValueOfSoil(fid) {
    var result = 4;//vs301
    var vs301 = 1;//vs301
    var b1_a = $("#soil_field-1").val();
    var b2_a = $("#soil_field-2").val();
    var b3_a = $("#soil_field-3").val();
    var b4_a = $("#soil_field-4").val();

    for (var i = 0; i < returnedSoil.length; i++)
    {
```

```
    if (returnedSoil[i] != undefined && returnedSoil[i].attributes != undefined &&
returnedSoil[i].attributes.vs301 != undefined) {
        if (fid == returnedSoil[i].attributes.FID)
        {
          vs301 = returnedSoil[i].attributes.vs301;

          if (vs301 >= b1_a && vs301 <= 800) //760-796
          {
            result = 1;
          }

          else if (vs301 >= b2_a && vs301 < b1_a)//360-760
          {
            result = 2;
          }

          else if (vs301 >= b3_a && vs301 < b2_a)//180-360
          {
            result = 3;
          }

          else if (vs301 >= b4_a && vs301 < b3_a)//50-180
          {
            result = 4;

          }

          else if (vs301 < 50)//50-180
          {
            result = 4;
          }
          else //
          {
            result = 4;
          }
```

```
                return result;

            }
        }
    }
    return result;
}
function getValueOfFault(fid) {
    var result = 1;
    var Fmd_1 = 1;
    var b1_a = $("#Fault_field-1").val();
    var b2_a = $("#Fault_field-2").val();
    var b3_a = $("#Fault_field-3").val();
    var b4_a = $("#Fault_field-4").val();

    for (var i = 0; i < returnedFault.length ; i++) {//FaultClass Fmd_1
        if (returnedFault[i] != undefined && returnedFault[i].attributes != undefined
&& returnedFault[i].attributes.Fmd_1 != undefined) {
            if (fid == returnedFault[i].attributes.FID)
            {
                Fmd_1 = returnedFault[i].attributes.Fmd_1;

                if (Fmd_1 < b1_a) {
                    result = 1;
                }
                else if (Fmd_1 >= b1_a && Fmd_1 < b2_a) {
                    result = 1;
                }

                else if (Fmd_1 >= b2_a && Fmd_1 < b3_a) {
                    result = 2;
                }

                else if (Fmd_1 >= b3_a && Fmd_1 < b4_a) {
```

```
                result = 3;
            }

            else if (Fmd_1 >= b4_a && Fmd_1 <= 0.757875) {
                result = 4;
            }
            else
            {
                result = 4;
            }
            return result;

        }
    }
  }
  return result;
}
function getValueOfLiq(fid) {
  var result = 4;
  var LQ_CATn = 1;
  var b1_a = $("#LIQ_field-1").val();
  var b2_a = $("#LIQ_field-2").val();
  var b3_a = $("#LIQ_field-3").val();
  var b4_a = $("#LIQ_field-4").val();
  for (var i = 0; i < returnedliq.length ; i++) {// LQ_CATn
    if (returnedliq[i] != undefined && returnedliq[i].attributes != undefined &&
returnedliq[i].attributes.LQ_CATn != undefined) {
        if (fid == returnedliq[i].attributes.FID) {
            LQ_CATn = returnedliq[i].attributes.LQ_CATn;

            if (LQ_CATn <= b4_a) //760-796
            {
                result = 4;
            }
```

```
            else if (LQ_CATn > b4_a && LQ_CATn <= b3_a)//360-760
            {
                result = 3;
            }

            else if (LQ_CATn > b3_a && LQ_CATn <= b2_a)//180-360
            {
                result = 2;
            }

            else if (LQ_CATn > b3_a && LQ_CATn <= b1_a)//50-180
            {
                result = 1;

            }
            else {
                result = 4;
            }

            return result;
        }
    }
  }
  return result;
}
function getValueOfDem(fid) {
  var result = 4;
  var FTDemValue = 1;
  var b1_a = $("#FT_field-1").val();
  var b2_a = $("#FT_field-2").val();
  var b3_a = $("#FT_field-3").val();
  var b4_a = $("#FT_field-4").val();
  for (var i = 0; i < returnedDem.length ; i++) {
    if (returnedDem[i] != undefined && returnedDem[i].attributes != undefined
&& returnedDem[i].attributes.GRIDCODE != undefined) {
```

```
          if (fid == returnedDem[i].attributes.FID) {
             FTDemValue = returnedDem[i].attributes.FTDemValue;

             if (FTDemValue >= b1_a && FTDemValue < b2_a)
                result = 1;
             else if (FTDemValue >= b2_a && FTDemValue < b3_a)
                result = 2;
             else if (FTDemValue > b3_a && FTDemValue < b4_a)
                result = 3;
             else if (FTDemValue >= b4_a)
                result = 4;
             else {
                result = 4;
             }
             return result;
          }
       }
   }
   return result;
}
///classification of 4 layer through predefined values
function getValueOfSoil2(fid) {
   var result = 1;//vs301

   for (var i = 0; i < returnedSoil.length ; i++) {
       if (returnedSoil[i] != undefined && returnedSoil[i].attributes != undefined &&
returnedSoil[i].attributes.SolidClass != undefined) {
          if (fid == returnedSoil[i].attributes.FID) {
             result = returnedSoil[i].attributes.SolidClass;
             return result;
          }
       }
   }
   return result;
} //predefined
```

```
function getValueOfFault2(fid) {
    var result = 1;

    for (var i = 0; i < returnedFault.length ; i++) {//FaultClass Fmd_1
        if (returnedFault[i] != undefined && returnedFault[i].attributes != undefined
&& returnedFault[i].attributes.FaultClass != undefined) {
            if (fid == returnedFault[i].attributes.FID) {
                result = returnedFault[i].attributes.FaultClass;

                return result;

            }
        }
    }
    return result;
}
function getValueOfLiq2(fid) {
    var result = 1;

    for (var i = 0; i < returnedliq.length ; i++) {// LQ_CATn
        if (returnedliq[i] != undefined && returnedliq[i].attributes != undefined &&
returnedliq[i].attributes.LiqClass != undefined) {
            if (fid == returnedliq[i].attributes.FID) {
                result = returnedliq[i].attributes.LiqClass;

                return result;
            }
        }
    }
    return result;
}
function getValueOfDem2(fid) {
    var result = 1;

    for (var i = 0; i < returnedDem.length ; i++) {
```

```
        if (returnedDem[i] != undefined && returnedDem[i].attributes != undefined
&& returnedDem[i].attributes.FTClass != undefined) {
            if (fid == returnedDem[i].attributes.FID) {
                result = returnedDem[i].attributes.FTClass;
                return result;
            }
        }
    }
    return result;
}
////////////////////////////////////////////////////////////////////////////////////////////////////
var count = 1;
var status1 = 1;
var status2 = 1;
var status3 = 1;
var status4 = 1;
var status5 = 1;
var weightedValues = [];
function getMainFlag(feature)
{
    var featureData = feature.attributes;
    var result = 1;

    var vs301 =
getValueOfSoil2(featureData.FID);//getValueOfSoil(featureData.FID);
    var Fmd =
getValueOfFault2(featureData.FID)//getValueOfFault(featureData.FID);
    var Lq = getValueOfLiq2(featureData.FID)//getValueOfLiq(featureData.FID);
    var ftdem =
getValueOfDem2(featureData.FID);//getValueOfDem(featureData.FID);



    var km_grid=parseInt(featureData.GrideClass);

    weight_soil = $("#soil_w").val();
```

```
    weight_fault = $("#fault_w").val();
    weight_lique = $("#liq_w").val();
    weight_field = $("#field_w").val();
    weight_dist = $("#dist_w").val();

    var weighted_value = (vs301 * weight_soil) + (Fmd * weight_fault) + (Lq *
weight_lique) + (ftdem * weight_field) + (km_grid * weight_dist);
    weightedValues.push({ FID: featureData.FID, Weighted: weighted_value });
    console.log("FID=" + featureData.FID +"--Weighted="+weighted_value);
    weightedValueArr.push(weighted_value);



    for (var j = 0; j <= step_array_a.length; j++) {
        if (weighted_value >= step_array_a[j] && weighted_value < step_array_b[j]) {
            return (j + 1);
        }
    }




}
function getMainFlag_1(feature) {
    var featureData = feature.attributes;
    var result = 1;
    var countss = 0;
    var vs301 = getValueOfSoil(featureData.FID);//getValueOfSoil(featureData.FID);
    var Fmd = getValueOfFault(featureData.FID)//getValueOfFault(featureData.FID);
    var Lq = getValueOfLiq(featureData.FID)//getValueOfLiq(featureData.FID);
    var ftdem =
getValueOfDem(featureData.FID);//getValueOfDem(featureData.FID);
    var km_grid;
    var DistKM = featureData.DistKM;
    var b1_a = $("#G_field-1").val();
    var b2_a = $("#G_field-2").val();
```

```
    var b3_a = $("#G_field-3").val();
    var b4_a = $("#G_field-4").val();

    if (DistKM > b2_a && DistKM <= b1_a) {
      km_grid = 1;
    }
    else if (DistKM > b3_a && DistKM <= b2_a) {
      km_grid = 2;
    }
    else if (DistKM > b4_a && DistKM <= b3_a) {
      km_grid = 3;
    }

    else if (DistKM <= b4_a) {
      km_grid = 4;
    }
    weight_soil = $("#soil_w").val();
    weight_fault = $("#fault_w").val();
    weight_lique = $("#liq_w").val();
    weight_field = $("#field_w").val();
    weight_dist = $("#dist_w").val();

    var weighted_value = (vs301 * weight_soil) + (Fmd * weight_fault) + (Lq *
weight_lique) + (ftdem * weight_field) + (km_grid * weight_dist);
    weightedValues.push({ FID: featureData.FID, Weighted: weighted_value });



    //storeweight(featureData.FID, weighted_value);
    weightedValueArr.push(weighted_value);

    for (var j = 0; j <= step_array_a.length; j++)
     {
      if (weighted_value >= step_array_a[j] && weighted_value < step_array_b[j])
       {
          return (j + 1);
```

```
        }
    }
}
function storeSoil(FID, VS, Class) {
    jQuery.ajax({
        type: "GET",
        url: "../Ajax.aspx",
        data: {
            rand: Math.random(),
            job: "Storesoil",
            FID: FID,
            VS: VS,
            Class: Class
        },
        context: this,
        success: function (a) {
             if (parseInt(a) < 0) {
                alert("Update Failed");
            }
        },
        error: function (a, c, b) {
            alert("Error Occurred");

        }
    })

}
function storeweight(FID, weight) {
        jQuery.ajax({
            type: "GET",
            url: "../Ajax.aspx",
            data: {
                rand: Math.random(),
                job: "Storewieght",
                FID: FID,
```

```
            weight: weight
          },
          context: this,
          success: function (a) {
              if (parseInt(a) < 0) {
                alert("Update Failed");
            }
          },
          error: function (a, c, b) {
            alert("Error Occurred");

          }
      })
}

////////////////////////////////Buildings//////////////////////////////////////////////////////
function DrawBuildings() {

    var buildings = $("#buildingsIds").find('input');
    var AllBuildingSelected = "";
    buildings.each(function (index, element) {
        var Controlid = $(this).attr("id");
        var BuildingId = Controlid.substring(1, Controlid.length);
        AllBuildingSelected += "" + BuildingId + " ,";

    });

    AllBuildingSelected = AllBuildingSelected.substring(0,
AllBuildingSelected.length - 1);

    GenerateBuildingMap(AllBuildingSelected);
}
function GenerateBuildingMap(Filter) {
    layerBuilding = new esri.layers.FeatureLayer(kc_buildings, {
        id: 'idB1',
```

```
        outFields: ["*"],
        strWhere: " MAHALLE in (" + Filter + ")",
         returnGeometry: true,
        mode: esri.layers.FeatureLayer.MODE_SNAPSHOT
    });

    var symbol0 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([0, 0, 0, 1]), 2), new
esri.Color([0, 0, 0, 0.5]));
    var symbol1 = new esri.symbol.SimpleFillSymbol("solid", new
esri.symbol.SimpleLineSymbol("solid", new esri.Color([1, 1, 1, 1]), 2), new
esri.Color([1, 1, 1, 0.5]));

    var renderer = new esri.renderer.ClassBreaksRenderer(null, getBuildingClass);
    renderer.addBreak(1, 1, symbol0);//red
    renderer.addBreak(2, 2, symbol1);//red

    //layerBuilding.setDefinitionExpression("FID<20000");
    layerBuilding.setRenderer(renderer);

    map.addLayer(layerBuilding);



    layerBuilding.on("update-end", function () {
        require(["esri/graphicsUtils"], function (graphicsUtils) {
            var zoomExtent = graphicsUtils.graphicsExtent(layerBuilding.graphics);
            map.setExtent(zoomExtent.expand(1));
        });
    })
}
function removeBuildings() {
    if (map._layers["idB1"] != undefined)
        map.removeLayer(map._layers["idB1"]);
}
function getBuildingClass(feature) {
```

```
    var featureData = feature.attributes;
    result = 2;

    return result;
}
dojo.ready(init);
```

CURRICULUM VITAE

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