

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING AND TECHNOLOGY

**A METHODOLOGY TO DEVELOP SMART SPATIAL MANAGEMENT FOR
NATURAL HAZARD RESILIENCE: THE CASE OF DUZCE PROVINCE**



M.Sc. THESIS

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Department of Urban and Regional Planning

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AUGUST 2019

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**DOĞAL TEHLİKELERE DAYANIKLILIK İÇİN AKILLI MEKANSAL
YÖNETİMİ GELİŞTİREN BİR YÖNTEM: DÜZCE İLİ ÖRNEĞİ**

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To my family,



FOREWORD

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ABBREVIATIONS

BRIM	: Building Resilience Information Modelling
DEM	: Digital Elevation Model
DMG	: Distributed Multi Generation
DROP	: Disaster Resilience of Place
DRR	: Disaster Risk Reduction
ES	: Ecosystem Services
GHG	: Greenhousegase
GIS	: Geographic Information Systems
GPS	: Global Positioning System
HFA	: Hyogo Framework for Action
ICT	: Information and Communication Technology
IoT	: Internet of Things
IPCC	: Intergovernmental Panel on Climate Change
ISBAK	: Istanbul Informatics and Smart City Technologies
LIDAR	: Light Detection and Ranging
LWIR	: Long Wave Infrared
MDGs	: Millennium Development Goals
MES	: Multi Energy Systems
MEU	: Ministry of Environment and Urbanism
MPWH	: Ministry of Public Works and Housing
NWDA	: Natural Wildlife Development Area
NHR	: Natural Hazard Resilience
RFID	: Redio Frequency Identificaiton Devices
SDGs	: Sustainable Development Goals
SES	: Socio-Ecological Systems
SFDRR	: Sendai Framework for Diaster Risk Reduction
SSM	: Smart Spatial Management
TUBITAK	: The Scientific and Technological Research Council of Turkey
UN	: United Nations
UNISDR	: United Nations International Strategy for Disaster Reduction



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A METHODOLOGY TO DEVELOP SMART SPATIAL MANAGEMENT FOR NATURAL HAZARD RESILIENCE: THE CASE OF DUZCE PROVINCE

SUMMARY

The production of space and developed systems caused global environmental problems as well as climate change. While only 3 percent of land is consumed as urban; however, urban areas are major places of carbon emissions estimating 71 percent according to the International Panel on Climate Change. Since the urban settlements are centers of capital and excessive amount of population, these areas are the most vulnerable areas to disasters and other catastrophes. Natural hazards are another type of adversity that settlements faced in recent years. Due to increasing climate change effects, the frequency and size of natural hazards are increased as well as uncertainty. While disaster risk mitigation methods have been focused on the activities after a disaster, natural hazard resilience (NHR) approaches are mainly focused on the preparedness and mitigation of risks before hazards. In addition, the decrease of vulnerability and integration of consequences into spatial planning are main outcomes of the study. Smart spatial management (SSM) is an efficient tool for provisioning NHR of socio-ecological systems from the perspective of urban ecology. SSM deals with the use of resources and controlling externalities of settlement dynamics in a smart way; besides, the main approach is to use information and communication technologies (ICT) or smart infrastructures to monitor the change and quality of the environment, analyze results, define vulnerable areas and integrate consequences into spatial planning to support NHR. Ecosystem services (ES) approach was adopted to analyze the fundamental areas for resilience building in an ecological perspective. Regulating services under ES help to understand the dynamics and resources in settlements both urban and rural; moreover, it is therefore important to assess the future settlement dynamics of the settlement. Düzce province is rich for ecosystem services and biodiversity; also, the city suffers from natural hazards as expressed in its history. Due to its ecological values and hazard history, Düzce province is selected as case study area, because interventions taken with environmental measures help to increase resilience without making major and structural changes in the system. Assessing NHR in the era of climate change will help decision makers to evaluate easily the settlement's resilience to natural hazards as well as to monitor the effects of taken actions within the settlement. To sum up, NHR strengthened by SSM approaches will contribute more efficiently in the process of hazard-prone settlements' spatial management than disaster crisis management based approaches as a result of increased adaptation capacity.



DOĞAL TEHLİKELERE DAYANIKLILIK İÇİN AKILLI MEKANSAL YÖNETİMİ GELİŞTİREN BİR YÖNTEM: DÜZCE İLİ ÖRNEĞİ

ÖZET

Günümüzde dünya nüfusunun yarısı kentlerde yaşamasına rağmen bu oran yalnızca anakaranın %3'lük kısmına karşılık gelmektedir. Bunların yanında Uluslararası İklim Değişikliği Konferansı'nda kentsel alanların karbon emisyonunun %71'ine karşılık geldiği yönünde tahminlerde bulunulmuştur. Kentlerin yaşadığı hızlı değişim ve bu değişimin yarattığı evrensel problemlerin başında doğal tehlikeler gelmektedir. Kentler yapıları gereği karmaşık ve birbiriyle iç içe geçmiş sistemlerden oluşurken, ekonomik değer üretiminin yüksek olduğu da görülmektedir. Nüfusun büyük bir kısmının da kentlerde yaşadığı göz önünde bulundurulduğunda bu alanlar doğal tehlikelere karşı en savunmasız ve en çok etkilenebilecek alanlar olarak ifade edilmektedir. Fakat kentsel alanları tek başına düşünmemek, yerleşmeleri çevresi ve kırsal alanlarıyla birlikte bir bütün olarak düşünmek gerekir. Günümüzde ise iklim değişikliğine bağlı olarak olası doğal tehlikelerin meydana gelme sıklığı ve şiddetinde artma görüldüğünden yapılacak çalışma bu yöne katkı sunmayı hedeflemektedir.

Tehlikere karşı hazırlıklı olma düşüncesi 1990'lardan beri küresel anlamda bilim insanlarının üzerinde durduğu bir konudur. Dayanıklılık (resilience) kavramı da olası tehlikelere karşı hazırlıklı olmak konusunda benimsenmiş yaklaşımlardan biridir. Bu kavram 1973 yılında C.S. Holling'in katkılarıyla ortaya koyulmuş sonrasında ise kent planlama alanında gelişim göstermiştir. Tehlikelere karşı dayanıklılık konusuna gelindiğinde ise dayanıklılık olası bir stresin oluşması durumunda yerleşmenin hiç veya az hasara maruz kalması ve eski haline dönebilmesi anlamına gelmektedir. Kentsel alanlar karmaşık bir yapıya sahip olmasının yanında farklı ölçeklerde ilişkileri de içerir. Ölçeklerarası bir ilişkinin yanında mevcut sistemler arasında da bağlantı yer aldığından kentlere yönelik dayanıklılığı farklı yönleriyle ele almak gerekmektedir. Adaptasyonu hedefleyen önlemler (Brown et al., 2012) doğal tehlikelere karşı dayanıklılıkta öne çıkan konulardandır. Bu önlemleri etkin ve verimli bir şekilde test etmenin ise kaynak yönetimiyle (Alberti, 2005; Beatley & Newman, 2013) sağlanabileceği ortaya koyulmuştur. Söz konusu kaynak yönetimi olduğunda yerleşme metabolizması modeli üzerinden konuyu ele almak faydalı olacaktır. Bu modelde doğal kaynaklar, yerleşme dinamikleri ve sonuçları arasındaki ilişki ortaya konulmaktadır. Ekolojik planlama bu modele entegre edildiğinde ise; kaynakların etkin kullanımı sayesinde yaşanabilirliğin artırılması, zarar azaltma yöntemleri kullanılarak negatif sonuçların etkisini aza indirmek veya kontrol etmek temel amaçlar olarak ortaya koyulmaktadır. Ekolojik planlama bakış açısından kaynakların yönetimi düşünüldüğünde bu ilişkiyi ortaya koyan yöntem ekosistem servisleri (ES) olarak ifade edilmektedir. ES temel olarak doğadan sağlanan faydaları ortaya koymaktadır. Ekolojik değerler ve ES küçük müdahalelerde büyük ölçüde dayanıklılığa katkı sağlayabilme potansiyeline sahiptirler. Bu nedenle, ekolojik servislerin tehlikere karşı dayanıklılık konusunda kentlere sunduğu kapasite göz ardı edilemeyecek ölçüde yüksektir.

Doğal tehlikeler tarihten günümüze yerleşmeleri etkileyen bir olgu olarak hayatımızda yer almıştır. Sebep oldukları can kaybının yanında önemli derecede ekonomik kayıplara da neden olarak sadece kentlerin yapısını değil ekonomilerini de negatif yönde etkilemektedir. Değişen dünya ve gelişen teknoloji artık her bilginin ve her aksiyonun kayıt alınmasını kolaylaştırmaktadır. Uygulanan akıllı çözümler ve yöntemler ile insan hayatıyla birlikte kentler de bu sistemlere ayak uydurmuş ve buna yönelik çözümler geliştirilmiştir. Akıllı kentler veya akıllılık ilk ortaya çıktığında sadece teknolojiye bağlı iken sonrasında bilginin üretimine dayalı olduğu da ifade edilmiştir. Akıllı kentlerin ilk uygulamalarının amacı sürdürülebilir ekonomik gelişme ve iyi yaşam kalitesi olarak belirtilirken, akıllı kent yaklaşımı temel olarak bilgi ve iletişim teknolojilerinin kullanılması ile ilgilidir. Bu yaklaşım bilgi ve iletişim teknolojileri ile insan davranışları arasındaki ilişkilere bağlı olarak gelişimini gerçekleştirmiştir. Kummitha ve Krutzen (2017) akıllı kent yaklaşımı dört ayrı dönemde ele almışlardır: bilgi ve iletişim teknolojilerinin gelişmesi, insan faktörünün sisteme eklenmesi, teknolojinin aktif kullanımı ve başlıca şirketlerin öne çıkması. Günümüzdeki akıllı kent uygulamalarına bakıldığında ise, bahsedilenlerden iki fikrin öne çıktığı görülmektedir: teknolojilerin aktif kullanımı ve şirketlerin rolü. Teknolojilerin aktif kullanımı yaşayan laboratuvar (living lab) anlayışını ortaya koymaktadır. Bu sistemlerde teknolojinin aktif kullanımıyla veri girişi ve girişi yapılan verinin sonuçlarının katılımcı bir yöntemle ele alındığı görülmektedir. Şirketlerin rolü ise günümüzde uygulaması gerçekleştirilen akıllı kent yaklaşımları ile örtüşmektedir. Kapsayıcı ve bütüncül bir planlamanın aksine şirketlerin önerdiği çözümler ve danışmanlığında akıllı sistemlerin uygulanması söz konusudur. Bu alandaki gelişmeler temel olarak süreçte insanın rolünü ve akıllı kente katkısının nasıl olacağını ortaya koymaktadır.

Yapılan planlama çalışmaları kentlerin sürdürülebilir gelişmesini hedeflemesine rağmen, kentsel gelişmenin bu kurallara uygun olarak gelişmediği Birleşmiş Milletler tarafından ortaya koyulmuştur (2018). Mekansal planlama ile kurulması gereken bağın yeterli düzeyde olmadığı görülmüştür. Akıllı kent ve mekansal gelişme düşünüldüğünde ise akıllı mekansal yönetim konseptinin gelişmekte olan bir fikir olduğu görülmektedir. Akıllı mekansal yönetim temel olarak bilgi iletişim teknolojileri yoluyla belirleme, gözlem, analiz etme, öneri geliştirme ve geleceğe yönelik politika geliştirme olarak özetlenebilir. Fakat bu yöntemde temel amaç elde edilen verinin akıllı yöntemler sayesinde coğrafi bilgisi yanında gerçek zamanlı olarak elde edilmesidir.

Ekolojik planlama bakış açısından doğal tehlikelere karşı dayanıklılık düşünüldüğünde afet riski yönetiminden farklı bir yöntem geliştirmek gerekmektedir. Doğal kaynaklarının yönetimi ihtiyacı ekolojik planlamaya perspektifinden konuyu ele almayı gerektirmektedir. ES tabanlı ekolojik planlama ve akıllı mekansal yönetimi entegre eden bir yaklaşım doğal tehlikelere karşı dayanıklılığın sağlanmasında önemli rol oynamaktadır. Bilgi ve iletişim teknolojilerinin dayanıklılığın sağlanması sürecine entegre edilmesi, yönetim modelinin doğal tehlikelerin savunmasızlıkların risklerin belirlenmesinde, mekansal gelişmenin yönetiminde, gelecekteki gelişme senaryoları ve uzun dönem planlamaya politika girdileri oluşturmada etkinleştirici olma ve kolaylaştırma özellikleri ile öne çıkmaktadır. Geçmişte kısıtlı imkanlar nedeniyle yeterli ölçümler yapılamazken, akıllı çözümler sayesinde tehlikelere ve afetlere yönelik parametrelerin çoğu hesaplanabilecek ve buna bağlı olarak uygun çözümler geliştirilebilecektir. Doğal afetlere ek olarak iklim değişikliğine bağlı olarak gelişen tehlikelere de dayanıklılık düşünüldüğünde akıllı kent yaklaşımlarında fayda

sağlanabilir. Önerilecek çözümler ve varolan bilgi kapasitesi doğal tehlikelere karşı dayanıklılıkta faydalı rol üstlenebilecektir. Doğal tehlikelere karşı dayanıklılıkta akıllı mekansal yönetim anlayışının geliştirilmesi bu çalışmanın temel amacıdır.

Düzce ili geçirdiği 1999 depremi sırasında büyük ölçüde yıkıma uğramış ve depremin neden olduğu ikincil afetler ile de can kayıpları yanında büyük ekonomik kayıplara da neden olmuştur. Kentte yer alan doğal tehlikelerin yanında insan kaynaklı ve teknolojik tehlikeler de bulunmaktadır. İstanbul İli'ne içmesuyu sağlanması amacıyla Melen Barajı'nın inşası, endüstriyel alanların giderek artması doğal tehlikeler yanında insan kaynaklı tehlikelerin de varolduğunun göstergesidir. Fakat bunların yanında kente bakıldığında, ekolojik açıdan geniş bir kapasitesi bulunması ve deprem yanında, heyelan, taşkın, erozyon gibi çoklu risklerin ve var olması nedeniyle Düzce İli çalışma alanı olarak seçilmiştir. Yapılan değerlendirmeler sonucunda Düzce ili için doğal tehlikelere karşı dayanıklılıkta zarar azaltma sürecinin tanımı ekolojik planlama bakış açısıyla yeniden tanımlanmış ve akıllı mekansal yönetimi destekleyici öneriler geliştirilmiştir.

Akıllı mekansal yönetimi hedefleyen öneriler akıllı kentler için tanımlanan 6 bileşenli yapı temel alınarak oluşturulmuştur. Bu bileşenler akıllı çevre, akıllı insan, akıllı yönetim, akıllı hareketlilik, akıllı yaşam ve akıllı ekonomidir. Doğal tehlikelere karşı dayanıklılığın sağlanmasın akıllı çevre bileşeninin temel amacı doğal tehlikelere karşı hassas ve ES tabanlı bir koruma ve yönetimi hedeflerken, uygulamaya yönelik politikalar doğala kaynakların korunması, çevresel gözlem, kaynak ve kirlilik yönetimi olarak belirlenmiştir. Akıllı insan bileşeninin amacı kişisel ölçekte doğal tehlikeye dayalı verinin sağlanmasıdır. Bu bileşene ait politikalar ise insanların afet sırası ve hazırlık sürecinde zarar azaltma sürecine katılımı ve bu konudaki bilinçlerinin artırılması olarak önerilmiştir. Akıllı yönetim bileşeninin temel amacı doğal tehlikeler karşı duyarlı yönetim olarak ifade edilirken, önerilen temel politikalar planlama sürecine katılım ve şeffaf bir yönetimin sağlanmasıdır. Akıllı hareketlilik bileşeninin temel amacı doğal tehlikelere karşı duyarlı hareketlilik olarak belirlenirken bağlantılı politikalar akıllı acil durum rotaları, akıllı ulaşım modları etrafında geliştirilmiştir. Akıllı yaşam bileşeninin temel amacı doğal tehlikelere karşı duyarlı yaşam kalitesi iken, bu bileşene ait politikalar artırılmış yaşam kalitesi, doğal tehlikelere duyarlı mekansal gelişme ve altyapı olarak belirlenmiştir. Son olarak akıllı ekonomi bileşeninin temel amacı doğal tehlikelere dayalı bir sigorta sistemi olarak ifade edilirken politikalar doğal tehlikeler için sigorta havuzu oluşturulması ve ekonomik faaliyetlerin çeşitlendirilmesi olarak belirlenmiştir. Yapılan öneriler doğal tehlikelere karşı dayanıklılığı desteklenmesi hedeflenerek ortaya koyulmuştur.

Sonuç olarak dğal tehlikelere karşı dayanıklılığı akıllı mekansal yönetim ve ekolojik planlama perspektifinden ele alan bu çalışma ile yerleşmeler için bütüncül ve entegre olmuş bir planlama ve yönetim sistemi oluşturulması hedeflenerek bu yönde öneriler geliştirilmiştir.



1. INTRODUCTION

Since 2008, more than half of the world population has been living in urban areas, and, according to Li et al. (2017) the predicted urbanized population overrun the 70% by 2050. Moreover, it is projected by the United Nations and emphasized in Social Development Goals that 5 billion of the population will live in urban areas by 2030 (Url-1). The consume of land and development system created in the world has been contributing in critical degrees into the process of climate change. Moreover, Alberti (2005) pointed out that urbanization is fundamental cause of conversion of land. The instability of climatic conditions and global warming increase the probability of catastrophic events in the world. Since the urban areas are centers of capital and an excessive amount of population, these areas have been considered as the most vulnerable areas to natural hazards and other adversities. However, cities consist of both urban and rural areas, which connected to each other as interrelated parts of a system. The recent situation requires an integrated approach to focus both urban and rural. From the perspective of urban ecology, cities are complex systems with its resources and natural systems as inputs and well-being, pollution as outputs. According to metabolism model (Newman, 1999) proposed for settlements, the model consists from resources, settlement dynamics and outputs represented by livability and waste. There are also external dynamics, that affect and change the whole metabolism model. These outside dynamics are natural hazards, human-induced hazards and urban development. Newman expressed the idea of systematic approach in urban ecology because of all systems both human related, economic and cultural systems as well as natural ecosystems affect each other (1999). Because of that, rural areas and the management of land cover and land use in these areas is as critical as cities in their resilience building and vulnerability reduction. Majority of the problems that cities are facing with climate change require focusing on control of urban development and natural resources in a smart way to support natural hazard resilience (NHR). Resilience means “*the bouncing back capability in a short time*” from the perspective of NHR. The development of smart tools and approaches in spatial management of settlements

will positively influence and contribute to NHR. Smart spatial management (SSM) has been developed to deal with problems of settlements and control spatial organization of settlements by integrating smart tools into settlements. SSM concept is an effective approach to manage resources and externalities of settlements and will help building resilience to natural hazards when recent development trends considered.

1.1 Purpose and the Content of Research

The evolution of cities and their dynamics have been causing externalities such as climate change, land degradation, adversities etc. Cities consist from both human systems and ecological systems together from an urban ecology perspective. As Alberti (2008) expressed, cities are complicated ecological systems controlled by human beings. Change is a natural part of the ecological system and the capability of these systems to reply and adapt to a change, which is a crucial element of maintaining sustainability as well as resilience in cities. The change of environment by human cause heterogeneity in landscapes with change in the cycles of nature like energy and nutrient dynamics. These changes caused in the long run climate change and this situation triggered instability of climatic conditions and increase in the frequency of natural hazards such as landslides, floods, extreme weather conditions and so on. The provision of natural hazard resilience in socio-ecological systems is probable with utilization of resources and control of externalities created by urban dynamics. Due to recent urban development trends, smart city concept can help to or make possible to enable resilience to natural hazards by controlling externalities and utilizing resources in an effective way. The case study area of Düzce Province is selected because of its diverse natural resources abundance together with multi natural hazard probability and past experienced disasters. Therefore, the aim of the research is to create an integrated model development combining NHR with smart city components through the SSM approach in the case of Düzce Province. It is crucial to create a bridge between resilient city and smart city to fulfill the potential gaps in the process of hazard resiliency and natural resource sustainability of settlements with the utilization of SSM concept. The uniqueness of this research is based on the exploration of SSM concept on more generalized spatial terms with the necessity of interdependence of cities with its periphery in regards to NHR and natural resource sustainability. Therefore, this

research will prefer to use SSM instead of smart city for the integration of smartness concepts in spatial planning discipline.

The structure of the research for creating such notion starts with the analysis of literature on resilience, resilient city, and smart city and evaluating the common ground among them if it exists. Content analysis in literature is conducted to analyze resilient city and smart city concepts. Resilience concept is a broad concept than resilient city; thus, resilience literature excluded in content analysis. Main research subjects will be evaluated for each development concept, on the other hand common ground in research subjects will be expressed if it exists. There are many publications focusing on what the concept means and how these concepts evolved in time while there are some publications try to create a common ground for smart and resilient cities. However, the analyzed examples do not have a direct relation with spatial planning discipline when building resilience to natural hazards.

Thesis consists of five fundamental chapters. The first one is introducing the general structure of the thesis in the content of purpose, content, hypothesis and research questions. The second and the third chapters are dedicated to express literature review for explaining the interrelation between NHR and SSM concepts in conjunction with findings from different country examples as well as clarifications of concepts through literature review. The fourth chapter aims to explain the case study area with the developed system and the fifth chapter is concluded with the final evaluation of the thesis study and suggestions for further research. Figure 1.1 illustrates all phases of the study from a broad content.

First of all, the literature review parts of the thesis (Chapter 2-3) is improved by research areas which are urban ecology, resilience, resilient city, smart city, smart resilience city or resilient smart city from the perspective of NHR, after that the review is concluded with the evaluation of both concepts. The content analysis and qualitative based approaches are main representatives describing the development of this part of the thesis.

Secondly, the case study approach is adopted for the site experiment part that conceptualizes the evaluation of existing and planned situation of the Düzce Province to support NHR and the criticizing the SSM approaches. Düzce Province is selected as an experimental site for the thesis because of the relevance of diverse natural assets

and both natural and human-induced risks; increase of population as a result of urban development, disqualified level of risk mitigation approaches to natural hazards as experienced with the newly occurred flood disasters in urban and rural areas of Düzce Province (Url-7).

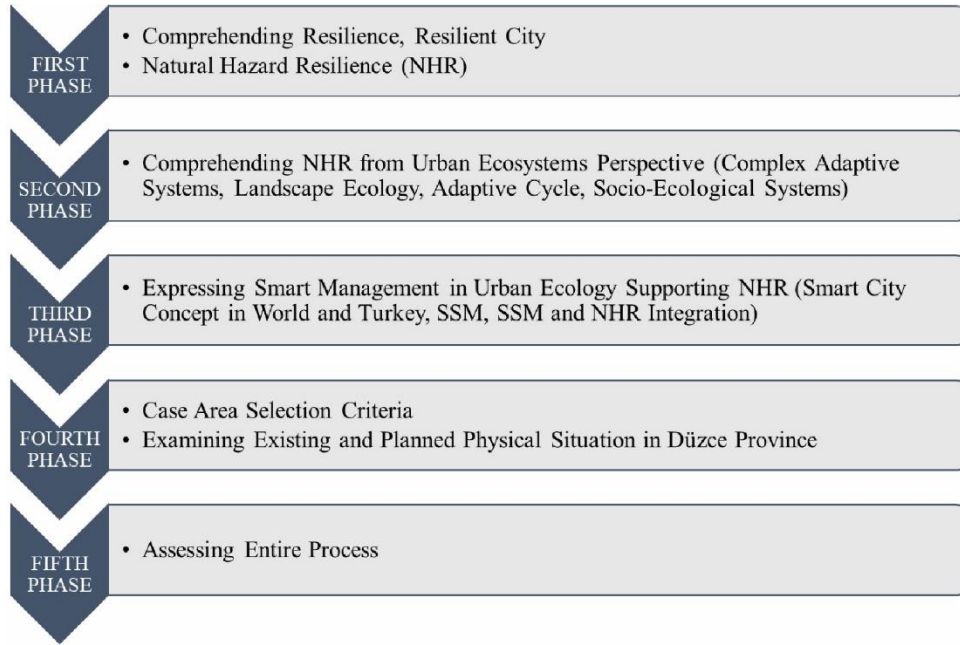


Figure 1. 1: Thesis study process.

1.2 Hypothesis and Research Questions

This thesis is constructed on the hypothesis of “Natural hazard resilience (NHR) can be strengthened through smart spatial management (SSM) approaches. SSM approach can contribute more efficiently in hazard-prone settlements’ by integrating settlement and its peripheral characteristics with multi natural hazard probability and natural resource sustainability than conventional disaster crisis management based approaches as a result of increased adaptation capacity.” NHR with smart management approaches can boost the capacity of settlements towards not only natural hazards but also potential human-induced hazards or threats. Hence, the main question assisting hypothesis is “Can the integration of NHR with SSM help to decrease vulnerability to hazards when compared with disaster crisis management approach?”

Accordingly, four supporting sub-hypotheses and relative research questions appointed are expressed as below.

Supporting Hypothesis 1: The uncertainty characteristic of hazards requires the resilience approach in settlements to overcome development problems in conjunction with natural hazards.

The resilient city approach in relation to natural hazards basically enables to maintain resilience to natural hazards in recent decades from the perspective of urban ecology. The main research question and subsidiary questions complying with the hypothesis are stated as below:

-How resilient city approach understood in urban ecology discipline in the face of natural hazards and recent urban development trends?

-What are the components of urban ecosystems?

-What is the meaning of urban resilience?

-How the concept evolved in time?

-What is the meaning of natural hazard resilience? Is it true to say that hazard resilience and disaster resilience have the same ground of notion?

-What are the international agreements on DRR and resilience?

-What is the main debate between resilience to natural hazards?

Supporting Hypothesis 2: SSM approaches are an efficient tool to improve the resilience and adaptive capacity of settlements in the face of NHR and natural resource sustainability.

Application of resilience measurements into urban planning and management practices is not enough to cope with natural hazards in the era of innovation and technology. Sustainable Development Goals stated by United Nations should shape the development of cities as resilient in the face of climate change; in addition, there are many city concepts created in time and smart city concept is one of these concepts. However, the meaning of smartness in the study is taken into account as smart management approaches. The evolution of the concept and the contributions into urban planning may have significant consequences. The main research question and subsidiary questions are stated as below:

-How the smart city concept may affect the development of settlements? What are the main contributions to increase NHR of cities?

- What is the meaning of “smart city concept” and how the concept evolved?
- What is the situation of smart cities in World and Turkey?
- How smart city concept can be developed to cover settlement and peripheral spatial interactions?
- Can SSM be more relevant concept for NHR?
- What potential integration approaches may exist between SSM and NHR?

Supporting Hypothesis 3: Considering natural threats in settlements (with urban and peripheral areas), vulnerability analysis in regards to existing and planned situations of settlements with SSM approaches can provide more resilient and adaptive spatial development capacity.

Assessing NHR in the face of natural hazards and climate change based threats will provide a way of understanding the features of settlements to build resilience. When the capacity of settlement is assessed and the weaknesses and vulnerabilities described, SSM approaches may create more innovative and efficient ground for raising the resilience of settlements. The main research question and subsidiary questions here are stated as below:

- How NHR supports? What kind of SSM approaches supported the management of natural threats?
- Is Düzce Province a relevant case for the content and the aim of the research?
- What are the existing natural risks & vulnerabilities and planned situation risks in Düzce Province?
- How SSM approach can enhance the resilience of Düzce Province?

Supporting Hypothesis 4: If resilience of the province supported by SSM approaches and this approach integrated into spatial planning, it can be evident SSM will help the resilience development towards natural hazards.

The consideration of resilience and SSM notion brought the idea of making a connection between these concepts and urban planning in cities and their peripheral physical interaction area. There are two critical points in this research. The first one is integration of SSM with NHR, and the second one is developing related spatial concepts. The only research question stated under this sub-hypothesis is given below:

-How the assessment of NHR be placed with SSM concept and its tools?

In Düzce Province, this process will provide an increased adaptive capacity to the city by showing natural threats in different scales and assessment will be finalized with a proposal of SSM tools for enhancing the lacking features of NHR in the province; moreover, the reflections of spatial planning also discussed in the final chapter.

1.3 Research Methodology and Literature Review

This section defines the evaluation techniques that are used in the thesis research and shows the general structure of the thesis. The content analysis (Stemler, 2001) approach has been used in the literature review on the concepts of smart city and the resilient city. After both research realms are followed by criticizing them one another for exploring if there is a connective ground for supporting NHR by SSM concept in spatial planning discipline.

The interrelation between resilient city and smart city and their reflection in natural hazard management process are evaluated in this research in forthcoming sections. It is important to find out how SSM approaches may increase the resilience and adaptive capacity of settlements in the face of uncertainty and increased risks of nature-based hazards. The scope of settlements in this research means both urban with peripheries and rural areas because these areas are interconnected to each other and not perceived as different in human settlements metabolism model (Newman, 1999).

The most critical point in the research is the meaning of smartness and smart approaches in SSM process. From the point of urban ecology, Newman introduced the metabolism model for human settlements, settlements have different dynamics, which are affecting the natural, social and economic resources, livability and waste created by settlements (1999). Alberti pointed out that protecting land and ecological patches in settlements may prevent natural hazards as well as support livability and control of waste in settlements. The spatial configuration and composition measures within landscape patches are beneficial approaches to evaluate the development of settlements with their impacts on environment (2005). The change of services that ecosystems provide and metabolism model of human settlements can affect supporting NHR from the perspective of urban ecology. This study is based on priorities defined in Sendai Framework for Disaster Risk Reduction (SFDRR). The operational

definition based on these priorities expresses a detailed approach to resilience building in settlements. The defined essentials have spatial, institutional, economic and social dimensions. This study will focus on spatial dimension and SSM. Figure 1.2 shows the structure of the research in a detailed manner with basic research hypothesis and research questions.

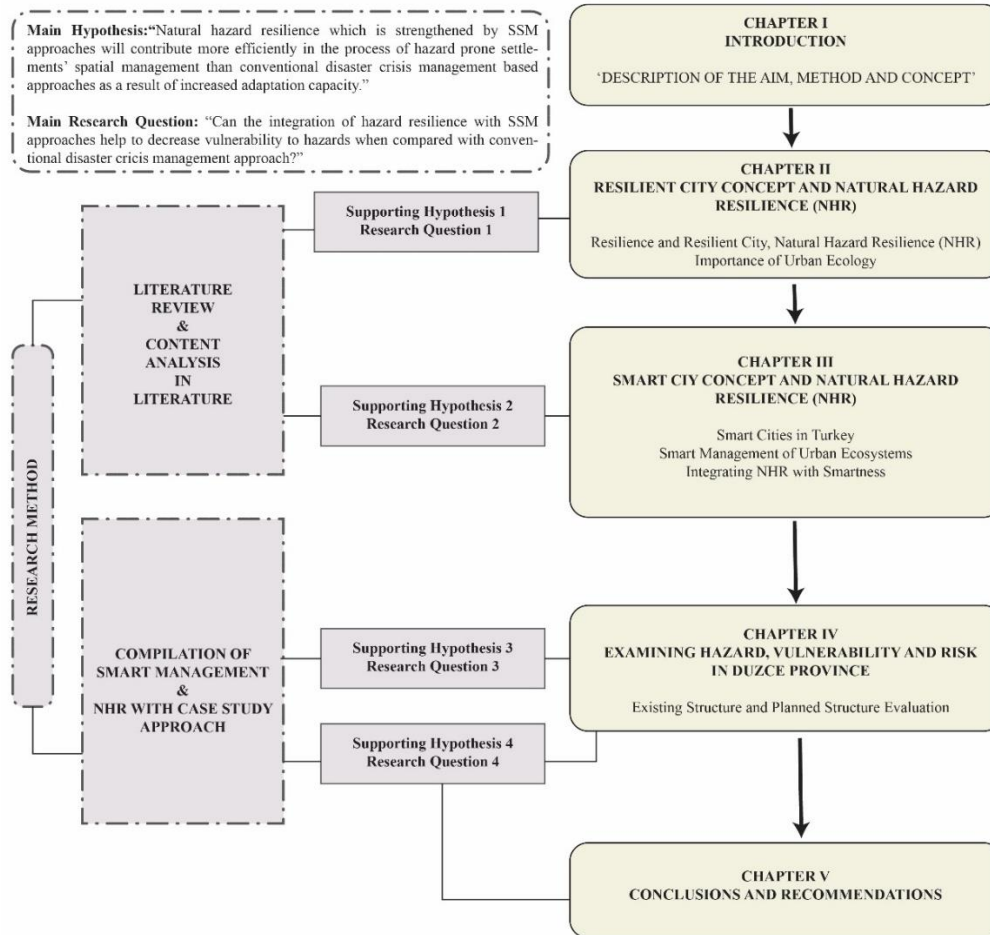


Figure 1. 2: Thesis flow chart.

As a primary research, content analysis in literature conducted with most cited articles in urban studies field for "smart city" and "resilient city" keywords in Web of Science database. Content analysis in selected articles analyzed by research subject and scope. First of all, the most cited articles analyzed in resilient city concept. These publications have been written between 2003 and 2017. As seen from Table 1.1, the subjects of early published papers were generally related to different dimensions of resilience such as economical, social, institutional etc. Hazard resilience subject was evolved through articles of Godschalk (2003), Prasad et al. (2009), Aerts et al. (2011), Agudelo-Vera et al. (2012), Lhomme et al. (2013), Jabareen (2013), Pickett et al.

(2014), de Jong et al. (2015) and Vona et al. (2016). The articles show basic tendency of resilience research in hazard area. All hazards can be classified as natural hazards which are earthquake, flood and climate change. In addition, there are publications which try to express the definition and scope of the concept.

Table 1. 1: Content analysis results for "resilient city" keyword (WOS, 2019).

Reference	Subject	Reference	Subject
Godschalk, 2003	Hazard Mitigation	Dieleman, 2013	Theoretical Research
Pickett et al., 2004	Ecological Resilience	Jabareen, 2013	Flood Resilience
Coaffee et al., 2008	Terror-resistant Cities	Suciu et al., 2013	Organizational Learning & Adaptation
Prasad et al., 2009	Resilience & Risk Management	Johnson & Blackburn, 2014	Social Psychology
Turner, 2009	Economic Resilience	Pickett et al., 2014	Hazard Resilience
Burch, 2009	Socio-Cultural & Institutional Resilience	Wakefield & Braun, 2014	Ecological Resilience
Wolfe, 2010	Economic Resilience	Vale, 2014	Governing the Resilient City
Bpuzarovski et al., 2011	Resilience by Urban Agriculture	Chang et al., 2014	Theoretical Research
Aerts et al., 2011	Flood Resilience	Papa et al., 2015	Theoretical Research
de Zeeuw et al., 2011	Social Resilience	Boulos et al., 2015	Climate Change
Brugman, 2012	Harvest Water & Energy	de Jong et al., 2015	Weather Resilient Cities
Agudelo-Vera et al., 2012	Climate Resilient City	Nakatani et al., 2015	Theoretical Research
Henstra, 2012	Economic Resilience	Vona et al., 2016	Seismic Resilience
Lhomme et al., 2013	Hazard Resilience	Spaans & Waterhout, 2017	Theoretical Research
Beatley & Newman, 2013	Theoretical Research	Kaika, 2017	Theoretical Research
Desouza & Flanery, 2013	Resilient Cloud-based Services	Zoomers et al., 2017	Theoretical Research
Stumpp, 2013	Biophilic Cities		

Another subject which is evaluated in content analysis is smart city. As seen from Table 1.2, the scope and subject area of the concept varies. Evaluated publications have been written between 1999 and 2017. The first source in smart city subject belongs to Mahizhnan (1999) and the publication is dealing with the improvement process of an intelligent city as smart city (Singapore) with the aim of increasing quality of life. Table 1.2 represents the subject from different dimensions, however, there are some publications trying to create an operational definition on smart city (Albino et al., 2015; Zubizerrata et al., 2016). The scope of the smart city varies institutional approaches to spatial approaches. Moreover, the spatial context of the

concept is not common when the table is analyzed. Angelidou (2014) was trying to accomplish spatial policies for future development while the others are mostly trying to create a new subject area in literature.

Table 1. 2: Content Analysis Results for "Smart City" Keyword (WOS, 2019).

Reference	Subject	Reference	Subject
Mahizhnan, 1999	Intelligent Cities	Crivello, 2015	Policy Mobility Analyzing
Fu, 2007	Smart Cafe Cities	Bolivar, 2015	Governance
Caragliu et al., 2011	Theoretical Research	Picon, 2015	Urban Intelligence
Allwinkle & Cruickshank, 2011	Smart City Explanation	Belanche et al., 2016	Urban Services
Leydestorff & Deakin, 2011	The Triple Helix Model	March & Ribera-Fumaz, 2016	Thoughts on Smart City
Hollander & Nemeth, 2011	Smart Decline	Battarra et al., 2016	Urban Planning Improvements
Kuk & Janssen, 2011	Smart Business Model	Wiig & Wyly, 2016	Smart City Politics
Leigh & Hoelzel, 2012	Industrial Development	Russo et al., 2016	European Plan for Smart City
Lombardi et al., 2012	The Triple Helix Model	Wiig, 2016	Smart Promotion rather than Smartness
Gibbs et al., 2013	Smart Growth	dos Santos, 2016	Environmental and Socio-economic Sustainability
Herrschel, 2013	Smart City Regionalism	Marsal-Llacuna et al., 2016	Theoretical Research
Neirotti et al., 2014	Smart City & Public Policies	Zubizerrata et al., 2016	European Smart Classification Standards
Vanolo, 2014	Theoretical Research	Anisimov et al., 2016	Application of Modern Technologies
Angelidou, 2014	Spatial Policy Development	Ahvenniemi et al., 2017	Sustainability
Debnath et al., 2014	Smart Transport Systems	Kaika, 2017	Public Opinion
Nowicka, 2014	Smart City Logistics	Anthopoulos, 2017	Learning the Meaning of Smart City
Luvisi & Lorenzini, 2014 <i>continued</i>	Radio Frequency Identification Devices	Buck & While, 2017	Competitive Urbanism
Albino et al., 2015	Measures of Smart City	Kummitha & Krutzen, 2017	Smart City Explanation
Angelidou, 2015	Urban Futures	Abella et al., 2017	Model of Value Creation in Smart Cities
McLaren & Agyeman, 2015	Sharing Cities	Mora et al., 2017	Theoretical Research
Anthopoulos, 2015	Smart City Explanation	Mosannenzadeh et al., 2017	Urban Energy Systems
Calzada & Cobo, 2015	10 Dimension Conceptual Framework	Anguluri & Narayanan, 2017	Green Space in Urban Planning
Stratigea et al., 2015	Participatory Planning Framework	Alizadeh, 2017	The Smarter Cities Challenge
Papa et al., 2015	Climate Change		

As the second part of review, the evolution of resilient city and smart city concepts and related keywords is searched in SCOPUS Database. The approach in the literature research is to analyze the most cited and related articles, book sections, books or conference proceedings with the content analysis technique to understand the main approaches of both concepts.

There is a change of the notion in the DRR in 21st century from Millennium Development Goals (2000) to Sustainable Development Goals (SDGs) (2015) in the United Nations; moreover, resilience of cities was literally clarified as a development goal, and one of the main goals for cities in SDGs is that “*making cities and human settlements inclusive, safe, resilient and sustainable*.”. Sharma and Chadrakanta (2019) expressed that The evolution and development of cities also changed with this notion change. Resilient city, smart city, world-class city, inclusive city and other terms have been emerged in time.

When the publication history for both city concepts is conducted in academic researches, Figure 1.3 shows the publication numbers of urban ecology, resilience and smart city keyworded publications between 1970 and 2018; while resilient city and smart and resilient city keyworded publications are illustrated in Figure 1.4 between 2000 and 2018 because these concepts have more recent roots. However, the publications increase after the second half of the 20th century in every area. Even though there are different approaches to resilience in different disciplines, the origination of the word comes from a Latin word “*resilio*” that has a meaning as “jump back” (Klein, Nicholls, and Thomalla 2003, 35; Manyena 2006, 433; as cited in Boin et al., 2010, p. 13). After the 2000s there is increasing attention to socio-ecological systems resilience (Adger et al., 2005; Folke, 2006; Brand and Jax, 2007), most of the studies have been conducted in recent years towards different pressures in cities: climate change, natural hazards, oil dependency, energy consumption and economy. After Hurricane Sandy in the US, there is a great focus on disaster resilience (Papa, Galderisi, Majello, & Saretta, 2015).

Smart city term is used in academic publications since 1997; moreover, 60% of the publications took place in the 2017-2018 period. Information and technology is a fundamental tool for raising attractiveness, efficiency, competitiveness among cities after 1990s (Papa et al., 2015). A resilient city is not as the common term as resilience in publications (Figure 1.4); however, after the emergence of the thought about the

resilience of socio-ecological systems, resilient city term started to appear in academic publications since 2003. Mileti defines local resiliency as “*Local resiliency with regard to disasters means that a locale is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life and without a large amount of assistance from outside the community*” (Mileti 1999, pp. 32–33). After that, the resilient city is named as sustainable web of human communities and social systems (Godschalk, 2003). Finally, there are 30 documents, which combine the two city concepts since 2014.

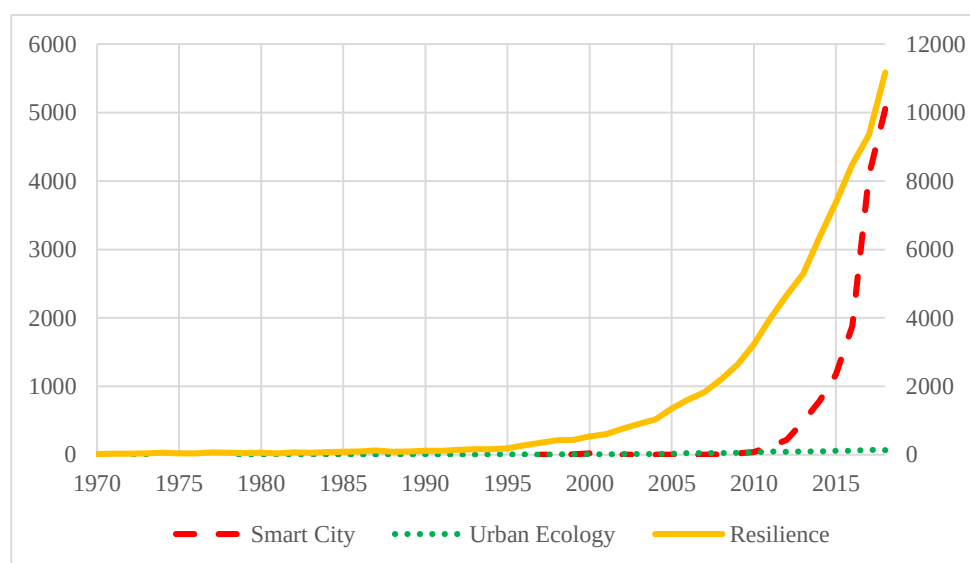


Figure 1. 3: Number of “resilience”, “smart city” and “urban ecology” keyworded publications in SCOPUS database between 1970 -2018 years.

The number of academic publications on “*urban ecology*” is 1372 since 1970 (Figure 1.3); besides, it is necessary to clarify that these publications are more coming from environmental and social sciences disciplines due to the context of the study. There are 141 publications since 1970 related to the context of the study. The fundamental explanation on planning of land use from the perspective of ecology and urban ecosystems is introduced in prominent researchers STA Pickett, ML Cadenasso, JM Grove, CH Nilon, RV Pouyat, WC Zipperer and R Costanza’s (2001) ‘Urban ecological systems: Linking terrestrial ecological, physical, and socio economic components of metropolitan areas’, J Niemelä’s (1999) ‘Ecology and Urban Planning’, Maria Alberti’s (2005) ‘The effects of urban patterns on ecosystem function’ and Peter Newman’s (1999) ‘Sustainability and cities: Extending the metabolism model’ articles.

The number of academic publications on “*resilience*” is 76905 since 1970 (Figure 1.3). Because resilience is very broad concept, it is needed to look at environmental sciences and social sciences literature, which have 29746 publications since 1970s. Despite high number of articles on resilience, following articles are considered within the context of the study. The basic explanation about resilience concept has been well introduced by the researchers Carl Folke, Steve Carpenter, Thomas Elmqvist, Lance Gunderson, CS Holling and Brian Walker (2002) in the prominent research titled ‘Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations’; Carl Folke, Stephen R. Carpenter, CS Holling and Ann Kinzig’s (2004) ‘Resilience, Adaptability and Transformability in Social-Ecological Systems’ and Carl Folke, Stephen R. Carpenter, Brian Walker, Marten Scheffer, Terry Chapin and Johan Röckström’s (2010) ‘Resilience Thinking: Integrating Resilience, Adaptability and Transformability’ articles.

The number of academic publications on “*resilient city*” is 392 since 2003 (Figure 1.4). A resilient city is a new emerging concept compared to resilience term in the literature. The study necessitates to focus on environmental and social sciences subject areas which have 265 publications; moreover, the fundamental statement about resilient city is well identified by the researchers David R. Gosschalk’s (2003) ‘Urban Hazard Mitigation: Creating Resilient Cities’; Kevin C. Desouza and Trevor H. Flanery’s (2013) ‘Designing, planning, and managing resilient cities: A conceptual framework’, and Sara Meerow, Joshua P. Newell and Melissa Stults’ (2016) ‘Defining Urban Resilience: A Review’ prominent articles.

While the number of academic publications on “*disaster resilience*” in all disciplines is 880 since 2000 (Figure 1.4); due to the context of the study, the publication number decreases into 439 papers when the search is narrowed within environmental sciences and social sciences. The basic explanation about smart city is well clarified in prominent researchers S. Bernard Manyana’s (2006) ‘The concept of resilience revisited’, Hongjian Zhou, Jing’ai Wang, Jinhong Wan and Huicong Jia’s (2010) ‘Resilience to natural hazards: a geographic perspective’, and Riyanti Djalante, Cameron Holley and Frank Thomalla’s (2011) ‘Adaptive Governance and Managing Resilience to Natural Hazards’ articles.

The number of academic publications on “*hazard resilience*” is 39 since 2007 (Figure 1.4). The study necessitates to focus on environmental and social sciences subject areas

which have 16 publications in number; moreover, the fundamental statement about hazard resilience is well identified in prominent researchers Fikret Berkes' (2007) 'Understanding uncertainty and reducing vulnerability: lessons from resilience thinking', Elizabeth C. Matthews, Meredith Sattler and Carol J. Friedland's (2014) 'A critical analysis of hazard resilience measures within sustainability assessment frameworks', and Hung-Chih Hung, Ching-Yi Yang, Chang-Yi Chien and Yi-Chung Liu's (2016) 'Building resilience: Mainstreaming community participation into integrated assessment of resilience to climatic hazards in metropolitan land use management' articles.

The number of academic publications on the "smart city" is 15195 since 1997 (Figure 1.3); furthermore, it is necessary to clarify that publications realized in environmental sciences and social sciences were taken into account due to the context of the study. There are 4861 publications in relation to smart city. The basic explanation about smart city is well clarified in prominent researchers Andrea Caragliu, Chiara Del Bo and Peter Nijkamp's (2011) 'Smart Cities in Europe', Michael Batty's (2013) 'Big Data, Smart Cities and City Planning' and Vito Albino, Umberto Berardi and Rosa Maria Dangelico's (2015) 'Smart Cities: Definitions, Dimensions, Performance, and Initiatives' articles.

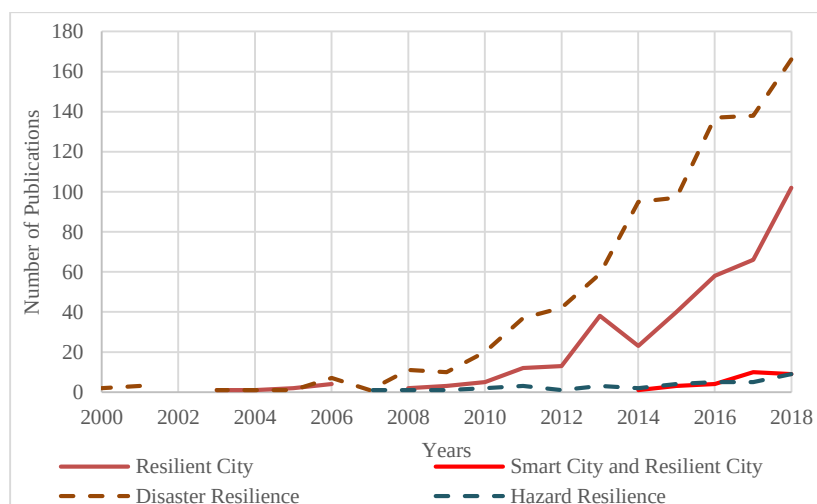


Figure 1. 4: Number of "resilient city", "disaster resilience", "hazard resilience" and "smart city and resilient city" keyworded publications in SCOPUS database between 2000-2018 years.

The number of academic publications on both "smart city and resilient city" is only 30 since 2014 (Figure 1.4); besides, it is necessary to clarify publications in environmental

sciences and social sciences study area due to the context of the study. There are 18 publications in these study areas on smart city and resilient city concept together. The fundamental explanation about both smart city and resilient is well clarified in prominent researchers Jing Pan's (2016) 'Smart Resilience: Resilience Dimension of Smart Cities', Y. Arafah, H. Winarso and D.S.A. Suroso's (2018) 'Towards Smart and Resilient City: A Conceptual Model', and Francesca Moraci, Maurizio Francesco Errigo, Celestina Fazio, Gianluca Burgio and Sante Foresta's (2018) 'Making Less Vulnerable Cities: Resilience as a New Paradigm of Smart Planning' articles.

In addition, it is necessary to explain the main perspectives in these 30 publications to understand the available collective literature about smart city and resilient city. Masutani (2014) explains the smart resilience surveillance system as a tool for resilient city management while Caragliu et al. (2015) only state the definition of smart cities. Cellucci et al. (2015) explains the importance of smart lighting and smart grid for developing a smart city with giving reference to resilient or durable infrastructure system; De Jong et al. (2015) stated the comprehensive analysis on twelve different city concepts; Kavehvasht (2016) sees smart traffic surveillance system for supporting resilient city; Pan (2016) expressed a real time hazard mapping module with smart approaches for assisting community resilience; Thomas et al. (2016) introduced the smart city literature as well as with public opinion; Zhao et al. (2016) put forth a computer-based group decision support system for resilient cities; Davison and Hand (2017) presented smart architectural development with utilization of Internet of Things (IoT) to sustain smarter buildings as well as smart and resilient cities; Deal et al. (2017) focused on socio-ecological resilience and use a planning support system to make connection between technological and socio-environmental systems to plan a more resilient city; Fu and Zhang (2017) also executed a bibliometric analysis for different urban development concepts; Gargiulo et al. (2017) saw innovative city planning as a tool for sustainable development; Grimes et al. (2017) introduced a guideline for resilience management, called as Smart Mature Resilience, towards natural disasters and environmental change; Hespanhol (2017) propounded antifragile cities from the theory of city resilience with digital mechanism approach; Hiller and Blanke (2017) introduced the resilience of privacy within smart city from the perspective of laws; Li et al. (2017) set forth that dimensions of city resilience contribute smart city building; Ng et al. (2017) proposed a data management tool for big data to smart, resilient and

sustainable planning; Vizvizi et al. (2017) presented debates on smart city and resilient city with their coping capacity towards migration related challenging issues; Arafah et al. (2018) provided a new approach for smart city and resilient city by executing five smart city models and identifying found resilient city components; Derickson (2018) presented smart city and resilient city as a promoter within recent development city trends from the perspective of urban governance; Fekete and Bogardi (2018) and Fekete and Fiedrich (2018) expressed hazard resilient cities supported by smart city perspective and innovative incentives for sustainable development; Hatuka et al. (2018) discussed the global, sustainable, resilient, creative, smart cities from the aspect of governance and citizenship; Lazariou and Roscia (2018) stated that cities ready from the perspective of smart energy as well as resilient, dynamic and sustainable; McKenney and Frey-Spurlock (2018) saw smart city and resilient city practices for in situ aging; Moraci et al. (2018) saw also resilience is main paradigm for smart and sustainable city, and proposed smart urban planning with the implementation through safe and resilient city; and Zoltan and Dora (2018) researched smart environment with the help of residential energy use, and, made relation between smart and resilient city and energy use for sustainability as well as well-being. Despite the publications in 2019 are not illustrated in figures, it is necessary to indicate the recent attempts in literature. Komninou et al. (2019) proved the emerging smart city development pattern with inclusive economy, resilient infrastructure, open data, and participatory governance; Rocrher and Köhler (2019) stated the integration of resource flows and infrastructure domains to reach more resource efficient, resilient and smart cities; Sharma and Chadrakanta (2019) showed that resilience term is firstly announced in SDGs and after that, new city development concepts have been emerged like smart city, resilient city, livable city, inclusive city and world-class city.

Despite the research on selected keywords has reached large numbers in time, it is an advantage to focus on related subject areas in relation to the aim of the thesis. From the Figure 1.5 and Figure 1.6 below and explanations before, the focus is environmental sciences and social sciences, which are relational study areas from literature.

If the analysis on keywords is conducted according to study areas, it is clear that 'hazard resilience' term has only 8 publications on social sciences while there are 15 publications on environmental sciences (SCOPUS, 2019). In both environmental

sciences and social sciences, study area the most cited paper is Tim Prior and Kristen Eriksen’s ‘wildfire preparedness, community cohesion, and social-ecological systems’. The aim of the paper is to find new approaches to adaptation to climate change based natural hazards creating enhanced resilience state towards wildfires with the support of social cohesion related society features and discovering the mitigation of effectiveness by the social aspect of SES (Prior & Eriksen, 2013).

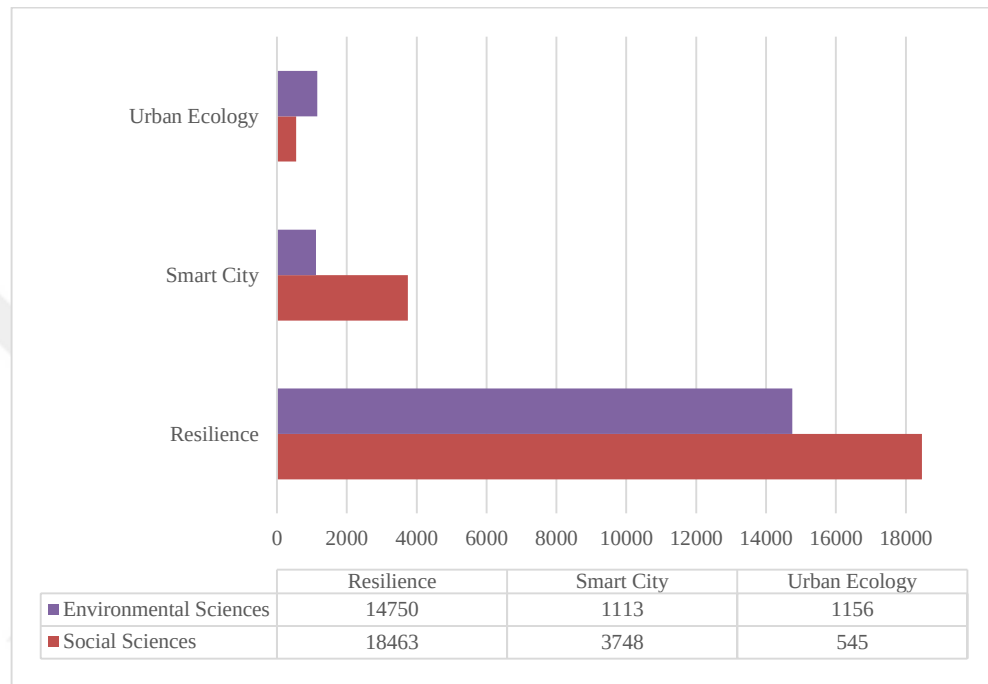


Figure 1. 5: Number of “urban ecology”, “smart city” and “resilience” keyworded publications in environmental and social sciences in SCOPUS database (2019).

Analysis of “*disaster resilience*” keyword shows that there are 319 publications on social sciences while there are 204 publications about environmental sciences (Scopus, 2019). Besides, in both environmental sciences and social sciences study area the most cited paper is Susan L. Cutter, Lindsey Barnes, Melissa Berry, Christopher Burton, Elijah Evans, Eric Tate and Jennifer Webb’s ‘A place-based model for understanding community resilience to natural disasters’. The main approach in the article is to propose a model which is called as Disaster Resilience of Place (DROP) for assessment of resilience to disasters either local or community level (Cutter et al., 2008).

The distribution of keywords by study areas shows that the highest publication number belong to resilience keyword in both study areas in Scopus Database. While there are 14750 publications on resilience in environmental sciences study area, there are 18463

publications in social sciences study area (SCOPUS, 2019; Figure 1.6). Because resilience is a broader concept, the most cited in social sciences study area is about psychology and it is not relevant to this study. The most cited paper in environmental sciences study area is Carl Folke's 'Resilience: the emergence of a perspective for social-ecological systems analyses'. The paper focuses on the evolutionary explanation of the resilience concept and making a bridge between the concept with socio-ecological systems (Folke, 2006).

Analysis of “*resilient city*” keyword shows that there are 319 publications on social sciences while there are 204 publications on environmental sciences (SCOPUS, 2019; Figure 1.6). Besides, in both environmental sciences and social sciences study areas the most cited paper is David R. Godschalk's 'Urban Hazard Mitigation: Creating Resilient Cities'. Godschalk (2003) mainly proposed in his paper extensive strategies aim to create resilient cities for hazards in urban area.

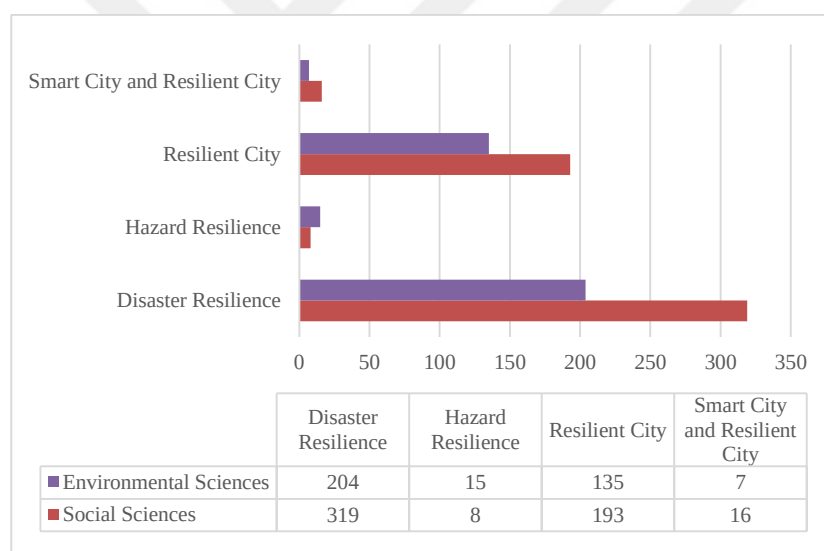


Figure 1. 6: Number of “disaster resilience”, “hazard resilience”, “resilient city” and “smart city and resilient city” keyworded publications in environmental and social sciences in SCOPUS database (2019).

The second highest publication number belongs to “*smart city*” keyworded publications in Scopus Database. While there are 1113 publication numbers in environmental sciences study area, on the other hand there are 3748 publications in social sciences study area (SCOPUS, 2019; Figure 1.5). When the number of publications and the distributions of the publications by study area examined, the number of publications about smart city concept increased recent years. Because the

smart city is another broad concept in different study areas like resilience concept, the most cited papers differ in two different study areas. While the most cited paper in environmental sciences study area is Pierluigi Mancarella's (2014) 'MES (multi-energy systems): An overview of concepts and evaluation models' titled paper focusing on the current assessment techniques and models with broad and crucial explanation to assess MES by DMG (distributed multi generation) systems; the most cited paper in social sciences study area is prepared by Robert G. Hollands' (2008) titled with 'Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?' which aims to clarify the labeling behavior of smart cities by prior thoughts/contrasts and provision of fundamental criticism towards few features of smart cities which is rhetorical in concept. It can be concluded here that papers in environmental sciences are more related to the physical environment than social sciences studies.

The search on "*resilient city and smart city*" keyworded publications are only 7 in environmental sciences on the other hand; there are 16 publications in the social sciences area (SCOPUS, 2019; Figure 1.6). While the most cited paper in environmental sciences study area is Martin de Jong, Simon Joss, Daan Schraven, Changije Zhan and Margot Weijnen's (2015) 'Sustainable-smart-resilient-low carbon-eco-knowledge cities; Making sense of a multitude of concepts promoting sustainable urbanization'; the most cited paper in the social sciences study area is Yang Fu and Xiaoling Zhang's (2017) 'Trajectory of urban sustainability concepts: A 35-year bibliometric analysis'. These articles mainly focus on recent urban development concepts and evolution of these concepts in the literature.

In addition to academic literature from the SCOPUS Database, the academic dissertation literature in Turkey does not differ from the international publications within the boundaries of theoretical and practical context. When the keywords searched from the database of National Thesis Center of Council of Higher Education of Turkey, there are dissertations which express concept of resilience and smartness. First of all, although there is only 1 dissertation on disaster & hazard resilience, this dissertation is not related to urban and regional planning discipline. Second, disaster & hazard resilience related thesis publications are only 8 in numbers; besides only one of them is related to business administration. The remaining dissertations are submitted in urban and regional planning area. Yalçınar (2002) developed an information system

to support earthquake resiliency. Yiğiter (2008) developed a GIS-based approach to integrate disaster management and information system. Aygün (2015) conducted a vulnerability and risk assessment for resiliency in response to climate change. Şirin (2016) proposed design criterias for resilient cities, on the other hand Akşit (2018) proposed a GIS-based site selection model to support resiliency to climate change. At the same time, Yaman-Galantini (2018) integrated urban resilience policies in to urban planning discipline. In the final dissertation related to urban and regional planning discipline, Adıktulu (2019) criticized lessons learned from urban regeneration to provide disaster resilience in settlements. All these explanations show that there are attempts to integrate smart tools into urban planning and disaster resilience (Yalçın, 2002; Yiğiter, 2008; Akşit, 2018), on the other hand the other dissertations deal with resilience as a response to climate change and disasters (Aygün, 2015; Şirin, 2016; Yaman-Galantini, 2018; Adıktulu, 2019).

Another inference from the dissertation database is that unlike the resilient city, disaster resilience, hazard resilience, smart and resilient city searches, there are many dissertations in smart city and resilience: 39 and 556 in total respectively. However, despite a high number of dissertations on these keywords there are only 8 dissertations on smart city and 24 dissertations on the resilience in urban and regional planning subject area. Economic resilience, resilience of SES, ecological resilience, social resilience and resilience to disasters are the main themes of the dissertations from the national database on resilience. Considering smart city concept from the national dissertation database, published dissertations mainly focus on the evaluation models, technical infrastructure, internet of things (IoT), lifeline systems and use of smart urban furnitures (National Thesis Center, 2019). As seen from the evaluation from National Thesis Center of Council of Higher Education of Turkey, any of the published dissertations is not focusing on the combination of the two urban development concepts, which are “smart city” and “resilient city”. To sum up, this study will contribute to recent academic literature from an important perspective on urban and regional planning agenda.

From the natural hazard resilience (NHR) perspective, the main theme of the study focus on theoretical explanation about “resilient city and hazard resilience” and “SSM”. As a first step, assessment of natural hazard resilience in accordance with smart measures supporting resilience or resilience measures supporting smartness was

difficult without drawing the connections and differences between these two concepts. Hatuka et al. (2018) pointed out the spatial features of emerging city concepts such as global city, sustainable city, resilient city and smart city. The spatial features of the resilient city are smart growth, compactness, high density while the features of the smart city are density, compactness, mixed-use and infrastructure development (Hatuka et al., 2018). While Neirotti et al. (2014) tackled with the domains of smart cities which are hard domains and soft domains (Neirotti et al., 2014), Matthews et al. (2014) dealt with resilience qualifications to hazards for assessment framework for sustainability, and, divided resilience measures into two basic categories: community resilience and structural resilience (Matthews et al., 2014).

Considering the explanation above, it can be concluded that there is limited number of publications, which considers the reflections in spatial planning, in smart city and resilient city concepts. To understand and clarify the evolution of resilience and smart city concepts, related literature research is a fundamental source. However, they can create a base for integration of these two urban development concepts and their assessments on the ground to provide a theoretical explanation on SSM to ensure NHR. SSM is a newly developing concept in smart city literature while NHR has its roots from literature as hazard resilience, disaster resilience, disaster mitigation etc. Approaches in SSM can support provision of NHR in settlements from this point of view.



2. RESILIENT CITY AND NATURAL HAZARD RESILIENCE (NHR) CONCEPTS

This chapter is dedicated to express resilience, resilient city and related approaches towards to better define the natural hazard resilience (NHR) concept. The section forwards the sub-hypothesis of the thesis study that is “*The uncertainty characteristic of hazards requires the resilience approach in settlements to overcome development problems*”, and it is targeting to reply the research question and sub-questions;

“How resilient city approach understood in urban ecology discipline in the face of natural hazards and recent urban development trends?”

What are the components of urban ecosystems?

What is the meaning of resilience?

How the concept evolved in time?

What is the meaning of disaster resilience and hazard resilience? Is it true to say that hazard resilience and disaster resilience have the same ground of notion?

What is the international agreements on DRR and resilience?

What is the main debate between resilience to natural hazards?”

This chapter maintains an analysis on resilience literature based on definitions, different aspects of concept and evolutionary explanation in time. The research was conducted with the keywords like “resilience”, “resilient city”, “disaster resilience”, “hazard resilience” and “natural hazard resilience”. Furthermore, the emergence of sustainability and resilience is discussed and resilience concept is dealt with from the perspective of NHR.

2.1 Resilience and Resilient City

The explanation on resilience and resilient city is maintained by an analysis of resilience literature based on definitions, different aspects of the concept in an evolutionary approach. The research was conducted with the keywords like

“resilience”, “resilient city”, “disaster resilience” “hazard resilience” and “natural hazard resilience”. Furthermore, the emergence of sustainability and resilience is discussed and the resilience concept is dealt with from the perspective of natural hazard resilience.

The aim of sustainable development was clarified as building and preserving economic, social and ecological systems. The emergence of resilience concept in literature conceived with the sustainable development concept, as social and ecological systems (SES) is behaving in a nonlinear way unlike engineering responses. Because these systems are more complex than engineering point of view. Sustainability, diversity and resilience of SES have a growing attention in case studies and these case studies show the clear connection among them (Folke et al., 2002).

In an etymological perspective, the origin of the word comes from a Latin word which is “*resilio*” that has a meaning as “jump back” (Klein, Nicholls, and Thomalla 2003; Manyena 2006; Boin et al., 2010). The resilience term improved since the 1950s in the fields of psychology to physics and ecology to the science of management; in addition, Holling (1973) was defined resilience from the perspective of ecology and clarified obvious segregation between ecological resilience and engineering resilience in 1990s (Papa et al., 2015). The literature research shows that the resilience notion originated mid-19th century in different disciplines (Scopus, 2019), the resilient city term acquired much attention just after Hurricane Sandy in the USA in 2012 (Figure 2.2).

The differentiation among keywords will help to understand the context of the resilience terms. There is a separation among reliability and resilience that is stated by Warrick (1982), resilience is expressed as the capability of a system in order to retain and jump back when the protection falls down; nevertheless, reliability is expressed as the constant policy of protection, which is formulated to invent secure systems.

Resilience term has been evolved related to spatial context since 1973, with support of ecologist CS Holing’s main contribution. He mainly criticizes with his definition of resilience that durability of a system to deal with disturbance without changing any steady state. After that, the dynamism of process, impossibility of bouncing back to original state have been considered in time. In this point of view, the meaning of resilience expressed as ability to cope with disturbance, and change of system if it is impossible to reach previous state of balance.

Table 2. 1: Definitions of resilience in different literature sources.

Reference	Definition
Holling, (1973)	<i>“A measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables.”</i>
Warrick, 1982; Janssen et al., 2006	<i>“The system assessment which is partly or completely of capability for absorbing and saving from a catastrophic adversity in the management of crisis and disaster.”</i>
Wildavsky, 1988	<i>“The capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back.”</i>
Luthar et al. 2000	<i>“A dynamic process encompassing positive adaptation within the context of significant adversity.”</i>
Gunderson & Holling, (2002)	<i>“The magnitude of disturbance that can be absorbed before the system changes its structure through variability.”</i>
Sutcliffe et al., 2003	<i>“The capacity to rebound from adversity strengthened and more resourceful.”</i>
Boin et.al., 2005; Boin et al., 2010	<i>“The capability of conversion in a proactive way and save from inconveniences which disturbs the steady state of system to decline the domain of ordinary and unforeseen inconveniences.”</i>
Walker et al., 2006	<i>“The ability of a system to absorb disturbance and still retain its basic function and structure.”</i>
Campanella, 2006	<i>“The capacity of a city to face devastating event reducing damage at minimum.”</i>
Birklan, 2010	<i>“The capacity for collective decision making both during and immediately after the onset of a crisis.”</i>
UNISDR, 2010	<i>“The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions.”</i>

The change of different definitions requires an alteration of approach in dealing with natural hazards. As a result, there was division among proactive resilience and reactive resilience within reaction to natural hazards. Reactive resilience advances focus on creating a strong system which is sound to alterations and strengthening the current situation of the society when the future is considered; however, proactive resilience advances approve the unavailability of the alteration and examine the system which able to follow altered situation and necessities (Klein, Nichols, and Thomalla 2003, 39; Bruijne et al, 2010). These explanations show the changing behavior of uncertainties and a structural change when a community faced a natural hazard.

World Bank (2007) expressed the combination of adaptation and mitigation as necessary to develop an efficient reaction to climate change in the province scale; in addition, it is not wrong to clarify that natural hazards can be in the same group with climate change and it requires a combined approach in multi-scales.

Organizational learning (Dieleman, 2013), the concept of learning through experience and adaptation (Godschalk, 2003) represented the experimental and proactive status of resilience. Resilience research focused on different perspectives throughout its evolution such as; a reaction to ecological difficulties, management of disasters and hazards, dealing with shocks in the growth of economies at urban and regional scales and supporting resilience with institutions and urban governance (Leickhenko, 2011).

As expressed before, different definitions and approaches about resilience, and, the evolution of the resilience can be followed through definitions. After the 2000s, there is an increasing attention to SES resilience (Adger et al., 2005; Folke, 2006); besides, the focus on resilient cities was increased after the emergence of SES resilience. Brown et al. (2012) and some other scholars clarify that urban resilience concept have to focus mainly raising adaptive capacity instead of specific adaptation measures in the era of climate change (Meerow et al., 2016). Resilience concept create a space for understanding SES and their sustainable development towards climate change, in particular (Meerow, Newell, & Stults, 2016); however, the disturbances cannot be degraded only climate change; moreover, there are different types of disturbances such as human-induced threats, natural threats and urban development.

When the subject is about adaptation to changes, it is critical to deal with resource management in settlements. Resource management in urban areas is vital criteria for the design of forthcoming cities toward resilient cities (Agudelo-Vera, 2012). The provision and maintenance of natural characteristics and systems of urban areas result from the beneficiaries of resilience; besides, a city's or region's green infrastructure ensured important services which make possible for urban regions and cities bounce back from and respond to natural hazards and climatic events. The protection of these types of larger ecological systems expressed as riparian areas and rivers, wetlands, floodplains and forest land is an important step for provision of a more hazard resilient condition of settlements. Tree canopy presence, preservation, and restoration of streams and rivers in urban areas will help to decrease the vulnerability in the climate change era (Beatley & Newman, 2013). The extinction of natural land cover results in

flood and erosion event in urban areas; moreover, it also causes an increasing effect of urban heat island and concentrates run-off of storm-water (Burayidi, 2015a).

Governing the ecological system practices shall accordingly be developed together with building these systems more alterable and more adjustable, capable of overcome shock and uncertainty, constructing the capability of system transcribing to alteration. The framework is prescribed as adaptive management and it consists of policies like near and steady observation, repetitive knowledge, detecting through experience and trial (Scoones, 1999; Boin et al., 2010, p. 18).

Like Newman (1999) expressed in metabolism model, cities are spaces for adaptive and complex systems (Batty, 2008; Godschalk, 2003). There are different types of efforts, which focus on preparedness for natural disasters (Tierney, Lindell and Perry, 2011), measures for hazard mitigation (Godschalk, 2003), social learning for disasters (Norris et al., 2008; Paton & Johnson, 2001), planning approaches (Auf der Heide, 2006) and models for land use to decrease the effects of natural hazards (Sands et al., 2015, p.207). Theorizing urban systems as socio-technical and socio-ecological, adaptive and complex systems goes beyond spatial scale at multiple levels. The roots of modern resilience idea belong to Holling (1996) with the ecology perspective. However, the evolution of resilience thought is followed by other considerations on natural disasters and management of natural hazard risks, adaptation to climate change, engineering, international development, planning and energy systems. There are many definitions for introducing resilience in different subject areas; nonetheless, all definitions point out one broad notion of *“coping capability of urban systems when they face in an adversity”* (Meerow et al., 2016).

The management of resources is critical for adaptation and resilience building; however, urban resilience is also influenced through the physical structure and form of a city, the availability of social capital, the structure of governance as well as through the situation in the adaptive cycle (Burayidi, 2015). Resilience includes the capability of overcoming unpredictable distress apart from the regular controlling situations in a theoretical approach. When the system is faced in distress, the system sustains to operate. In the overcoming stage, improve new abilities, which raise the possibility of being successful in the near future (van Eeten et al., 2010).

The adaptive cycle of a complicated systems can be explained with multi-actor, multi-scalar and transient drivers of shift. Gunderson and Holling (2002) utilized from the

adaptive cycle, which is a structure in order to show the progress and organic conversion of complicated socio-ecological systems. The adaptive cycle framework consists of four stages representing diverse resilience level in every stage in the SES. These stages contain a period about exploitation and growth (r), a period of conservation (k), a period of release and collapse (Ω) and a period about reorganization and renewal (α) (Gunderson and Holling, 2002).

As Chadha et al. (2007) clarified that natural hazards are probable disasters if appropriate mitigation precautions have not developed. Dynamic resilience is enhanced through adjustment and adaptation to hazards both natural and human-made, and, disaster learning from the view of adaptive cycle theory of Holling (2011; Zhou, Wang, Wan, & Jia, 2010). The idea of resilience gains importance after these developments and features of resilient cities started to become more important.

Rockefeller Foundation's 100 Resilient Cities Framework defined the attributes of resilient systems/cities which are expressed as resourceful, integrated, inclusive, redundant, robust, reflective and flexible (Url-2). Attributes of resilient cities are explained below:

- Resourceful means the identification of different ways in the utilization of resources
- Integrated means the collection of diverse institutions and systems
- Inclusive means the prioritization of vast information to form a participated system in decision making
- Redundant means the intentionally developed backup resources to deal with disconnection
- Robust means the controlled, constructed and well-comprehended systems
- Reflective means the utilization of previous knowledge to guide forthcoming improvements
- Finally, flexible means the capability to assimilate different strategies as a response in a changing situation (Url-2).

Therefore, Womsler et al. (2013) clarified the conditions of resilient cities by defining resilient city as the ones having a control for assisting precautions for strengthening institutions, individuals and communities in order to:

- decrease or prevent recent and forthcoming hazards,
- decrease or prevent recent and forthcoming sensitivity for leaning hazards,
- construct a working structure and mechanism aiming response to disasters,
- construct a working structure and mechanism aiming for recovery from disasters.

To sum up, resilient city paradigm has been evolved through the idea of dealing with hazards/disasters and being adapted to these stresses. Cities are expressed as complex adaptive systems and it is needed to control all dynamics at all scales in cities to improve resiliency of the system. Moreover, it is needed to manage these sorts of systems with adaptive cycle process which are interpreted by Gunderson and Holling with multi-scalar interactions that can fit the management of urban systems and human ecosystems together (2002). Moreover, the cycle mainly focused on reorganization continuum in a multi-relational manner. If the system encounters an adversity or stress, the stages of release and renewal from adaptive cycle process will be more resilient when system is ready for any stress.

2.2 Conceptual Assessments of Hazard and Disaster Resilience

Meaning of disaster and hazard is a confusing subject in the literature and sometimes disaster is used as in the meaning of hazard. Hazard is defined as the natural, technologic, and human-made events or series of events that have the potential of causing loss of lives and damaging on socio-economic assets and order of society and its activities, natural environment and sources of nature (Kadioğlu, 2015). Disaster, on the other hand, is described as the natural, technologic and human-made events resulting with devastating impacts such as cause loss of human life, physical, economic and social losses, or, affecting society by disrupting normal life situations without the local capacities to overcome (Kadioğlu, 2015). It can be concluded that the availability of loss and the probability of loss is important for understanding the difference

between disaster and hazard. Moreover, Boin et al. (2005) shortly explain the disaster as “*a shock with an unexpected result.*”

Akyel (2005) clarified the types of hazard in his article “*Disaster Management in Turkish Public Management System*”. Hazards can be grouped into three basic categories according to their sources: natural hazards, technological & human-induced hazards and conflict-induced hazards. Natural hazards are defined as earthquake, storm, tornado, flood, volcanic eruption and naturally occurred forest fires; moreover, natural hazards/disasters also divided into two groups: slowly developed and sudden hazards/disasters. Suddenly developed hazards/disasters can be expressed as flood, earthquake, sound wind, landslide, tsunami and volcanic movements while slowly developing hazards/disasters can be clarified as erosion and drought (Ural, 1996). Technological and human-induced hazards/disasters are expressed as nuclear accidents, industrial accidents, plane crashes, mining accidents, ship accidents and pipeline explosions while conflict-induced hazards/disasters are expressed as war and terrorist attacks (Akyel, 2005).

Stevenson et al. (2015) expressed the idea that the awareness of society about past disasters and possible adversities is not enough for the hazard mitigation process. There is always a possibility of facing a catastrophe in changing world with changing dynamics. As Clarke (2006) expressed the idea that events with high impact and low chance may have catastrophic adversities (Clarke, 2006; Boin, 2010). Additionally, UN (2015b) expresses that climate change has been increasing the frequency of hazards and their negative impacts on societies. It is clear that, natural hazards are extreme and occurring with higher frequencies and their impacts in the future will be more severe all around the globe.

The preparation process to hazards is vital when it is considered that it is not possible to prevent whole disasters. The main issue here is about the capability of mitigation methods about recovering from destructive circumstances and decreasing the range of destruction. Resilience development for potential hazardous events provide wise approaches for encountering indefinite dangers (Boin et al., 2010).

While there are various restrictions on implementation, creating a sustainable development can boost the adaptation and mitigation capacity, decrease emissions and vulnerability. Mitigation consists of actions, which decrease the violence of forthcoming disasters; moreover, these actions contain structural mitigation activities

defined as maintaining zoning order, building codes in the city; non-structural mitigation activities defined as an improvement of public awareness timetables (Prasad et al., 2009).

Thinking disaster process comprehensively is beneficial for the rising debates about resilience. Rather than considering the steps of the disaster cycle, that are mitigation, response, preparedness, and recovery, kind of separate stages of the cycle of disaster; however, it should be considered like different directions of the structure that assists or impedes resilience (Birkland, 2010).

Mitigation is analyzed by two main groups in general. These groups are expressed as non-structural mitigation measures and structural mitigation measures. Philip Ganderton suggests a practical and precise explanation that separates criteria of mitigation as process and project mitigation. While project mitigation includes the construction of resistant structures to natural stresses like floodwalls and levees, process mitigation implies the use of procedural instruments for changing the response of actors in mitigation practices. The behavior of actors will therefore encourage and not sabotage objectives of not only community level and regional level but also the national level. Process mitigation consists of arrangements aiming to decrease the vulnerability of a neighborhood, a building or a site as well as providing the reliance of society by codes of building, planning, and zoning. Besides, the evaluation of consequences differs from each other in project and process mitigation efforts. Consequences of project mitigation are evaluated in an easy way in contrast to the consequences of process mitigation (Mason, 2006; Boin et al., 2010).

In the preparedness phase mainly focused on mitigation efforts, it is crucial to take provisional steps to restrict the size of harm if a disaster strikes. There are some efforts including structural provisions like levees and seawalls, land use planning (Masterson et al., 2014) and regulation development (Atkinson, 2014) on fireproof construction materials and seismic codes. However, it is also the important part in the preparedness phase to determine the place, time and size of reinforcement. The limitation of technological developments caused by political and economic conditions. For instance, the implementation of stringent codes for buildings is hard because of the economic status of society and poor regulatory framework in distressed countries (Sands et al., 2015).

The information of early disaster can contribute to the reduction of risks to a hazard and improvement of the process of recovery after adversity. There are some conclusions for the pre-disaster and post-disaster operations for adverse events. First of all, a hazard assessment before a disaster can inform decision-makers about possible risks and increase their capability to deal with those risks. The inclusion of gathered data in the construction sector can, therefore, raise the resilience level of the buildings. As a second conclusion, the combination of vulnerability reduction and mitigation to post-disaster planning can have some benefits and costs, which can be social, economic or political. The identification of disaster-prone areas and residential land use zoning according to these areas both decrease the public and private exposure into further corruptions and maintain the resident and markets by boosting their feeling of security and certainty when they thought their choices about recovery process (Stevenson et al., 2015).

The third stage of natural hazard management system handles the attempts in order to guide the restart of normal action level before disasters. As expressed in literature, there is no series of principles to distinguish two phases from each other: '*response*' and '*early recovery*'. The disparity might be compared by the segregation attempts for '*rescue and search*' and attempts for '*recovery and search*'. The fundamental emphasis switched from rescuing lives to maintaining a fast restart for main economic and social functions (Sands et al., 2015). Hazard management system and its resiliency is controlled through defined phases; preparedness, mitigation, response and recovery; however, there is a requirement to develop a broader and defined steps and their reflection on urban planning and policy development.

Planning is a vital part of every phase of environmental disaster management process including preparedness, response, first recovery and construction in long-term. Even though appropriate methodologies of planning have been evolved (for instance, Masterson et al., 2014), the real responses of methodologies of planning are possible to show insufficiency because of required planning attempts which contain advanced decision making beneath excessive uncertainty conditions. Previous plans, as well as the best ones, will inevitably be finalized with missed chances and mistakes. The process of working together in society in a disaster situation will bring new opportunities; therefore, there will also be foreclosed options. As a result, the

inevitable part of the process should be based on flexibility and adaptation (Sands et al., 2015).

The examples provided from the literature show that all phases of natural disasters as important as any other phase. The influences are therefore considered as cumulative, meaning the deficiency in the preparedness phase can cause a fluctuation in another phase. The setup process of temporary housing and other needs and return process to renovated regions is vital for survived victims of the disaster. In conclusion, cautious planning of reconstruction might develop resilience and decrease the vulnerability of the society against disasters for the future (Sands et al., 2015).

In addition, five primary elements supply a hazard resilient system. The first one is new entity elements are sound and capable of resistance to damage. Second element is about engagement of lifeline organizations to cooperative planning for figuring out the possible effect of different lifeline systems' turnovers and formulation of new functioning systems in order to sustain. The third factor mainly focuses on the availability of joint support contracts between supplier of lifelines. Another element figures out the broad cover of insurance that providers of lifelines have. The last is about the preparedness culture of overarching, which is adjusted through adaptive and highly educated human resources, within lifelines organizations (Stevenson et al., 2015). The idea of being disaster resilient is described here as being structurally and organizationally resilient in terms of lifeline systems and vital infrastructures in this context.

Resilience building in response to natural hazards results in improvement and promotion of organizations, mechanisms, and capabilities at all stages, especially at community scale; unification of risk decreasing approaches onto application and design of preparedness to emergency, response and recovery for the reconstruction of influenced societies in a systematic way (Prasad et al., 2009).

The continuum of climate resilient city is identified by Henstra (2012) as hazard, vulnerability and risk assessment, increasing community awareness and knowledge of weather-related risks, risk-appropriate land use planning and infrastructure protection and emergency management.

According to Tezer et al. (2016) hazard mitigation process consists of hazard identification, vulnerability and risk assessment, emergency management and

response & recovery. Identification of hazards is starting point of the mitigation process. Jha et al (2013) expressed the identification process as collection and analysis of natural hazard data. Moreover, the data can be obtained by probabilistic hazard models for seismic hazards, historical hazard catalogues and geomorphological data about place. Mapping all hazards and probabilities is also recommended for better understanding. Assessing vulnerability can be possible with knowing the population under the risk of hazard and their belongings. Finally, risk assessment can be seen as a comprehensive evaluation of all these data. In risk assessment, hazard prone areas and vulnerabilities have to be assessed together and the capability to overcome natural hazards is fundamental outcome of the process.

2.3 Global Urbanization and International Agreements on Resilience and Disaster Risk Reduction

According to UN, the spatial expansion of urban areas is continuing and 1.5 times faster than the growth of population. Thus, the necessity of better solutions on spatial planning and more effective transportation arrangements in urban areas need to be highlighted for supporting and making settlements safer, more resilient and inclusive as well as sustainable. Furthermore, the loss of lives and damages on settlements as a consequence of natural disasters have an unprecedented increase in between 1990 and 2013. At the same time, the number of people living in slums increased too, in between 2000-2014 (UN, 2018). This data show that settlements still need to improve better spatial land management policies and tools to overcome these problems. Especially, as urbanized areas being the prominent in size of human populations, economic resources and diverse technological opportunities, they need to be more resilient to sustain their resources and human capital.

The pronounced acceptance of sustainable development dates back to 1987 with the Brundtland Report: “Our Common Future; a Report of the World Commission on Environment and Development” before the Earth Summit in 1992 in Rio de Janeiro where the adoption of Agenda 21 which was an action plan based on global participation to develop life of people and to preserve natural resources with support of 178 countries around the world. The other attempts for sustainable development in response to poverty, rapid urbanization and economic development were in Habitat II in 1996, followed by Millennium Development Goals (MDGs, 2015). Disaster related

global agreements took significance afterwards as a result of the increase of extreme and more frequent natural disasters with devastating impacts on human lives and settlements. The global commitments are Hyogo Framework for Action in between 2005-2015, Transforming Our World: 2030 Agenda for Sustainable Development (with 17 Sustainable Development Goals –SDGs and 169 related targets-), Sendai Framework for Disaster Risk Reduction (2015), Addis Ababa Action Agenda on Financing for Development (2015), and Paris Agreement on Climate Change (2015). The year, 2015 is very important for setting transnational policies and multilateralism based on SDGs, which is about few thematic issues such as oceans, transport, energy, technology and science, climate and water (Url-1, 2015).

Transforming Our World – The 2030 Agenda for Sustainable Development is a comprehensive action plan shaping the universal agenda with its 17 SDGs and 169 related targets (Figure 2.1) by focusing on planet, people, prosperity, partnership and peace. Moreover, the document expressed natural resource depletion, land degradation, intense and frequent disasters as well as climate change some of the most important challenges the world was faced (UN, 2015a). One of the goals is related to sustainable communities and cities, which is defined as “*Goal 11. Make cities and human settlement inclusive, safe, resilient and sustainable.*” The implementation of integrated plans and policies against efficiency of resources, climate change adaptation, disaster resilience and inclusion with respect to *Sendai Framework for Disaster Risk Reduction 2015-2030* can be provided by management of risks to disasters in all stages. Due to all changes in climatic structure and natural resources as a result of climate change and development patterns, DRR management is critical (UN, 2015a).

The focus on disaster risks reduction was firstly put forward with the *International Framework for Action for the International Decade for Natural Disaster Reduction in 1989* and after *Yokohama Strategy* in 1994 followed this with the aim of resilience building and sustainable development (Url-9). Furthermore, existing challenges were identified in five categories such as governance, preparedness, risk identification, evaluation, observing & early notice, management of knowledge and reduction of risk factors. After the organization of disaster risk reduction (DRR) conference in 2005, *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters* was documented, and, five priorities were defined as;



Figure 2. 1: UN's sustainable development goals (2015) (Url-1).

enabling risk reduction as a necessity at both local and national level; identification, assessment, observation of risks and provision of early notice systems; utilization of information, education and innovation for the construction of resilience and safety in all stages; reduction of fundamental risk elements; finally, consolidation to preparedness to disaster for a beneficial response in all stages (UN, 2005).

After Hyogo Framework for Action, the *Sendai Framework for Disaster Risk Reduction in between 2005-2015* released in the Third United Nations World Conference on DRR in 2015 with four priorities: understand risk to disasters, strengthen governance to disaster risks to control disaster risk, invest in reduction of disaster risk aiming resilience, and, enhance preparedness to disasters for beneficial response, recovery, reclamation and reconstruction. SFDRR agreement emphasizes the rise of extreme events due to climate change in recent years. All policy development frameworks in the world focused on the challenges created by climate change, and its influences. United Nations International Strategy for DRR was clearly clarified the dominant influences of climate change and its consequences, while the capability to deal with all these externalities will be provided by resilience thinking (UN, 2015b).

2.4 Natural Hazard Resilience (NHR)

NHR in the literature was only focused on definition and relevant ideas with sustainability. Roostaie et al. (2019) expressed the evolution of sustainability and resilience paradigms through assessment frameworks for sustainability. Building

resilience through environmental efforts is also more beneficial and cost effective (Beatley & Newman, 2013; Alberti, 2005). United States cope with natural hazards that cause loss of life and money year by year; furthermore, the concept of resilience as a response to natural hazards is a new trend while dealing with climate based natural stresses and regime shifts. There is only one publication available when SCOPUS database searched for “natural hazard resilience” keyworded publications; thus, the focus on NHR is more limited and only document cannot define the characteristics of resilient settlements to natural hazards, but the document analyzes sustainability and resilience paradigm based on sustainability assessment frameworks. Despite there is one publication on NHR, the subject has been taken into consideration with different terms; disaster resilience, hazard resilience, disaster mitigation etc. Finally, the publication states the differences, resemblances and integration between sustainability and resilience paradigms. However, this study is focused on the assessment of NHR in settlements.

Current disaster management system deals with some steps when the management of hazards and their reflection on urban planning come to the discussion on hazard resilience. These steps are defined as hazard identification, vulnerability and risk assessment, mitigation of risks and monitoring (Tezer et al., 2016). Dealing with natural hazards is a critical issue in the era of climate change; UNISDR (2012) was therefore expressed that climate change stimulates intense events and raises the exposure with climate based hazard vulnerability (2012; Hung et al., 2016). As explained before, recent efforts at international level like HFA and SFDRR 2015-2030 aim to deal with risk of natural hazards/disasters through resilient community building (UN, 2005; UN, 2015); moreover, Intergovernmental Panel on Climate Change (IPCC) clarified the approaches for resilience building that sustainable, integrated and flexible approaches can help to build resilience in response to climate change risks and extreme events in local level (IPCC, 2012).

As Djalante et al. (2011) described one of the most forced international environmental change problem as natural hazards which is severe, intense and highly frequent; thus, there was a focus at all levels on resilience building as a response to natural hazards all over the globe. There are different definitions on community resilience, disaster resilience, hazard resilience, resilient governance, climate change resilience in recent studies. Nonetheless, because of the focus related to climate change and global

environmental problem concern, there is a need to define NHR in the era of climate change in urban areas.

As a result of all things considered above, NHR can be defined as the capability of a complex and integrated system to resist, overcome, adapt and recover from natural hazards as soon as possible without structural, functional and identical change. The identification of hazard prone areas, risks and vulnerabilities are critical for creating a sound resilient system in response to natural hazards meaning NHR. Godschalk (2003) have clarified the attributes of hazard resilience as diverse, redundant, strong, autonomous, collaborative, efficient, and interdependent. The attributes of resilience in hazard management system are;

- diversity – provision of several activities and functions within the system
- redundant – provision of related activities and functions within the system
- strong – capacity to withstand any stress
- autonomous – capacity to utilize outside of the system in an independent way
- collaborative – provision of public participation
- efficient – provision of positive rate between supplied and delivered energy
- interdependent – provision of connected elements that nourishing each other (Godschalk, 2003).

The approach to natural hazard resilience should start from national level for an effective implementation (Cutter et al., 2013; Djalante et al., 2011); thus, the management system supporting NHR should be defined in detail. Godschalk (2003) expressed that early disaster management efforts are more concentrated on recovery, response stages after a disaster and structural measures, on the other hand mitigation and preparedness stages is important for resilience building in the long run. The attributes of hazard management system therefore define the elements of the NHR; as there is no change in hazard management system components in time. A NHR settlement should be diverse, redundant, strong, autonomous, collaborative, efficient, and interdependent; furthermore, the management system should support these attributes. The scope of attributes consists of natural environment, built-up environment and socio-economic environment when the supporting activities considered in the process.

Hazard resilience approaches more focused on climate based hazards/disasters, and, the participation of the community was strongly recommended within the recent study approaches. The management of land use, participation of the people and their reflection on urban planning is vital when the management of hazards considered in settlements. Hung et al. (2016) and Cutter et al. (2008) have proposed qualifications of the resilience building in response to natural hazards from the perspective of urban planning and community participation. UNISDR also defined the qualifications, which measures the compliance of activities with goals of HFA and SFDRR (UN, 2005; UN, 2015b).

SFDRR defined 4 priorities to deal with DRR. These priorities are;

- understanding disaster risk,
- strengthening disaster risk governance,
- investing in DRR for resilience and
- enhancing disaster preparedness for effective responses to “Build Back Better” in recovery and rehabilitation and reconstruction.

The first, second and fourth priorities are related with land management and spatial organization while the third priority of the SFDRR is dealing with economic side of the DRR. UNISDR proposes an operational structure to provide resilience in cities at local scale based on SFDRR. This structure is called as “*The Ten Essentials for Making Cities Resilient*”.

UNISDR (2015) created a toolkit based on SFDRR for building resilience, on the other hands the dimension of defined essentials is expressed in Table 2.2. According to the table, dimensions are grouped as spatial, institutional, economic and social. The assessment of Essential 2 is provided by identification of most severe and probable scenarios and utilization of information from those for decision-making activities. The assessment of Essential 4 is provided by putting land use management and urban planning at the center of urban resilience, conducting specific and systemic mapping of vulnerability and mainstreaming resilience into master plans and development strategies. The provision of Essential 5 is enabled by raising awareness on ecosystem degradation and environmental change, promoting management of vital ecosystems for strengthening resilience to disasters and strengthening management of ecosystems based on scenarios on risks. The assessment of Essential 8 is provided by assessing

critical infrastructures in terms of adequacy and capability, strengthening infrastructures at critical locations, establishing commitments between environmental organizations and private sector. Finally, the provision of Essential 9 is enabled by creating and improving plans for preparedness, strengthening early warning systems and upgrading services for emergency response. This study will be focused on the spatial dimension related essentials. The process will be followed by hazard identification, vulnerability and risk assessment, which can give the information about current situation of the area about hazards and hotspots. However, the assessment of the planned structure of the city and comparison with current structure is also vital for stating the sustainability and resilience of settlements.

Table 2. 2: Ten essentials for making cities resilient (UNISDR, 2015).

Essentials	Dimension
Essential 1: Organize for Disaster Resilience	Institutional
Essential 2: Identify, Understand and Use Current and Future Risk Scenarios	Spatial
Essential 3: Strengthen Financial Capacity for Resilience	Economic
Essential 4: Pursue Resilient Urban Development And Design	Spatial
Essential 5: Safeguard Natural Buffers to Enhance Ecosystems' Protective Functions	Spatial
Essential 6: Strengthen Institutional Capacity for Resilience	Institutional
Essential 7: Understand and Strengthen Societal Capacity for Resilience	Social
Essential 8: Increase Infrastructure Resilience	Spatial
Essential 9: Ensure Effective Disaster Response	Spatial-Institutional
Essential 10: Expedite Recovery and Build Back Better	Spatial

2.5 NHR from the Perspective of Urban Ecology

In resilience literature, building resilience to hazards can be provided by adaptation measures (Brown et al., 2012); moreover, the adaptation of the settlements can be conceived by resource management because it is an easy way to provide resilience at lower interventions on it (Beatley & Newman, 2013; Alberti, 2005). Because of this, there is a need to focus on ecological planning to understand the relations in environmental systems to increase resiliency to natural hazards.

Urban ecology deals with the efficient use of resources and minimizing risks coming from the nature in a complex SES. The protection of habitats and control of biodiversity within different land uses like regional parks is fundamental concern (Niemela, 1999). The occurrence of disturbances both natural and unprecedented

results from increased population. Unlike natural ecosystems, urban ecosystems require high amount of energy and raw material with extensive capacity to deal with waste and emissions (Alberti, 2005).

Newman (1999) asserted that, From the perspective of metabolism model, settlements consist of three basic components as inputs, settlement dynamics and outputs (Figure 2.2). Resource inputs are expressed as water, food, land, energy, building material and other resources, while settlement dynamics are related to transport, cultural dynamics and economy. Outputs are in two basic categories representing livability and waste outputs. Livability depends on health, employment, income, education, leisure activity, accessibility, housing, community and quality of urban design while waste outputs consist of wastewater and solid waste, toxic materials, sewage, noise, heat of waste, green house gases (GHG) emissions and air pollution. That kind of settlements can be interpreted as complex and dynamic ecosystems like cities. The way of looking cities within this framework may ease dealing with the changes in the ecosystems (1999).

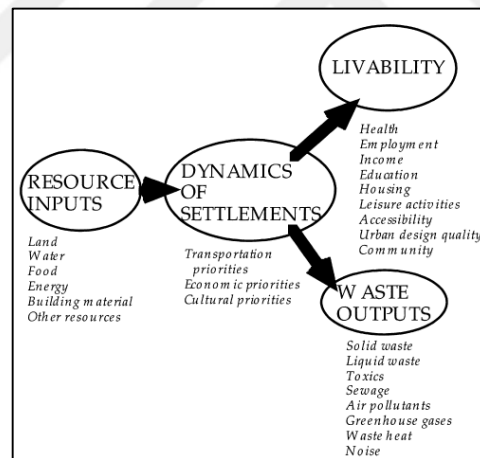


Figure 2. 2: Extended metabolism model for human settlements (Newman, 1999, p.220).

Urban ecosystems are comprised by different subsidiary systems with social, institutional, environmental and economic dimensions. Each sub-system consists of different complex system structures in different functional and structural levels. Alberti (2005) criticized an evolutionary perspective on land use and its ecological influence based on spatial version of human actions and native habitats. Spatial form of human actions together with natural interactions influence ecological processes and socio-economic environment in different scales (Alberti, 2005). From the perspective

of urban ecology, development in urban areas can influence the natural land cover pattern by changing the shape, composition, interconnectivity and shape. These developments therefore generate disturbances, which are intense and unprecedented by physical differences on landscape structures (Alberti, 2005). From the viewpoint of landscape ecology, patches and patterns are the basic components of the landscape and land cover. The native habitats of species, competition and availability of resources can be influenced by vital representatives of patches as size, edge and shape. Moreover, patch characteristics can also ease the management and integration of biophysical processes, which consist of soil erosion prevention, flood mitigation and air quality protection in ecosystems (Naiman & Decamps, 1990; Alberti, 2005).

Millenium Ecosystem Assessment (MEA) Report was firstly developed idea of ecosystems services. According to MEA, ecosystems services (ES) means advantages taken from the nature by people. Moreover, ES grouped into four basic categories as provisioning, regulating, cultural and supporting services (Alcamo, 2003). On the other hand, Burkhard et al. (2012) have clarified the relationship between ecological structure and ES together with human benefits (Figure 2.6). The framework proposed by Burkhard et al. (2014) used for this research due to its applicability. The supply of ecosystems can be provided through ES. These services are grouped into three fundamental categories: regulating services, provisioning services and cultural services (Burkhard et al., 2014). Provisioning services and cultural services are not directly related with decreasing or absorbing the influences of hazards in settlements while regulating services are directly related with NHR improvement.



Figure 2. 3: Conceptual framework showing the ecological integrity and ES with human benefits from the perspective of supply and demand (Burkhard et al., 2012, p.19).

Regulating services are identified as global climate regulation, local climate regulation, air quality and temperature regulation, water flow regulation, water purification, nutrient regulation, erosion regulation, natural hazard regulation,

pollination, pest and disease control and waste regulation. The potential of land cover/land use for the provision of ES is shown in the Figure 2.7. As expressed in the matrix, both natural land covers and urban land uses have the potential on regulating services (Burkhard et al., 2014). According to Figure 2.7, forests, natural grasslands, agricultural areas, agro-forestry areas, heathland areas and green urban areas has the regulation services potential at average and above capacity. Moreover, Alberti (2005) was therefore expressed the importance of forest land cover in terms of provision of both species and endemic plant groups with controlling floods and storm-water mitigation. Forests in urban areas also affect microclimate, air pollution particules and preservation of carbon. Settlement dynamics such as road construction, housing growth, waste storage and landfill areas are main adversities that caused by urban development in settlements.

Alberti et al. (2001) have been proposed the different dimensions' urbanization to connect with the processes and landscape patch structures within urban ecosystems, and these dimensions are intensity, connectivity and heterogeneity of land use with urban form. With these dimensions, researchers also proposed composition and configuration metrics to predict the capability of ecosystems to assist vital functions of ecosystems. Besides, provision of organization, time and space in different scales is fundamental to figure out interactions and dynamics among landscape processes and patterns within urban ecosystems (Alberti, 2005). Due to urbanization occurred in the most fertile landscapes (Imhoff et al., 1997), it is important to assess changes and integrate these on spatial organization of the settlements.

Analyzing the change and conversion of the land cover/land use to assess NHR can be fundamental metrics used for explaining influence on ecosystem structure. Besides, regulating service capacities of the land cover/land use classes therefore reveals the critical areas for provision of NHR (Figure 2.4). These regulating ES can positively affect the livability and waste outputs of the human settlements. The defined changes can be analyzed through spatial configuration and composition (Figure 2.8). Spatial or landscape configuration is related with the distribution patterns spatially within the area while composition is related with the size and presence of the several patterns in the area (Alberti, 2005).

Land Cover/Land Use Classes (CORINE)

Regulating Services

Provisioning services

Other services

High ES Capacity

Abiotic outputs from natural systems (after ICES)

*abiotic outputs from natural systems (after CICES)

Figure 2. 4: ES potential matrix (Adopted from Burkhard et al., 2014).

2.6 Chapter Evaluation

The notion of sustainable development dates back from the 1987s with Brundtland Report and 1990s with Earth Summit in Rio de Janeiro through adoption of Agenda 21. Moreover, Habitat II, MDGs, SDGs and SFDRR follow these policy attempts in response to urbanization, overpopulation, disaster resilience and global environmental degradation. Resilience and resilient city concepts are identified as a response to natural hazards and the idea of resilience in environmental planning starts with C.S. Holling's prominent contribution to the scientific literature in 1973, on the other hand, the idea of resilience in spatial planning starts with Burby's (1998) book, which is named as "Cooperating with Nature". The analysis about the paradigm shows that the

resilient city mainly aims to answer uncertainties and hazards in cities. The structure on human ecosystems and urban systems shows the complex structure and process relations between components on both side of livability and waste management. Therefore, panarchy can be an efficient understanding to explain the process, relation and scale based on the structure of resilience from the perspective of both negative and positive contributions of nature (Tezer et al, 2018).

Additionally, climate change has been another contributor of increased frequency and severity of natural hazards and the notion of disaster or hazard resilience has been gathering more attention with trans-national agreements around the world. However, the focus is not concentrated on NHR as understood from literature research. At the same time, the concept of NHR did not have a ground in the past attempts. The destruction that natural hazards cause is getting more severe in time; however, the resiliency to natural hazards is not considered till now. Hazard management frameworks consist of preparedness, mitigation, response and recovery phases in the contemporary disaster management procedure. While early crisis and hazard management systems mainly concentrate on response and recovery, NHR concentrates on preparedness and mitigation of natural hazards as well as climate change relation. Despite availability of hazard management system, spatial development of settlements does not have a relation with this system at all. As a result of this, settlements continuing to grow. Urban areas are expressed as most vulnerable settlements to hazards due to capital and amount of people at risk. The effects of climate change increase the vulnerability of the settlements; at the same time these changes can create new vulnerabilities different than settlements. The study will be focused on the spatial dimension from the perspective of urban ecology by analyzing changing patterns of the land cover/land use together with hazard identification, vulnerability and risk assessment. It is important to express the planned situation to assess NHR in the area spatially. From the perspective of urban ecology, regulating ES can provide the potential information restored in the land cover/land use. The ES potential of the land cover/land use will be assessed through spatial configuration and composition. Newly developing technologies made possible to assess and control change as a response to natural hazards. Recent development trends use a more technology based approaches for sustainable development. Use of these approaches may help to develop NHR within the context of urban ecological planning.



3. SMARTNESS AND NHR INTEGRATION

This chapter focuses on the second conceptual component of the thesis and it is dedicated to assess the literature on SSM and its relation with NHR. Chapter 2 clarified the significance of NHR components with positive and negative contributions of nature on human settlements and the need of figuring the spatial management of complex interactions through smart systems. Therefore, this section will provide comprehensive background of concepts and their relations with human settlements through smart systems.

As put forward in the introduction chapter, one of the supportive hypotheses of the thesis was defined as “*SSM approaches are an efficient tool to improve the resilience and adaptive capacity of cities in the face of NHR and natural resource sustainability.*” Aiming that the provision of background of theory to reply the main question, “*How the smart city concept may affect the development of settlements? What are the main contributions to increase NHR of cities?*”

What is the meaning of “smart city concept” and how the concept evolved?

What is the situation of smart cities in World and Turkey?

How smart city concept can be developed to cover settlement and peripheral spatial interactions?

Can SSM be more relevant concept for NHR?

What potential integration approaches may exist between SSM and NHR?

This chapter maintains an analysis of smart city literature based on definitions, different perspectives of concept and evolutionary explanation on it. The research was conducted with keywords like “smart city”, “smartness” and “smart spatial management”. Moreover, the emergence of SSM to support resilience to natural hazards is discussed.

3.1 Smart City as a New Concept

Before mentioning the smart city as a term, it will be beneficial to express the use of “smart” term as a concept in spatial planning. According to Papa et al. (2015) smart term was firstly used in the movement of “Smart Growth” that fundamentally dealing with urban growth and sub-urbanism aiming to determine features of urban design in 1990s in the North America. Pellegrini (2003) as well, explained the smart growth as an ideal city movement for suppressing urban sprawl; therefore, it is right to say that the concept mainly aims to promote urban growth in a sustainable manner.

On the other hand, the emergence of “Smart City” term was first used and developed at the end of 1990s with the release of ICT infrastructure and its consequences on the global market (ABB-Ambrosetti, 2012). The Smart City approach was more linked with innovation and technology from the perspective of economy at the global context (Gibson, Kozmetsky and Smilor, 1992). However, Papa et al. (2015) emphasized that the movement shifted its focus from ICT and technology-driven approaches to more social capital and human-based focus meaning a more smart urban advances related approach in the middle of 1990s (Papa et al., 2015).

Komninos (2002) defined that the early smart city attempts dealt with sustainable economic development and good quality of life through investing in social and human capital with modern and conventional infrastructures through the utilization of participation based governance. Another definition, which is clarified by the Center of Regional Science in 2007, characterizes the fundamental components of smart city approaches, which are smart people, smart economy, smart mobility, smart living, smart environment, and smart governance.

At the beginning, Albino et al. (2015) emphasized the main concern of the smart city concept which was basically relying on newly developed infrastructures in cities like ICT. Eger (2009) highlighted that smart city concept was subject of studies at the end of 1990s under the structure of New Urbanism, which was a community-based approach as a response to overcrowding, traffic congestion, lack of open space, air pollution and extinction of historic values. Construction of a smart city focuses on more human capital aspect instead of depending on ICT infrastructure to conceive a smarter city (Shapiro, 2006; Holland, 2008). Albino et al. (2015) clarifies the

components of smart governance. Smart governance consists of the inclusion of different actors who are part of public services and decision-making (2015).

First smart city attempts are mostly based on installation of ICT and devices as seen from Table 3.1. However, the integration of people into ICT release process followed by processing data to increase quality of life of people in settlements.

Table 3. 1: Definitions of smart city according to different scholars.

Reference	Definition
Mahiznhan, 1999	<i>“refers to installation of smart devices to create a digital, intelligent city etc.”</i>
Odendaal, 2003	<i>“capitalizes on the opportunities presented by ICT in promoting its prosperity and influence.”</i>
Nam & Pardo, 2009	<i>One that “integrates technologies, systems, infrastructures, services, and capabilities into an organic network that is sufficiently complex for unexpected emergent properties to develop.”</i>
Caragliu et al., 2009	<i>“fuel sustainable economic growth and high quality of life through investments in human and social capital and traditional and modern communication infrastructure, with a wise management of natural resource, through participatory governance.”</i>
Washburn, 2010	<i>“with the support of ICT which is implemented to vital services and infrastructures”</i>
Komninos et al., 2011	<i>“is connected to notions of global competitiveness, sustainability, empowerment and quality of life, enabled by broadband networks and modern ICTs.”</i>
Batty et al., 2012	<i>“in which ICT is merged with traditional infrastructures, coordinated and integrated using new digital technologies.”</i>
March and Ribera-Fumaz, 2016	<i>“refers to projects and planning strategies that aim to join up new forms of inclusive and low carbon economic growth based on the knowledge economy through the deployment of information and communities.”</i>
Russo et al., 2016	<i>“configured as a set of interacting systems with people, focused as a possible model to follow for pursuing sustainability in real cities of twenty-first century.”</i>
Hiller & Blanke, 2017	<i>“designed to ubiquitously collect information about people, places and activities, and to use that data to provide more efficient services and to build resilience against disasters.”</i>

There is a change from the assessment of sustainability to smart city objectives in the 21st century while the general goal of smart cities is to develop sustainability with the utilization of technology. Innovative infrastructures, transport systems, logistics and energy systems which are efficient and using green and modern technologies in everyday life in urban areas. These initiatives are expressed as a facilitator for improved quality of life and reduced environmental influences; so that, smart cities

bring all together government, society, and technology to make possible a smart mobility, smart economy, smart living, smart governance, smart people and smart environment (Ahvenniemi et al., 2017).

There are numerous approaches generated to deal with Smart City concept while Caragliu et al. (2009) gave attention on the connections among social perspective, technology and governance. The evaluation of smartness of smart cities has been subjected to some researches to explore assessment tools. Leydesdorff and Deakin (2011) proposed a *Triple Helix Model*, Lazariou and Roscia (2012) composed an index called as *Smart City Index*; moreover, Lombardi et al. (2012) improved triple helix model into *Four Helices Model* by adding society as a knowledge source with other three sources (government, university and industry) of knowledge development (Albino et al., 2015). Deakin (2012) generated a model for encouraging innovation of social capacity and underlining the connection between smart city and sustainable development through “Triple Helix Model” which takes relationships of industry, university and government as sources of knowledge; however, Lombardi et al. (2012) have turned this model into Four Helices Model by attaching society as a source of social memory that is also a knowledge source of society. It can be concluded that the evolution of the smart city concept, assessment tools for measuring the smartness level of cities are the main categories of researches in academical publications.

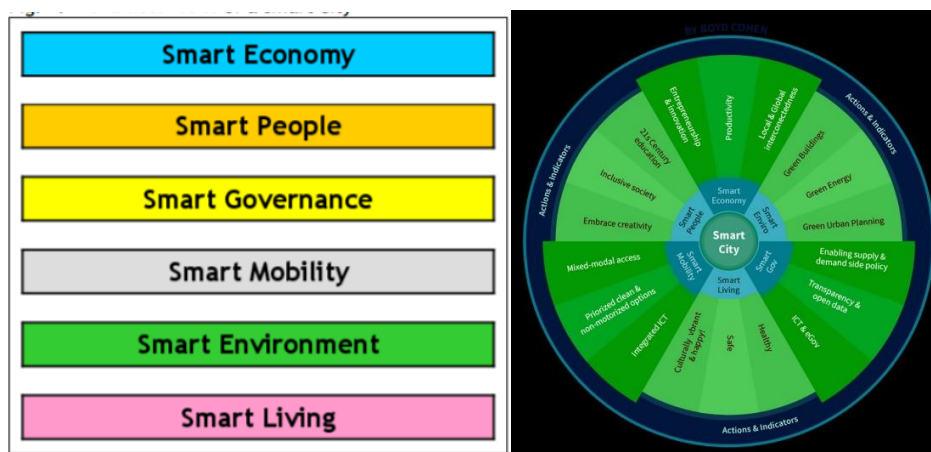


Figure 3. 1: Characteristics of smart city (left) Giffinger and Pichler-Milanovic, 2007; and, smart city wheel (right) Cohen, 2013.

The European level standards also include these clarified 6 axes (Figure 3.1) of smart cities. Smart economy is related to competitiveness capacity of cities and its qualifications are clarified as entrepreneurship, productivity, innovative spirit, labor

market flexibility, embeddedness at international level, economic situation and trademarks. On the other hand, smart people are related to human and social capital and their qualifications are identified as interest in life-long learning, diversity of ethnic and social structure, cosmopolitanism, public life participation, open-mindedness, creativity, flexibility and qualification level. Moreover, smart living is related to citizens' quality of life and its qualifications are specified as health situation, cultural facilities, quality of housing, individual safety, touristic attractiveness, social cohesion and housing quality. Smart governance is interrelated with citizen participation and its qualifications are defined as social and public services, political perspectives and strategies, participation in decision making and transparent governance; furthermore, smart environment is interrelated with sustainable growth and qualifications of natural resources are clarified as reduction of pollution, natural condition attractiveness, sustainable management of resources and environmental protection. As the final axis, smart mobility is interrelated with ICT and transport and its qualifications are specified as international and local accessibility, innovative, safe and sustainable transport systems and ICT infrastructure presence (Zubizarreta, Seravalli, & Arrizabalaga, 2016).

New urbanism, smart growth, and compact urban development are sustainable urban concepts and these concepts are constructed to combine three fundamental axes of sustainability with ecological integrity, social capacity and economic welfare (Gibbs et al., 2013) In respect to characteristics of the smart cities, Neirotti et al. (2014) has clarified the application areas of the concept which include mobility and transport, living, buildings, energy and natural resources, people, economy and government. Moreover, bottom-up initiatives supporting to create a ground for the easy access of data and making possible a self-decision making mechanism for the members of society are the drivers of governance in smart cities.

Kummitha and Crutzen (2017) have clarified the notion change in smart city literature with four basic categories of thought:

- a restrictive school of thought,
- reflective school of thought,
- rationalistic school of thought and
- critical school of thought.

Restrictive school of thought includes to focus on integrated development methods/models with ICT-based infrastructures without referring social inclusion or justice utilizing from the smart city applications, on the other hand reflective school of thought contains the focus on positive side of ICT infrastructure considering integration of human components within the process of construction, which is indicated the notion of augmented human capacity. Rationalistic school of thought consists of the focus on the promotion of capabilities and skills of the societies. The concept here would follow the active use and creation of technology: so that, the idea of the urban lab and living lab concepts and transformation of triple helix model into four helices model emerged in this context. Final school of thought as mentioned as critical school of thought, which mainly focuses on acts of companies and the leading role in the planning and administration of smart cities has promoted strong critique by academics as urban space privatization (Kummitha and Crutzen, 2017).

Smart cities are vital components to overcome particular adversities which societies are facing like overpopulation, pollution, security, health, transport, natural hazard management and climate change (Abella et al., 2017). Smart governance structure has to overcome uncertainty and complexity in cities; additionally, it also has to deal with resilience and adequacy (Scholl and School, 2014) by addressing both smart city and resilient city together.

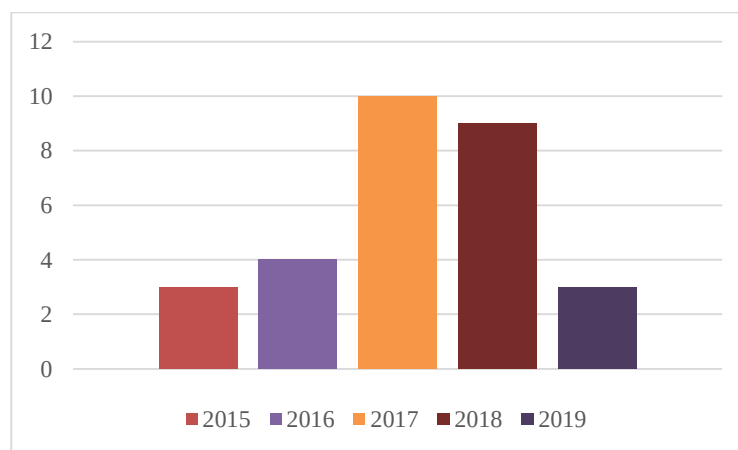


Figure 3. 2: Number of “smart city and resilient city” keyworded publications in SCOPUS database (2019).

Figure 3.2 shows the literature review on both smart city and resilient city keyworded publications. It is clear from the figure that, the combination of these two concepts has its roots from very close history. On the other hand, when the content of the

publications analyzed, it is not possible to find clear boundaries between two concepts. There are 30 publications since 2014 and only 4 of the publications combine the resilience and smart city terms with each other (Pan, 2016; Deal et al., 2017; Arafah et al., 2018, Lazariou & Roscia, 2018). Between these 30 publications, only 1 publication focuses on hazard resilience issue (Pan, 2016). However, the paper proposes *Building Resilience Information Modelling* (BRIM) system for hazard mapping aiming participatory decision making in real time efforts. Dealing with natural hazards within the framework of resilience and smartness was not clearly defined in the literature as expressed before. Spatial integration of smart solutions in settlements is an emerging concept.

3.2 Smart Cities in the World and Turkey

The applications and examples of smart cities around the world differ from each other. Leading countries and cities in smart city concept in the world were specialized in one axis that was defined before when expressing the fundamental literature on smart cities' perspective of Europe. Smart city is an emerging concept in Turkey; besides, the extended and current situation of Turkey about smart cities is expressed in a Bulletin of Smart Cities which is generated by General Directorate of Geographical Information Systems, Ministry of Environment and Urbanism in 2019.

According to the Bulletin of Smart Cities, there are many problems identified for cities such as population increase, long life expectancy, global warming and climate change, pollution, technical capacity demand, resource depletion, increased energy demand, rural problems, increased communication demand and old infrastructure. There are newly emerging city concepts as a response to these problems. Prominent concepts are smart city, sustainable city, connected city, digital city and liveable city. Expansion of the use of ICT in local administrations brings forward the significance of smart city approaches. Turkey has a new strategy document as a result of these developments in the world. The name of the document is “*2019-2022 National Smart Cities Strategy and Action Plan*”. The definition of the smart city in this document is expressed as “*the more livable and sustainable city that is implemented through cooperation between stakeholders, used new technology and reformist approaches, justified by data and specialty and developed solutions that increase value of life based on future*

needs and problems”. The plan has 4 strategic goals and 26 actions. Prioritized actions are;

- Preparing province based local smart city strategy and road map
- Enabling the sustainability of smart city index which is developed by smart city maturity evaluation model
- Enabling the plan, implementation and spread of smart city projects which will have high public value
- Enabling a comprehensive and planned investment place to use sources for smart city investments in an efficient and effective way, creating a place for financial encouragement (MEU, 2019).

Smart cities are evaluated with 17 fundamental areas in the plan: governance mechanism investment and source use, smart governance open and big data, smart environment, smart economy, smart energy, smart people, smart transportation, smart buildings, smart health, disaster and emergency management, smart security, information security, information technologies, communication technologies, smart spatial management, geographical information systems and smart infrastructure. SSM is expressed as firstly being resilient in response to natural disasters such as earthquake, flood, landslide which cause loss of lives and property and secondly being sustainable and livable socially, culturally and economically. Disaster and emergency management is clarified as a comprehensive system which is decreasing damages by taking precautions, providing preparedness for disaster and emergency situations, intervening in a situation, analyzing disaster and emergency data in a smart way and including the process of turning normal life situation. Moreover, the use of GIS will provide a location based information development. The use of GIS is expressed the whole system of hardware, software, human resources, standards and methods for provisioning, gathering, processing, analyzing, managing, sharing, representing and keeping updated data (MEU, 2019). Under these focus areas, smart spatial management, disaster and emergency management and GIS integration becomes strongly related with building NHR in settlements. Taking all these explanation on focus areas into consideration, they should support smart city; however, these focus areas are also implying resilience to disasters.

There are also proposed evaluation tools for smart cities in Turkey. Smart City Maturity Model provides a qualitative evaluation tool for cities and the model was developed by the Ministry of Environment and Urbanism. Furthermore, Smart City Index with 60 criteria provides a quantitative evaluation for cities and the index was developed by Istanbul Informatics and Smart City Technologies Inc. (ISBAK A.Ş.) which is a company of Istanbul Metropolitan Municipality (MEU, 2019).

The Bulletin of Smart Cities therefore, expresses the current implementations in Turkey. The implementation of 8 (eight) cities are indicated in a detailed way. These cities are İstanbul, Ankara, Antalya, Bursa, Gaziantep, Kayseri and Kahramanmaraş. As seen, these are metropolitan cities of Turkey. The smart city related experiences of other cities does not have a place in the document due to unavailability of smart city attempts. Furthermore, the world examples of smart cities are also evaluated. These cities are London, Singapore, Barcelona, Amsterdam, Seoul, Paris, Dubai, Berlin, Santander, Moscow, San Francisco and New York. Before explaining the situation of the cities in the world, there are different smart city approaches available in different parts of the World due to the characteristics and problems of the cities. There are 5 levels defined for smart cities in the World:

- First level, there is no defined smart city plan available, independent projects can be seen
- Second level, there is a defined smart city plan available, but independent projects still can be seen
- Third level, there are partially integrated smart projects available, projects have local administration support and open budget
- Fourth level, there are integrated projects, business models are developed and local government and central government has a strong power
- Fifth level, projects are completely integrated each other, there is a smart city ecosystem available and this ecosystem can be organized in itself (MEU, 2019).

Smart city examples defined 5 different level when developing a smart city. From the first level to fifth level the integration level of activities increased. Smart cities from the world mainly aim to support the quality of life of their citizens; however, these

cities are coming into prominence with one dimension. Table 3.2 shows the specialization of cities in smart city implementations. The main cause of this situation can be explained by the needs of cities. Each city has its own potential and each of them requires a different approach at the implementation stage. The applications of smart cities are defined and shaped by the needs, potentials and future dynamics of those cities (MEU, 2019).

3.3 Smart Spatial Management (SSM): Definition, Scope and Relation with Smart City

SSM was expressed as *“being resilient in response to natural disasters which cause loss of live and property such as earthquake, flood, landslide and being sustainable and livable socially, culturally and economically”* in the Bulletin of Smart Cities document (MEU; 2019). The definition concentrates on the resilience definition and shape the definition as a response to natural hazards. In this study, despite the main study focused on building NHR as a response to natural hazards, SSM cannot be limited with the integration of hazards into spatial planning but at the same time, SSM should be accepted as a broader concept integrating more comprehensive ecological information (hazards and ES based information) as well as spatial development problems of existing and planned situations that settlements face. However, in this thesis, the main concern is to develop SSM system for building resilience to natural hazards.

Chigbu (2018) was made a definition of smart land management as *“utilization of technological infrastructure and geographical data, combination with open and big data supported by information systems as a solution to land-based problems”*. As seen from the definition, use of technological infrastructure with spatial data is main concern in the smart management of land. Thus, it can be thought that the use of technology makes possible to manage space in a smart way. Furthermore, Středová et al. (2015) proposed a system aiming climate evaluation for SSM. They setup technological monitoring devices for air quality and humidity in different locations, gathered information from these infrastructures and calculated the model as a final step. As seen from the examples, the use of technological tools with geographical data provides the information for SSM. If a system will be installed in cities for any

purpose, the system provides a continuous and realtime data for evaluation. Because of this, the use of smart approaches in spatial planning and management is vital.

There are only two publications trying to express the meaning of SSM. Chigbu (2018) expressed SSM with integration of technological infrastructure, geographical data and big data, on the other hand Středová et al. (2015) defined SSM with installation of smart devices which has geographical data to provide real-time data for climate based evaluations. However, the scope of SSM was explained in the Bulletin of Smart Cities from the perspective of resilience to natural hazards. By combining the definitions and approaches from literature with Turkey's SSM definition, a comprehensive definition for SSM can be written. SSM basically uses ICT to observe the changing situation on the earth with geographical data, analyzes the data, directs and integrates the data in spatial planning & organization and takes precautions to support resilience to natural hazards within the scope of this study.

3.4 NHR Integrated SSM Approaches

SSM approaches which supports resilience to natural hazards are generally related with ICT installation. Smart approaches to deal with spatial management in settlements will be explored here. From the literature research, it is easily understood that most of the smart city approaches dealing with governance and participation of the people to the planning process. Moreover, different perspectives to cope with natural hazards are also criticized.

The applications which combine the smart spatial management with GIS, are generally based on city surveillance data (Masutani, 2014; Kavehvas, 2016), radio frequency identification devices-RFID (Luvisi and Lorenzini, 2014), ICT oriented infrastructures (Stratigea et al., 2014; Cellucci et al., 2015), web based GIS data (Ndiaye et al, 2018); and disaster management (Pan, 2016; Chen et al., 2017; Hartama et al., 2017), green management (Crncevic et al., 2017, Luvisi and Lorenzini, 2014) implementations.

Smart applications for spatial organization and management are based on city surveillance and more updated data collection to found a better route to reach a final evaluation. Real time data provides traffic efficiency and raise the resilience of cities due to shorter travel time. Masutani (2014) has clarified the importance of real time data provision and network setup for provisioning resilience in cities.

Javehvash (2016) has expressed another advantages of system of traffic surveillance to create both smart and resilient city. The system aims to enable higher quality of life by provisioning lower air pollution and traffic density. Despite there are positive outcomes of the system, there are also several situations that may affect the process of city surveillance. The data gathered by images in the process and it could be helpful to use a three-dimensional image for supporting city surveillance system. Moreover, the computational capabilities of technological components also affect the consequences of research.

Use of RFID tags to manage and protect green areas especially trees can provide a city to be both green and smart. As a first step, RFID tags are installed on trees to detect real time data from exact locations. The use of these tags can show the transformation of trees into wired objects which are sources of IoT in a smart city. Besides, the use of sensors and these kinds of tags in land surveillance can be enhanced by geospatial data collection methodologies like satellite imagery for a better green management (Luvisi and Lorenzini, 2014).

As known from the literature, the smart city applications are the most effectively used in e-governance systems to integrate people to the planning and policy making processes. Stratigea et al. (2015) explained the use of ICT based participation process to direct policy making activities in spatial planning as a part of the smart cities concept, because it is important to learn the weaknesses of the area and needs of the people. This kind of data can be provided through a digital interface, which helps people through e-participation. Moreover, the work also enlightened another approach to smart city planning as being the application-pulled rather than being technology pushed. The most fundamental part of the smart city defined here begins with the idea of city not smartness. If a smart city system is trying to be created, it is important to consider the smart city as a whole rather than considering piece by piece different smart applications. Cellucci et al. (2015) also clarified the integration of ICT into urban planning by arguing that the provision of new infrastructures to cities by ICT does not require fundamental changes in planning and management systems but provide to examine fundamental functions of cities.

The provision of geospatial data and processing through GIS was subjected to the work of Ndiaye et al. (2018). They processed the rainfall data, land cover and changing structure of land cover and digital elevation model (DEM) which contain the data

about geographical characteristics of the area to examine vulnerability to flood caused by both humans and the nature. In the process, the use of rainfall data and modelling the data statistically would provide the vulnerability in the future. GIS provides to process data which are both geographical and statistical. As a result of vulnerability prediction, the process can be concluded through suitable decisions to cope with flood risk in settlements within the context of this paper.

Pan (2016) focused the resilience dimension of the smart cities by proposing Building Resilience Information Modelling (BRIM) which consists of modules on mapping hazards with real time data, vulnerability indicator for building and bringing together stakeholders to cooperate in the process of decision-making. The proposed model embraces the resilience dimension of smart city in a systematic way. The model is key to use collective information to deal with hazards not only in social and in environmental dimensions but also in built environment dimension with a technology-based way.

The use of geographical data as well as real time data can be beneficial to cope with natural disasters. For search & rescue activities after an earthquake, the provision of global positioning system (GPS) data and integration with GIS based infrastructure may help to create effective and alternative ways in emergency times to direct rescue routes with real-time data. Furthermore, the geographical location and visualization may help to manage emergency management (Chen et al., 2017). Another approach, which is combining location information with GIS focusing on the mitigation of spatial risks in urban settlements through smart planning. In the paper, the geospatial data is provided by mobile phones and combined with GIS tools to visualize geographically and is directed the emergency management when a disaster strikes (Hartama et al., 2017).

Crnčević et al. (2017) dealt with the integration of green systems planning into urban planning for adaptation regulation into climate change through ICT-based tools. Green infrastructure planning can be key to spatial planning for creating cities of climate-smart. Moreover, the most important consequence from this process is that availability of legal frameworks and integration of smart management system into these frameworks are vital. Luvisi and Lorenzini (2014) also focused on the green infrastructure planning and management in a smart way.

Nadal et al. (2017) written about the source of geospatial data, which is provided by generally mobile devices to monitor the situation of the environment. The use of Light Detection and Ranging (LIDAR) and Long Wave Infrared (LWIR) data with suitable sensors make possible to integrate satellite with ground through GIS. Use of satellite data for the provision of geographical data in order to monitor and manage the environmental structure is vital. (Nadal et al., 2017).

There are different approaches to SSM in the literature to express the connection between smart land and spatial planning. These approaches are generally used to deal with uncertainty as well as natural hazards; moreover, it is not possible to manage with the environment without GIS to integrate both spatial and statistical data. SSM will ease the provision of systematic data in this context.

3.5 Chapter Evaluation

Smart cities are an emerging concept in the last decade despite its origination dates back to late 1990s. The installation of ICT and other smart measures in settlements and environment was the main concern to create a smart city in the first attempts. However, the integration of human and the urban living lab context gained more importance in time. In response to these developments around the world, evolution of smart cities in Turkey was explained in the Bulletin of Smart Cities document in detail in 2019. SSM can be the policy to deal with existing and emerging problems that settlements face such as population increase, long life expectancy, global warming and climate change, pollution, technical capacity demand, resource depletion, increased energy demand, rural problems, increased communication demand and old infrastructure. Despite smart cities was mostly clarified with 6 main axes in the European Union standards, state authorities in Turkey defined 17 basic areas in 2019-2022 National Smart Cities Strategy and Action Plan to enhance this issue. These work areas are governance mechanism investment and source use, smart governance open data and big data, smart environment, smart economy, smart energy, smart people, smart transportation, smart buildings, smart health, disaster and emergency management, smart security, information security, information technologies, communication technologies, smart spatial management, geographical information systems and smart infrastructure.

Figure 3.3 shows the relationship of SSM and NHR within the framework of settlement dynamics. Settlements has their own dynamics; however, natural hazards, human-induced hazards and urban development are outside dynamics for settlements. If the effect of these dynamics controlled by the ecological planning approach, there are two main aim in the process:

-protecting, restoring, sustainable use and decrease of risk by mitigating risks to decrease and control outputs of settlement dynamics.

-utilizing benefits gathered from resources to increase livability features of settlements.

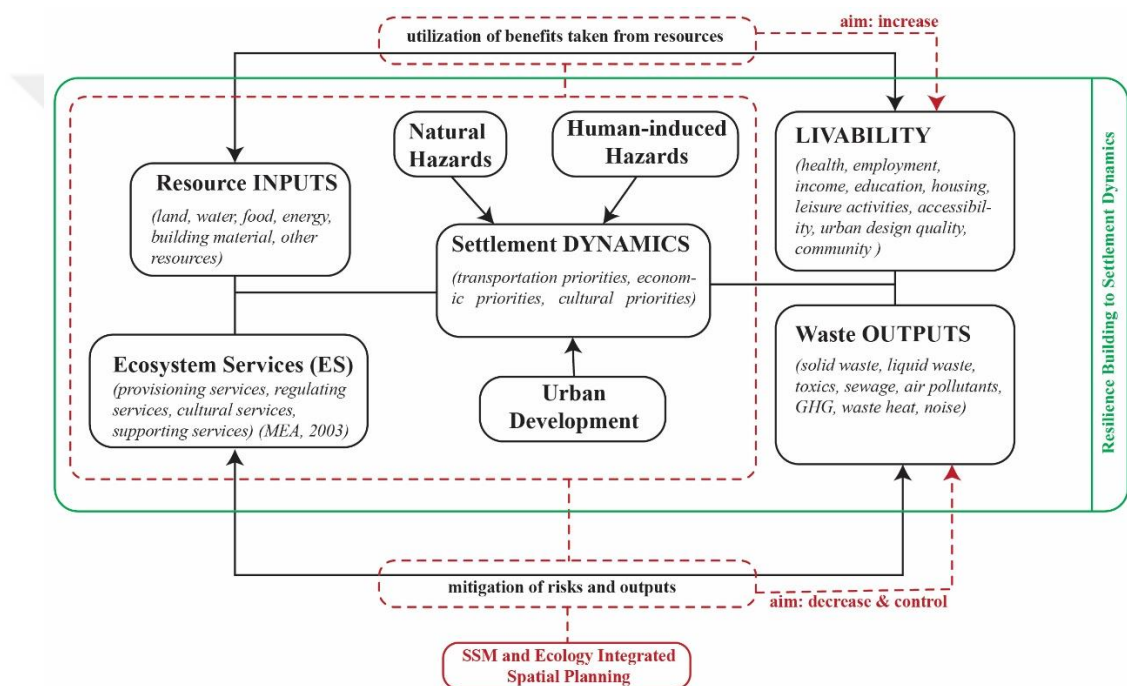


Figure 3. 3: Integration of SMM with ES (Developed from Newman, 1999; Alberti, 2005 and Burkhard, 2014).

SSM ve ecology integrated spatial planning will be beneficial building resilience under all dynamics of settlements. SSM basically uses ICT to observe the changing situation on the earth with geographical data, analyzes the data, directs and integrates the data in spatial planning and organization and takes precautions to support resilience to hazards. There are different approaches to support SSM; moreover, the combination of SSM with GIS basically based on the surveillance cameras, RFID tags and other type of sensors, ICT oriented infrastructures, web based data and the provision of these datum mainly aim to cope with disaster and green management. Specialists focused on

DRR since 1990s, but, the capacity to deal with DRR is increased with SSM approaches. The use of information and communication technologies (ICT) and technological devices on land cover/land use configuration, availability of big data can ease the overcome capability in response to natural hazards, so that, SSM concept is clarified as a vital part of the study.



4. ENSURING NHR BY SSM IN SPATIAL PLANNING: THE CASE OF DÜZCE PROVINCE

Düzce Province has been assessed as the case study of the thesis as a result of its relevance in multifaceted ways. The city is located in between İstanbul and Ankara axis and the development of the city has been influenced from this condition. At the same time, the city has various ecological resources that provide services for society. Urban and rural settlements in the province have been affected from multi types of natural hazards throughout its history many times. 1999 Earthquakes in August and November effected the province in a devastating way. been centered the focus on more resiliency and disaster management rather than response. The pressure of urban growth has been caused industrial and residential development on natural resources such as pasture land, forests, agricultural land as well as sensitive watershed areas. There is also potential human induced and technological hazards due to the construction of a dam and new industrial areas.

On the other hand, natural values in the province are very diverse too. They indicate high level of the importance in regards to ecosystem functions and services. High ES potentials in the area may be utilized to deal with NHR in the area in a collective and systematic way. Declared protection areas and nature parks are conserved by laws and it is not possible to change function or ecosystem characteristics of the area. Considering that, Düzce Province has wide natural resources as forests, land cover for regulation of NHR within the borders of the city. As a result of all, the case study area is selected as Düzce province due to the capacity to deal with NHR is high in the area.

This chapter shows the expression about hypotheses “*Considering natural threats in settlements (with urban and peripheral areas), vulnerability analysis in regards to existing and planned situations of settlements with SSM approaches can provide more resilient and adaptive spatial development capacity.*” with “*If resilience of the city supported by SSM approaches and this approach integrated into spatial planning, it can be evident that increased awareness, adaptive capacity and SSM will help the city’s resilience development towards natural hazards.*” Furthermore, to assess NHR

of the province, the most important thing is to assess current situation and planned situation of the province and vulnerabilities. In addition, this section is constructed to reply the questions;

Is Düzce Province a relevant case for the content and the aim of the research?

What are the existing natural risks & vulnerabilities and planned situation risks in Düzce Province?

How SSM approach can enhance the resilience of Düzce Province?

How the assessment of NHR be placed with SSM concept and its tools?

This chapter maintains the analysis of hazard mitigation system based on hazard identification, vulnerability and risk assessment. The research was supported by several mapping techniques to assess spatially.

4.1 Methodology

Analyzing the “SSM to support NHR in urban ecology perspective”, it is fundamental to analyze the land cover/land use and its vulnerability to hazards. In Düzce Province, there are several hazard risks available and these risks should be integrated with spatial planning process. Potential natural hazards, vulnerabilities and risks analyzed after expressing the hazard history of the province. The study continues with vulnerability and risk assesment to visualize and indicate recent situaiton of the settlements. For the expression of future in Düzce Province, 1/100.000 scale Environmental Master Plan is used as a source of development. The study is finalized with alternative development decisions to support NHR in the province.

This section therefore expresses the data provision and analysis structure of the study. The data for the analysis is taken from Copernicus Corine Land Cover Database for 2012 and 2018 years as satellite data, 1/100.000 scale Environmental Master Plan, and data from TUBITAK project -115K475- “*Developing an Ecologic Planning Based Participatory Model for Mitigation of Spatial Risks*”. The analysis and spatial presentation of data is processed with ArcGIS 10.6 software and all spatial maps produced for the thesis.

The analysis in the study will start with the identification of natural hazards and vulnerabilities in the Düzce Province. At the same time, the assessment on ES and

naturally critical areas will be defined from the perspective of potential capacity based on CORINE land cover classification. The land cover/land use data of 2018 is taken from Copernicus Land Monitoring Service Website under the name of CORINE Project which aims to provide land use / land cover data based on satellite imagery according to the classification defined by European Environmental Agency (EEA) and the land cover/land use data has been produced for 1990, 2000, 2006, 2012 and 2018 years (Url-3) to assess the spatial development trends.

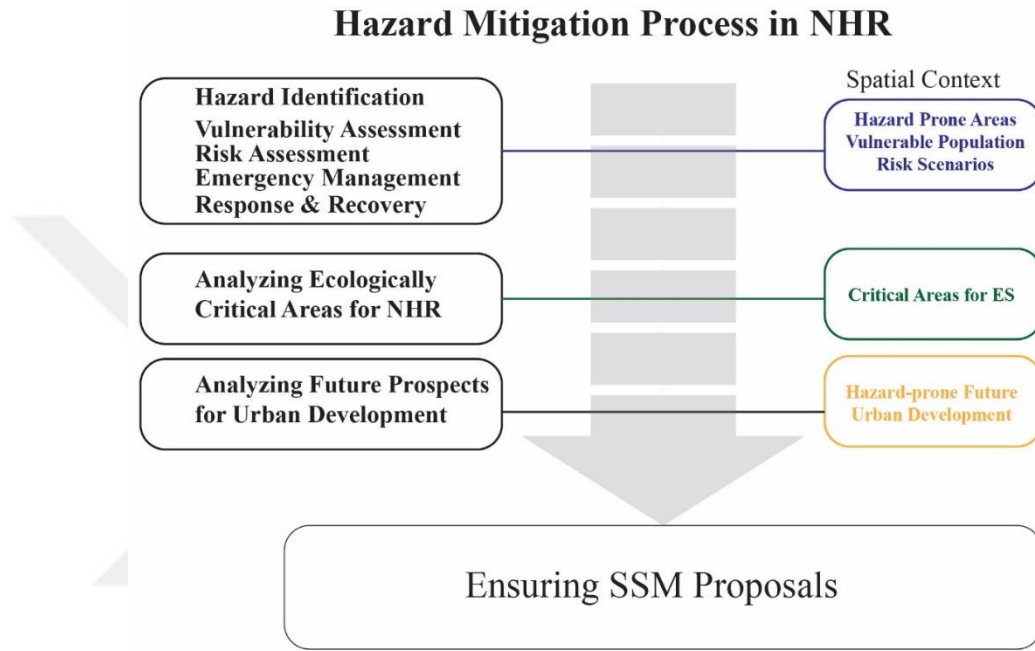


Figure 4. 1: Methodological explanation of the case study scope.

After defining naturally critical areas and vulnerable areas to natural hazards it is important to evaluate the future scenarios of these areas. The future scenario evaluation will be based on 1/100.000 Environmental Master Plan of Düzce Province. The future scenarios and vulnerabilities will show the critical points and hot spots for dealing with NHR; furthermore, integration into urban planning form the perspective of SSM will be final part of the research.

4.2 Location and General Characteristics

Düzce Province is located on the west part of the Black Sea Region (Figure 4.1)., moreover, the neighbors of the province Bolu from the west, Zonguldak from southwest, Sakarya from east and east part of Sakarya province as well as province is surrounded by Black Sea at north with 30 kilometers shoreline. Total land area of the

province is 2593 square kilometers and as can be seen in the Figure 4.2. Administrative division of the city is that the province consists of 8 districts which are Akçakoca, Cumayeri, Çilimli, Central District, Gölyaka, Gümüşova, Kaynaşlı and Yığılca with 2 secondary municipalities; besides, there are 10 municipalities available in the city and 65.7% of the people lives within the municipality borders while there are 279 villages available as rural parts of the city (ICDR, 2009).

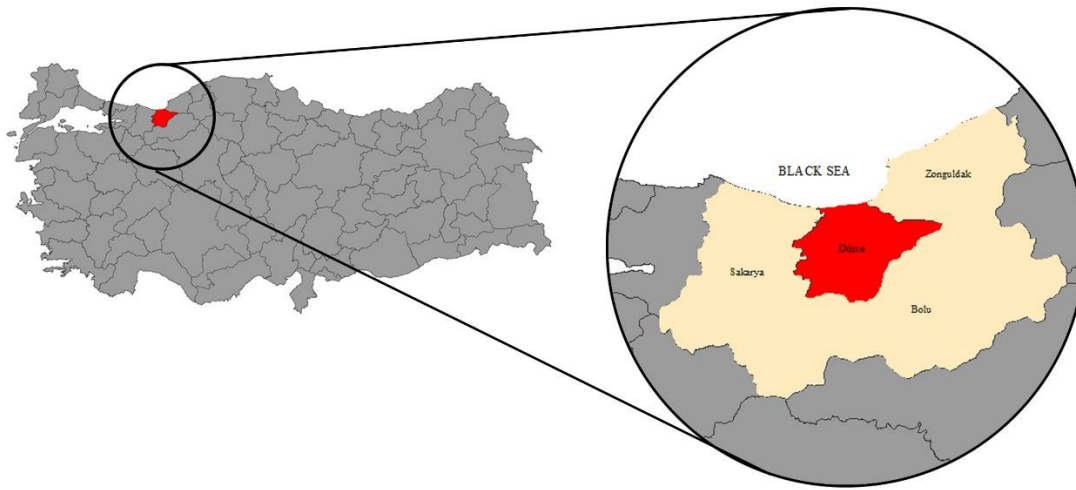


Figure 4. 2: Location of Düzce Province.

The climatic characteristics of the province are influenced from the Black Sea Climate Region which means rainy and temperate humid in general. However, there is also transitional effects of Aegean and Continental climates as well. The influence of latitude causes that southern districts have lower temperatures than other districts of the province. Central District and other districts are hotter and colder in contrast to Akçakoca District which is located at Black Sea shore on the north of the province. Due to the availability of mountains around the province, the speed of the wind decrease in the inner/central parts of the province, so that, there can be seen foggy weather in winter months (Url-2).

The geographical structure of the province consists of flat plain at the central part and mountains around the plain. There are Akçakoca Mountains at North, Bolu Mountains at East, Elmacık Mountains at South part of the province while Düzce Plain located at center and the plain is vital for agricultural activities with its fertile structure. The main streams in the city are Küçük Melen Stream, Asar Stream, Aksu Stream and Büyük Melen Stream; moreover, all these streams join each at Efteni Lake and poured into

Black Sea with Büyük Melen Stream except Akçakoca shoreline (Url-2). There are also 2 dams available in the province: Hasanlar Dam and Melen Dam. Hasanlar Dam was constructed in 1992 with the purpose of flood control, irrigation and energy as well as recreational tourism and water sports potential (ICDR, 2014) while Melen Dam was constructed in 2018 as a source of potable water for Istanbul. In addition to all these features, mountains around the province enables plateau tourism potential for the city as well as camping, trekking which is a common characteristic of a Black Sea Region.

4.3 Flora, Fauna and Protected Areas

The flora and fauna characteristics of the province assessed with its endemic species and naturally protected areas. There are 102 families, 471 genera and 1200 species and taxon in the area and these numbers are shown in the Table 3.1. The general vegetation cover of the province consists of Euro-Siberian (Euxine) flora area and Mediterranean flora area while Irano-Turanian flora area has lower influence. The characteristics of euxine zone starts from the mountain near shoreline up to the sub-mountain areas in inner parts and these areas covers with deciduous and mixed forest vegetation including *Fagus orientalis*, *Abies nordmanniana*, *Picea orientalis*, *Pinus sylvestris* while sub-euxine zone covers mostly *Pinus brutia*. Besides, the northern and southern parts of the Elmacık Mountain have Mediterranean Flora influence. Main vegetative cover around Elmacık mountain is forests and there are forestry activities within these vegetation cover. The forests in the area are used for wood fuel production, timber and fiber; in addition to these, the collection of mushrooms known as *Hypericum perforatum*, *Trichaloma caliautum* and *Lactirus deliciosus* from its natural habitat. The population which live in plateaus of the mountains such as Pürenli, Odayeri, Kardüz, Torkul etc. utilizes the open areas within forests for livestock feeding and agriculture. Elmacık Mountains have alpine and sub-alpine vegetation cover in the pasture lands. However, these areas under threat of livestock feeding and inappropriate forestry implementations. Also, inappropriate forestation attempts give harm to the natural vegetative structure of the alpine and sub-alpine taxonomy (DICDR, 2017; SICDR, 2014).

Table 4. 1: Total number of family, genus, species and taxon in Düzce Province (DICDR, 2017).

	Family number	Genus number	Species and taxon	Endemic
Pteridophyte	6	8	12	-
Gymnospermae	3	4	7	1
Angiospermae	93	459	1181	65
Total	102	471	1200	66

The forest vegetation of the city consists of *Tilio tomentosa-Carpinetum betulus* (available at elevation between 385-780 meters), *Querceto petraea-Pinetum nigrae* (available at elevation between 610-950 meters), *Rhododendro ponticum-Fagetum orientalis* (available at elevation between 600-1200 meters), *Rubus hirtus-Abietum bornmulleriana* (available at elevation between 1300-1600 meters); moreover, riparian vegetation includes *Periploca graeca-Alnus glutinosa* (available at elevation between 100-120 meters). There is also shrub vegetation, sub-alpine and alpine vegetation, rock vegetation and aquatic and everglade vegetation types available in the area. Shrub vegetation covers elevation between 415-475 meters with *Arbutus andrachne-Phillyrea latifolia* plant collections and elevation between 575-630 meters with *Cistus creticus-Erica arborea* plant collections. Sub-alpine and alpine vegetation collections covers elevation between 1600-1800 meters with *Naradetum stricta-Plantagini holostemum*. Rock vegetation covers elevation between 180-185 meters and 388-400 meter with vegetation collections which are *Polypodietum vulgare-Origanum* while aquatic and everglade vegetation covers south part of the Efteni Lake at 100-meter elevation and in the water which has 50-meter depth with *Phragmitetum-Thypho*; also, *Trapaetum natantis* vegetation collection covers therefore south part of the Efteni Lake at 100-meter elevation and in the water which has 1.5-meter depth (DICDR, 2017).

Hasanlar Dam and Küçük Melen Stream Watersheds also located intersection of Euro-Siberian and Mediterranean vegetation covers, so that, there are different types of vegetation available in southern and northern side of the watershed. Southern part has the impact of Aegean vegetation cover including *Arbutus unedo*, *Arbutus andrachne*, *Laurus nobilis*, *Phillyrea latifolia*, *Pistacia terebinthus*, *Erica arborea*, *Cistus creticus* as bush classification, while northern side of the watershed has Black Sea vegetation cover including *Fagus orientalis*, *Castanea sativa*, *Quercus petraea*, *Quercus cerris*, *Quercus frainetto*, *Carpinus betulus*, *Tilia tomentosa*, *Acer campastre*, *Fraxinus*

angustifolia, *Fraxinus pallisae* as leaved forest cover. Besides, the area also has endemic species that are *Lathyrus undulatus*, *Campanula lyrata*, *Seseli resinosum*, *Phlomis russeliana*; rare species which are *Fritillaria pontica*, *Galanthus pilicatus*, *Scilla bifolia*; valuable species in terms of medicine which are *Galeobdolon luteum*, *Hypericum clycinum*, *Digitalis ferruginea*; furthermore, these species and assets of the natural environment creates a rich biodiversity in the area (DICDR, 2017; SICDR, 2014).

In terms of endemic species, there are 3649 endemic taxa available in Turkey while these numbers were expressed as 300 endemic taxa in European-Siberian flora zone; therefore, 66 endemic plant species exists in Düzce province. The category of threats and endemic species are shown in Table 3.2. However, according to Bern Agreement the species called as *Cyclamen coum* is under protection despite it is not an endemic species (DICDR, 2017).



Figure 4. 3: Endemic species in Düzce Province, *cephalaria yaltirikii* (left), *cephalaria duzceensis* (right) (DICDR, 2017).

In terms of rare species, there are 14 taxa available under 11 family category as rare but not endemic. These species are stated as *Ilex aquifolium*, *Stachys officinalis*, *Senecio doria*, *Artemisia verlotorum*, *Arum byzanthium*, *Arum nickelii*, *Aristolochia rotunda*, *Juniperus communis*, *Malus sylvestris*, *Trapa natans*, *Equisetum sylvaticum*, *Trifolium berytheum*, *Medicago turbinata* and *Fraxinus pallisae* (DICDR, 2017).

Fauna within the area is affected by migration routes of the birds and the location of the city between these routes. The richness of biodiversity, vegetation diversity and available aquatic sources have strengthened the wildlife habitat in the city. Forest land

cover is functioning as shelter for wildlife animals with Efteni Lake and Black Sea shoreline; moreover, in addition to these areas, pasture areas and agriculture areas are expressed as shelter for wildlife animals (DICDR, 2017).



Figure 4. 4: General view from Efteni Lake NWDA (DICDR, 2017).

The availability of these habitats necessitates a protection and there are some areas under protection due to its natural values or wildlife habitat characteristic. These conservation areas are Güzeldere Waterfall Nature Park, Kurugöl Nature Park, Aydınpinar Waterfalls Nature Park, Yılançayı Nature Park and Demirciönü Nature Conservation Area as naturally protected areas, and, Efteni Lake Natural Wildlife Development Area (NWDA), Yedigöller NWDA and Yeşilöz NWDA as wildlife protection areas within the borders of province. In addition to all these biodiversity and richness of wildlife in the city, Efteni Lake is also a wetland area for protection and production of water birds. There are 175 different bird species (1123 of them are endangered according to International Union for Conservation of Nature - IUCN) around the lake with 11 fish species, 2 amphibian species, 6 reptilian species, 9 mammal species and 14 invertebrate species (DICDR, 2017).

The natural values of the province proved the importance of the area for ecosystem functions and services. ES potentials of these areas and protection status may help to deal with NHR in the area in a collective and systematic way. Declared protection areas and nature parks are conserved by laws and it is not possible to change function or ecosystem characteristics of the area. As seen from the explanation, Düzce province has wide resources, land cover for regulation of NHR within the borders of the city. As a result of all, the case study area is selected as Düzce province due to the capacity to deal with NHR is high in the area.

4.4 Historical Background of Natural Hazards and Disasters in Düzce

North Anatolian Fault Line passes through plains of Düzce Province. Besides, the influence of urbanization and industrialization affected the city's development in time. However, due to availability of fault lines, instability of soil under heavy rainfall and flooding, natural hazard risks are highly available in the city. The destructive earthquakes expressed in Table 4.2 by Düzce Governorship (Url-3). As seen from the Table 4.2, the destructive earthquakes happened in the history, these events were expressed as disaster because of the scale of the destruction is high. The written history of destructive events in Düzce province dates back to 1940s, but, there was no deaths recorded in the history. Undoubtedly, the most destructive earthquake in Düzce Province is 12/11 earthquake occurred in 1999. The size and scope of the disaster was high and it could not be easy to overcome after a disaster for the province because Düzce as district was under the Bolu Province before 1999 Earthquake. After earthquake disaster, Düzce was declared as “province” with a decree of law in 09.12.1999 to heal the impacts of disaster with higher financial support from central government. This clearly demonstrates the encouragement of private sector in the province with subsidies provided by government (Url-4).

Table 4. 2: The most destructive earthquakes in Düzce (Url-3).

Date	Magnitude	Death (person)	Building Damage
10/02/1944	-	-	900
17/08/1999	7.4	270	20503 (heavy damage)
12/11/1999	7.2	845	15389

Natural hazard potential of Düzce province was clarified as earthquake, landslide and flood in a report called as “Düzce Province Report” which is prepared by members of Turkish Republic State Planning Organization (Özaslan et al., 2001). As expressed before, Düzce plain located on the North Anatolian Fault line (NAF) which is the most active fault line in Turkey. This fault line starts from the eastern parts of the country – Karlıova and continues by dividing into two main fault line around Bolu Province. Around Sakarya and Düzce provinces, two fault lines which is known as Hendek fault line and Düzce fault line attach to the main North Anatolian Fault Line system (Özaslan et al., 2001).

The historical disaster background of Düzce Province is analyzed in Disaster and Emergency Management Presidency database. There is a project called as “Turkish Disaster Knowledgebase” which is used for clarifying the historical disasters and losses. Moreover, there are also maps which were prepared by related unit of Ministry of Public Works and Housing in 2008 and these maps therefore show the spatial and temporal distribution of disasters in the whole country with province details. First of all, the historical disasters in Düzce Province are shown in Table 4.3 in detail. As seen from Table 4.3, the most probable and frequent disaster in the province is landslide. After landslide, the second highest frequency belongs to flood and the least frequency ratio belongs to earthquake although it has more severe and devastating impacts. There is also one rock fall declared-disaster occurred in 1983.

Table 4. 3: Historical disasters in Düzce Province between 1979 – 2008 years.

Year	Disaster	Year	Disaster	Year	Disaster
1979	Flooding	1989	Landslide	1999	Landslide, Earthquake
1980	Landslide	1990	Landslide	2000	Earthquake
1981	Landslide	1991	Landslide	2001	Landslide
1982	None	1992	Landslide	2002	Landslide, Earthquake
1983	Rock fall, Flooding, Landslide	1993	Landslide	2003	Landslide
1984	Landslide	1994	None	2004	Landslide
1985	Landslide	1995	Landslide	2005	Landslide
1986	None	1996	Landslide	2006	Landslide
1987	Landslide	1997	Flooding, Landslide	2007	Landslide
1988	None	1998	Flooding, Landslide	2008	None

The occurrence of serious disasters in the past can inform the potential threats in the future. However, it is also important to understand the size of damage when explaining disasters. The Turkish Disaster Knowledgebase project of Disaster and Emergency Management Presidency (AFAD) is helpful to clarify the damages on people and buildings with respect to types of disasters. From the website of the project it is possible to search historical disasters by provinces. In Analysis Module – Reports part, the systems have the capability to question disasters and accidents like earthquake, fire, landslide, flooding, terrorist attacks, highway car crashes, explosion, storm and typhoon and extreme weather conditions. The questioning time interval is selected as 01.01.1979 – 10.08.2019 for the consistency with data in Table 4.3. There is no result for fire, terrorist attacks and extreme weather conditions in the given time interval.

However, the other types of disasters and accidents are available in the given time interval. Due to the scope of this study, only disaster events will be expressed; hence, the results of earthquake, landslide and flooding will be given in Table 4.4. As seen from the Table 4.4, the highest loss of life and damage caused by 1999 earthquakes in Düzce Province. The second highest damage caused by flooding; nonetheless, it is clear from the table that the fundamental damage was on buildings not lives of people. There were two flooding events which were occurred in 1998-1999 and 2005-2006 time intervals. Flooding and landslide data ends in 2006 and 2016 respectively. However, there is also one harmful flooding and landslide disaster occurred in 2019 July. The massive rain in 17 and 18 July caused a huge destruction in Akçakoca, Cumayeri and Gölyaka Districts of the province. The size of destruction is not clear in recent days; nevertheless, the news on flooding in Düzce Province can reveal the size of destruction.

Table 4. 4: Disaster loss and damage information in Düzce based on historical data (Source: Turkey Disaster Knowledgebase Database).

Disaster	Loss Type	Time interval	Loss Number
Earthquake	Death (person)	1999-2000	1492
	Injured (person)	1999-2000	5356
	Damaged building (number)	1999-2000	133496
Landslide	Death (person)	2015-2015	1
	Injured (person)	-	0
	Damaged building (number)	1991-1992	20
		2001-2002	8
		2012-2013	13
		2013-2014	2
		2014-2015	10
		2015-2016	3
		Total	56
Flooding	Death (person)	1998-1999	1
	Injured (person)	-	0
	Damaged building (number)	1998-1999	60
		2005-2006	50
		Total	110

The climatic features of the province bring heavy rainfall in the area, and, there is a probability of mass movement due to the geological and geomorphological features of the ground. Moreover, it was a known fact that most of the mass movements happened in 1998 because of extreme rainfall. The landslide risk areas located near Yazlık Stream which goes through Düzce Akçakoca Motorway at north and Büyük Melen Stream Valley which located northern part of the Cumayeri District. The secondary

risk areas for landslide was expressed as foothills of Almacık mountain at south (Özaslan et al., 2001).



Figure 4. 5: The result and effect of 17-18 July 2019 flooding and landslide in Düzce Province, (Anadolu Agency, Url-5).

Due to the topographical structure of the area which are listed as rocky areas with steep slope and almost flat plain, the alluvial soil was formed near lowlands of Düzce province. Furthermore, the geometrical shape of the streams and minor elevation difference between Efteni Lake and stream beds cause shallow streams; thus, there is a risk of flooding in the central part of Center District (Özaslan et al., 2001).

4.5 Natural Hazards and Settlement Vulnerability in Düzce Province

The possible threat of natural hazards in the area are listed as earthquakes, landslide, liquefaction, erosion and flooding for Düzce Province (Özaslan et al., 2001; Aydın et al., 2018). The first phase of hazard mitigation starts with the hazard identification for given area, after that, the process is continued by stating vulnerabilities in the area and provisioning possible solutions and precautions for these vulnerabilities when dealing with hazards/disasters in recent efforts of resilience building attempts for hazard/disaster resilience.

Areas which are prone to natural hazards is shown in the Figure 4.6. According to the Figure 4.6, the available hazards are listed as flood, erosion, landslide, liquefaction, earthquake and combination of erosion, flood or landslide. Definition of flood prone areas is determined by the geological structure and geomorphological structure of the area. Firstly, digital elevation model was created for the area, after that, determination of natural structure of the province is provided by flow direction and the accumulation of flow analysis. These analyses revealed the stream web of the province; furthermore,

geomorphological structure, impermeable geological structure and stream web were evaluated together. As a result of all these analysis, flood prone areas were determined. Erosion areas, landslide areas, fault line data was taken from the related authorities while liquefaction areas are defined with the intersection of near groundwater level areas and plain areas. Table 4.5 therefore shows the distribution of natural hazards in Düzce Province. Furthermore, as a result of Table 4.5, %31.8% of the province has natural hazard risk and the higher risk belongs to flood. Flood risk is spread over the province at percentage with 43.53% due to the stream web structure of the area and geomorphological structure of streams. Second highest rate belongs to the liquefaction and flood risk with percentage of 21.60%. Third highest rate belongs to the liquefaction with percentage of 15.86%. Liquefaction prone areas mostly located central part of the city which is a place of alluvial soil, near underground water, intersection of streams and northern part of the main earthquake fault line as well as actual center of the province. Central part of the city is place for accumulation of stream flows; hence, flood risk is also common natural hazard with liquefaction in the central part of the province.

Table 4. 5: Natural hazard prone areas in Düzce Province.

Natural Hazard Type	Area (Ha)	% in province	% in total hazard
Erosion	12098.32	4.864%	15.318%
Flood	34385.76	13.824%	43.537%
Landslide	298.62	0.120%	0.378%
Liquefaction	12526.56	5.036%	15.860%
Erosion + Flood	2420.47	0.973%	3.065%
Erosion + Landslide	18.04	0.007%	0.023%
Flood + Landslide	161.82	0.065%	0.205%
Flood + Liquefaction	17067.25	6.861%	21.609%
Erosion + Flood + Landslide	3.55	0.001%	0.004%
Total Area of Hazard prone areas	78980.39 Ha		
Total Area of Province	248741.50 Ha		

As seen from the Figure 4.6, and Table 4.5, there are active fault lines northern and southern parts of the central district and high level erosion risk areas are located mostly the south part of the Yığılca district; moreover, landslide risk areas are distributed all over the province. In addition to all, the central part of the district has lower elevation and the geomorphological structure is called as plain. All streams are connected to each other in the plain area at Efteni Lake and carried to Black Sea by Büyük Melen Stream. Due to the lower slope near streams, the probability of flood occurrence is

high in rainy weathers and suitable climates. The plain also has lower groundwater level and the availability of water in underground with alluvial soil brings the risk of liquefaction. Due to the location of alluvial soil and lower groundwater level, the central part of the Center District is under the risk of liquefaction. The central part of the city is located on the high yield areas and it is critical to deal with natural hazards in these areas due to the lack of natural land cover and availability of higher amount of people.



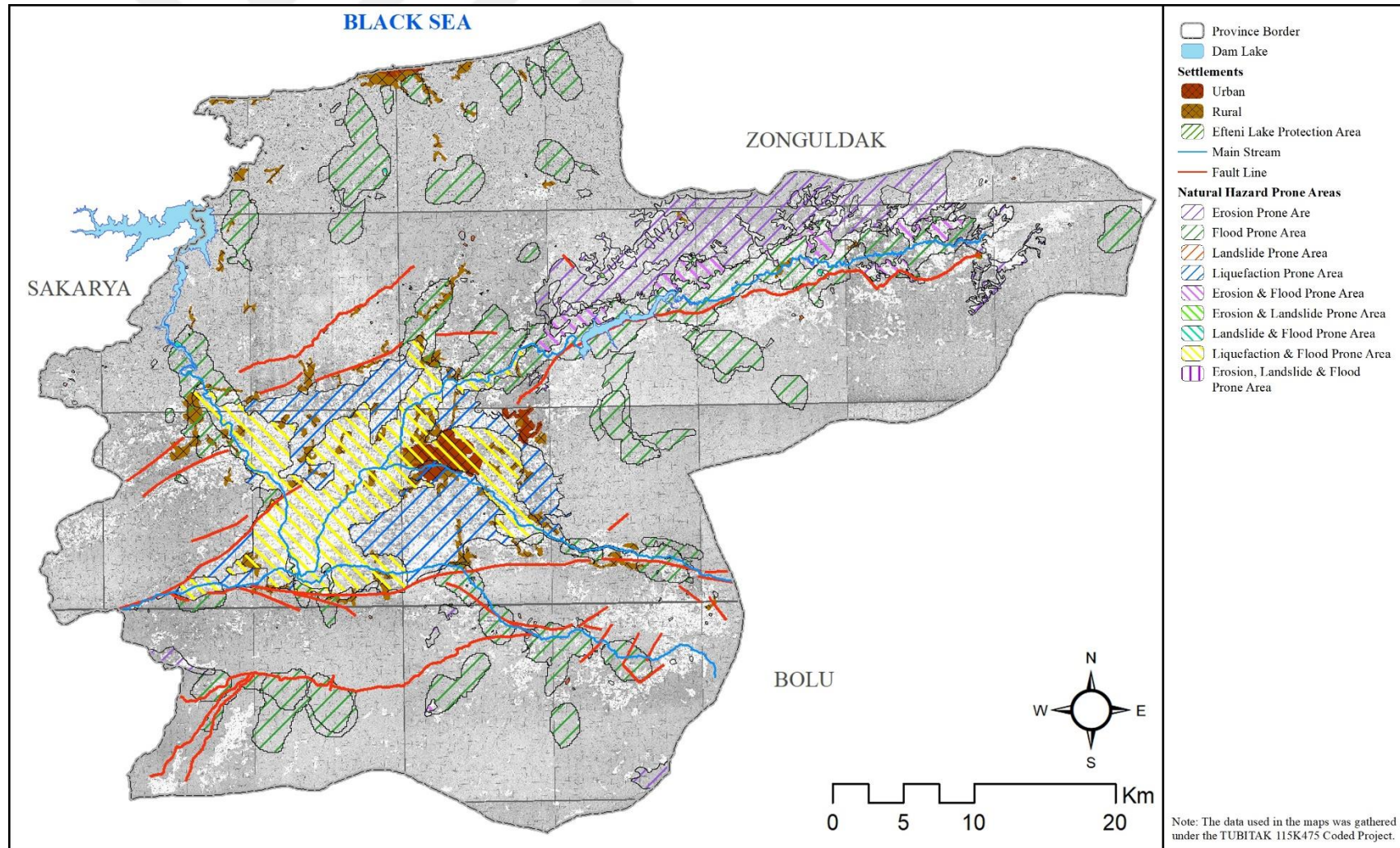


Figure 4. 6: Natural hazard prone areas in Düzce Province.

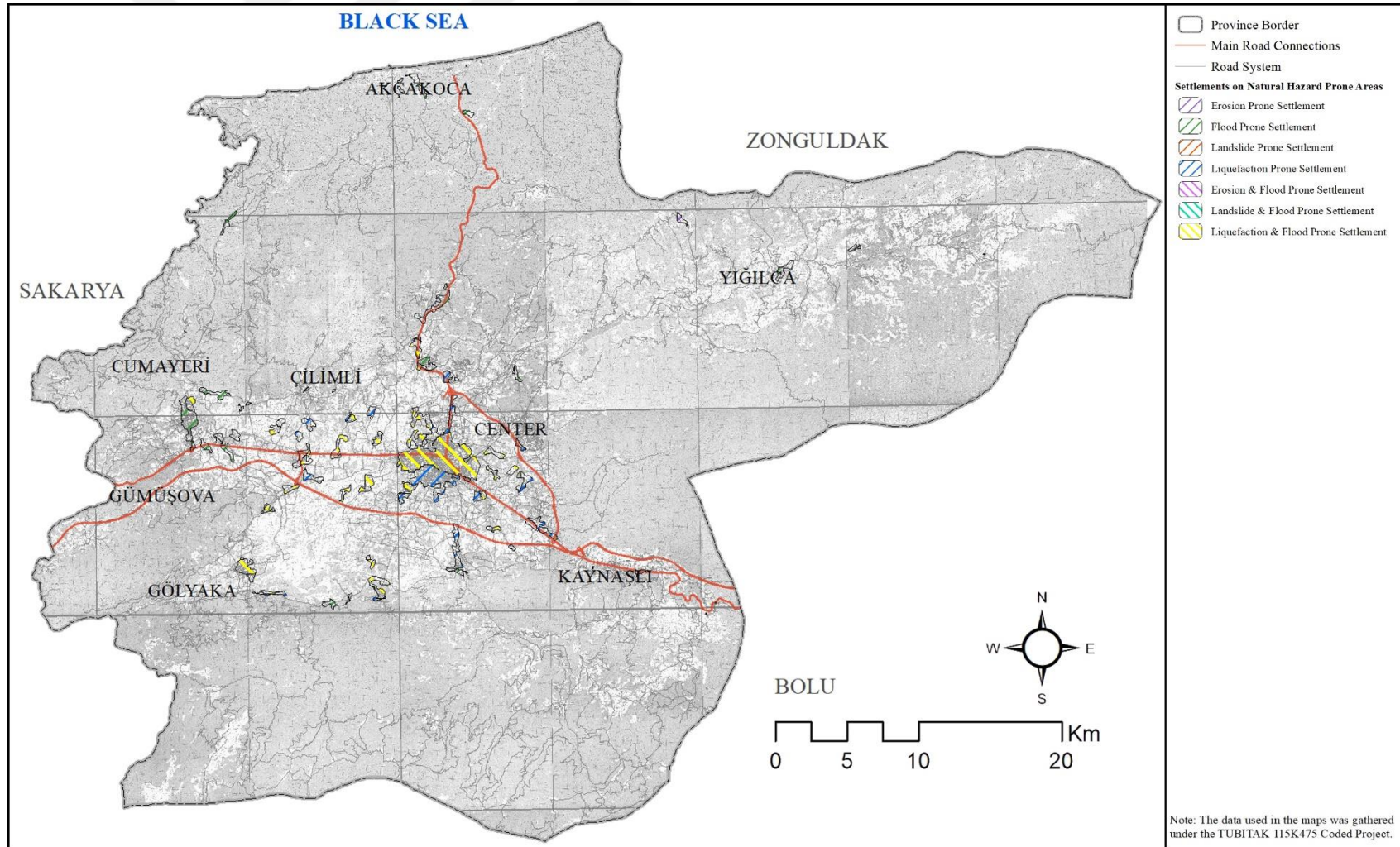


Figure 4. 7: Settlements on natural hazard prone areas in Düzce Province.

Central area of the province where the Düzce Plain exists has been exposed to urbanization and most of the people is living in central district. The availability of risks and population in a risky area create a vulnerability situation. In order to define vulnerability situation of the province, the settlements under natural hazard risk are defined, after that, population size under the risk of natural hazard could be defined easily.

Table 4. 6: Natural hazards of districts in Düzce Province.

DISTRICT	NATURAL HAZARD TYPE	Area (Ha)	%
AKÇAKOCA		133.28	3.138%
	Flood	133.12	3.135%
	Landslide	0.16	0.004%
ÇİLİMLİ		335.50	7.900%
	Flood	58.27	1.372%
	Liquefaction	154.51	3.638%
	Liquefaction + Flood	122.72	2.890%
CUMAYERİ		51.25	1.207%
	Flood	0.15	0.004%
	Liquefaction	0.25	0.006%
	Liquefaction + Flood	50.85	1.197%
GÖLYAKA		197.26	4.645%
	Flood	7.35	0.173%
	Liquefaction	49.52	1.166%
	Liquefaction + Flood	140.39	3.306%
GÜMÜŞOVA		330.57	7.784%
	Flood	275.67	6.492%
	Liquefaction + Flood	54.90	1.293%
KAYNAŞLI		101.13	2.381%
	Flood	15.97	0.376%
	Landslide	2.08	0.049%
	Liquefaction	83.08	1.956%
CENTRAL DISTRICT		2994.01	70.504%
	Flood	263.07	6.195%
	Landslide + Flood	0.02	0.001%
	Liquefaction	942.27	22.189%
	Liquefaction + Flood	1788.65	42.120%
YIĞILCA		103.61	2.440%
	Erosion	28.01	0.660%
	Erosion + Flood	0.31	0.007%
	Flood	75.29	1.773%
Area of Province		4246.60	100.000%

Figure 4.7 and Table 4.6 shows the natural hazard prone built-up areas in the districts of Düzce. The main contribution of the table is that Central District has the highest level of natural hazard prone areas and the most vulnerable area to natural hazards because of the highest amount of population and being the center of economic activities. Çilimli and Gümüşova Districts have second and third highest natural hazard vulnerability rate in Düzce Province; however, Central District has the highest natural hazard coverage rate which is around 70.5%. Liquefaction and liquefaction with flood are the common natural hazards in Central District and adjacent districts like Çilimli, Gümüşova, Gölyaka and Cumayeri. Erosion hazard is only probable in Yığılca District and landslide hazard is located in both Center, Kaynaşlı and Akçakoca Districts.

4.6 Analysis of ES Integrated Critical Areas for NHR

This section is dedicated to analyze ES based critical areas for NHR according to Burkhard et al.'s Corine Land Cover/Land Use Classification based ES potential approach (2014). Provisioning services consist raw material provision in general while cultural services consist positive influences of nature on people in general. However, regulatory services in ES consist of regulating natural hazards and waste. The dynamics of settlements has some externalities like livability and waste. When areas critical for natural hazard regulation, natural hazard and waste regulation is determined, critical areas for both supporting NHR and dealing with externalities of the settlements can be clarified.

Critical areas for regulating services will be analyzed in two different approaches: regulation of natural hazards and regulation of natural hazards and waste. Global climate regulation, local climate regulation, water flow regulation, erosion regulation and natural hazard regulation services are defined as services for NHR in the research while global climate regulation, local climate regulation, air quality regulation, water flow regulation, water purification, nutrient regulation, erosion regulation, natural hazard regulation, pollination, pest and disease control and regulation of waste services are defined as services for both natural hazard and waste regulation.

Table 4. 7: Regulating services for natural hazards and waste management.

Regulating Services	NHR	Waste Regulation
Global Climate Regulation	+	+
Local Climate Regulation	+	+
Air Quality Regulation	-	+
Water Flow Regulation	+	+
Water Purification	-	+
Nutrient Regulation	-	+
Erosion Regulation	+	+
Natural Hazard Regulation	+	+
Pollination	-	+
Pest and Disease Control	-	+
Regulation of Waste	-	+

Regulating ES for both NHR and waste regulation is critical for the definition of ecologically critical areas for NHR. To indicate the changing situation of the environment, the regulating ES capacity for Düzce Province is assessed in two different time interval: 2012 and 2018. Table 4.8 shows the distribution of Regulating ES and it is clear to explain that there is no huge difference between the years 2012 and 2018 for both NHR and natural hazard and waste regulation. However, while the size of no capacity, very low capacity, low capacity and very high capacity areas are increasing, the size of average capacity and high capacity areas is decreasing. The land cover/land use of high capacity areas in NHR consist of natural grasslands; besides, very high capacity areas in NHR consist of broad leaved forest, coniferous forest and mixed forest areas. The average capacity areas for both natural hazard and waste regulation consist of water courses, water bodies, fruit trees and berries, agriculture and natural vegetation, inland marshes and natural grasslands. The average capacity areas for NHR consist of fruit trees and berries, agriculture and natural vegetation, inland marshes and water bodies. As a result, it is clarified that forest areas are the most important land cover for the regulation of both waste and natural hazards. Due to the aim of the research, high capacity and very high capacity regulating ES areas for natural hazard regulation are defined as ecologically critical areas when dealing with natural hazards. The land cover/land use of critical areas consist of natural grasslands as high capacity regulating ES and broad leaved forest, coniferous forest and mixed forest as very high capacity regulating ES.

Table 4. 8: ES capacity level for regulation of natural hazards and waste in Düzce Province between 2012 – 2018 years.

ES Capacity Level	2012		2018	
	Regulating Services for Natural Hazard & Waste Regulation	Regulating Services for Natural Hazard Regulation	Regulating Services for Natural Hazard & Waste Regulation	Regulating Services for Natural Hazard Regulation
	Area (Ha)	Area (Ha)	Area (Ha)	Area (Ha)
No Capacity	328.19	328.19	495.20	495.20
Very Low Capacity	7593.82	7593.82	8778.46	8778.46
Low Capacity	41237.34	41500.19	41780.51	42161.54
Average Capacity	80729.98	79190.74	78778.30	77121.52
High Capacity	0.00	1276.39	0.00	1275.75
Very High Capacity	118869.58	118869.58	118925.06	118925.06

Figure 4.8, 4.9, 4.10 and 4.11 illustrates the regulating ES capacity distribution in Düzce Province by 2012 and 2018. Central part of the province has the very low capacity areas as settlements, these areas surrounded by low capacity areas at the same time. Around low capacity areas and northern and northwestern part of the province, there are average capacity areas as mainly fruit trees which is known with hazelnut gardens and agriculture and vegetation covered areas. Except north and northeast, other sides of the province is surrounded by very high capacity areas as forests. High capacity areas as natural grasslands for natural hazard regulation is scattered through the province.

As seen from Figure 4.7 and 4.8, regulating ES capacity in Düzce Province in 2012 for natural hazard regulation is distributed as 0.13% as no capacity areas, 3.05% as very low capacity areas, 16.68% as low capacity areas, 31.83% as average capacity areas, 0.51% as high capacity areas and 47.79% as very high capacity areas while regulating ES capacity for natural hazard and waste regulation is distributed as 0.13% as no capacity areas, 3.05% as very low capacity areas, 16.58% as low capacity areas, 32.45% as average capacity areas, 0.00% for high capacity areas and 47.79% for very high capacity areas.

Besides, the Figure 4.9 and 4.10 illustrate the regulating ES capacity in Düzce Province in 2018 for natural hazard regulation and natural hazard and waste regulation. Natural hazard regulation is distributed as 0.20% as no capacity areas, 3.53% as very low capacity areas, 16.95% as low capacity areas, 31.00% as average capacity areas, 0.51% as high capacity areas and 47.81% as very high capacity areas while natural hazard and waste regulation is distributed as 0.20% as no capacity areas, 3.53% as very low capacity areas, 16.80% as low capacity areas, 31.67% as average capacity areas, 0.00% for high capacity areas and 47.81% for very high capacity areas.

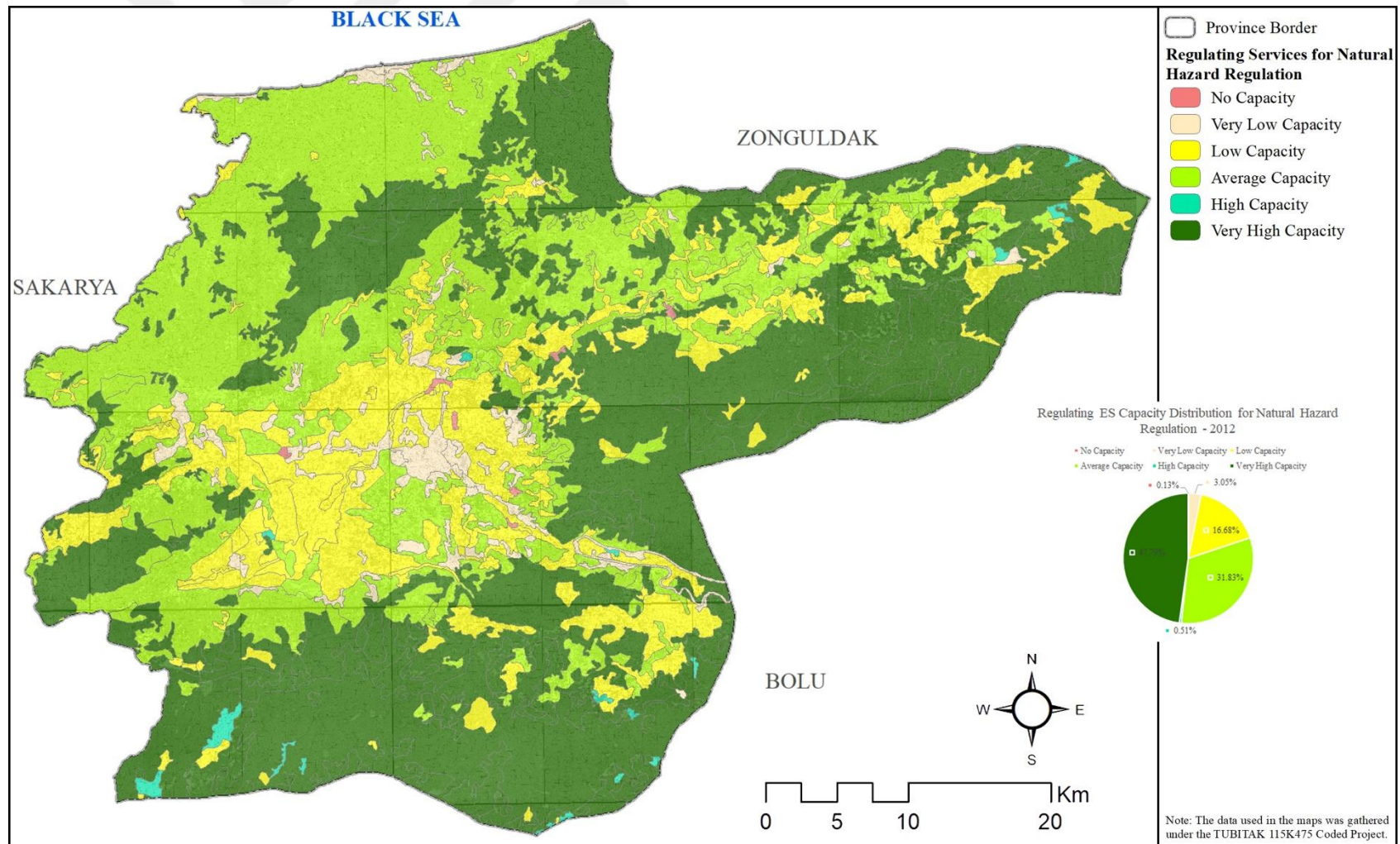


Figure 4. 8: Regulating ES for natural hazard regulation in 2012.

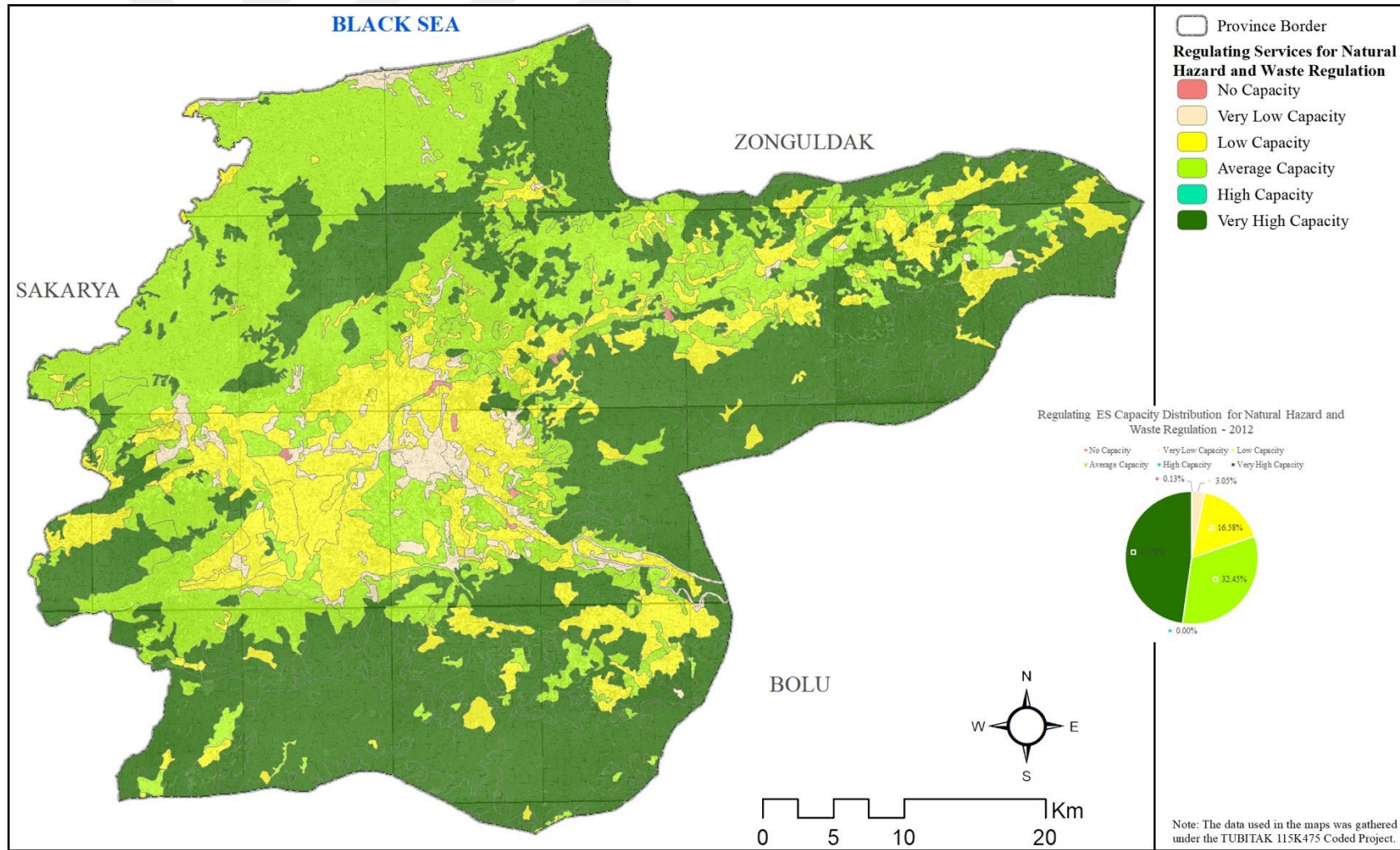


Figure 4. 9: Regulating ES for natural hazard and waste regulation in 2012.

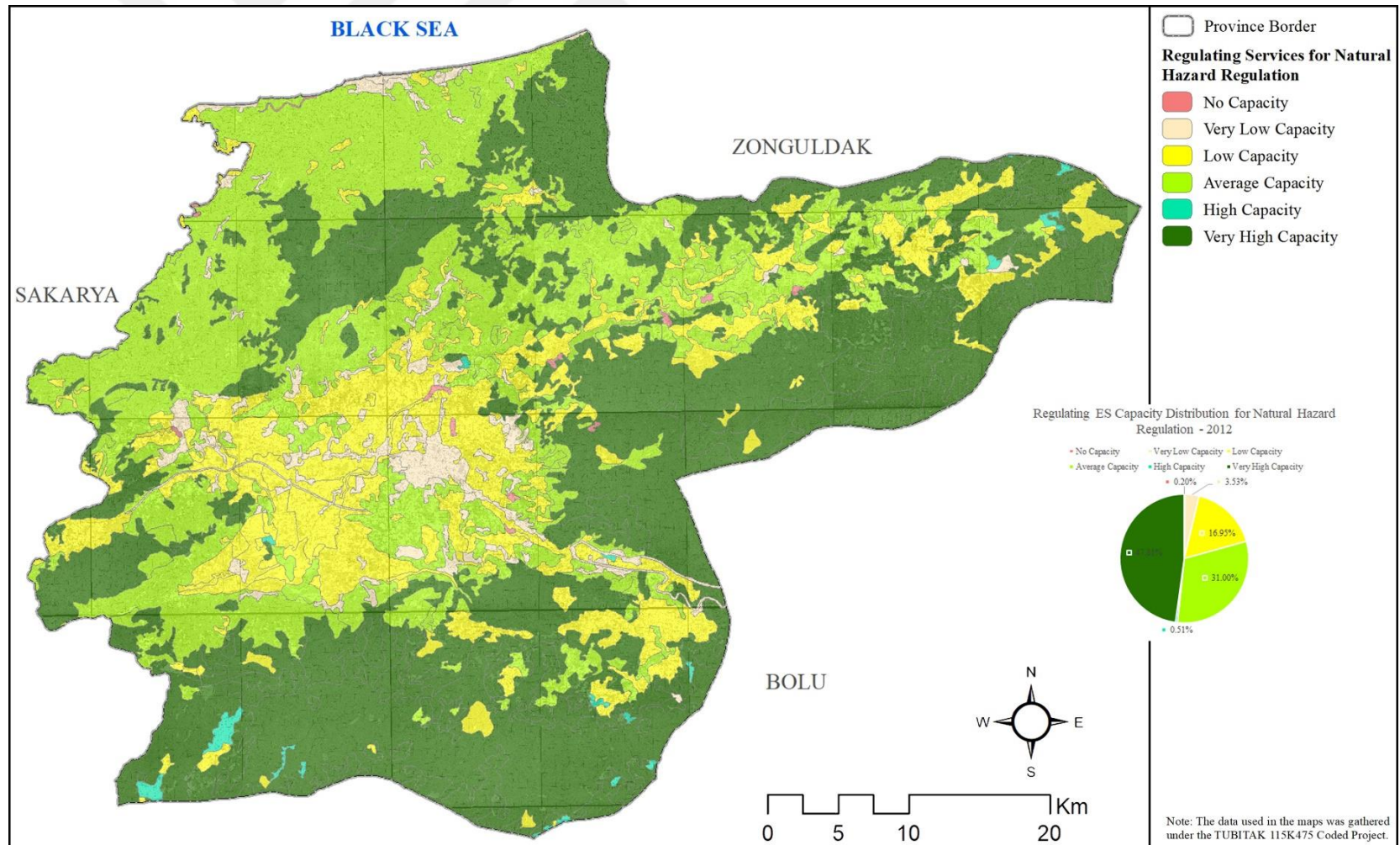


Figure 4. 10: Regulating ES for natural hazard regulation in 2018.

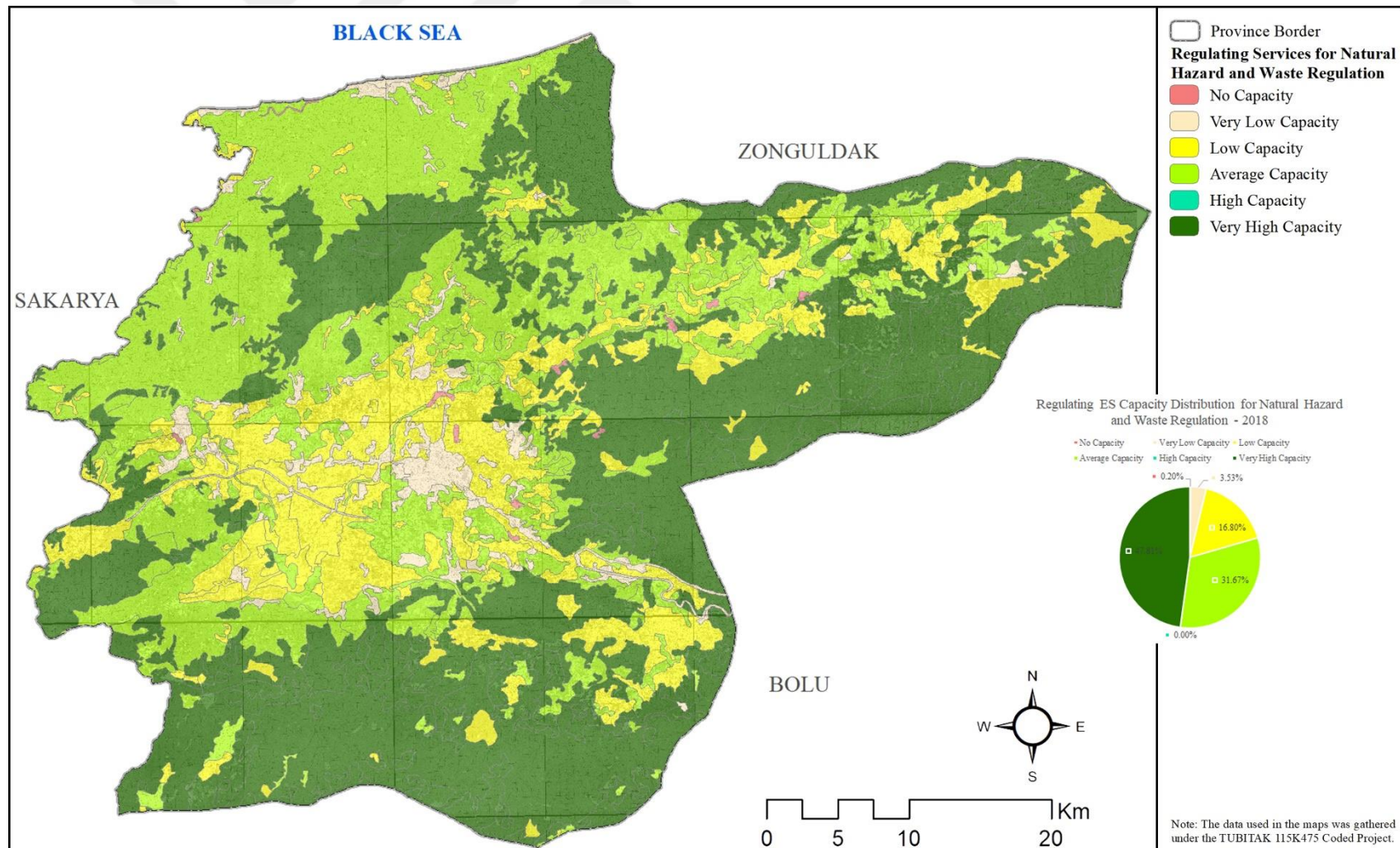


Figure 4. 11: Regulating ES for natural hazard and waste regulation in 2018.

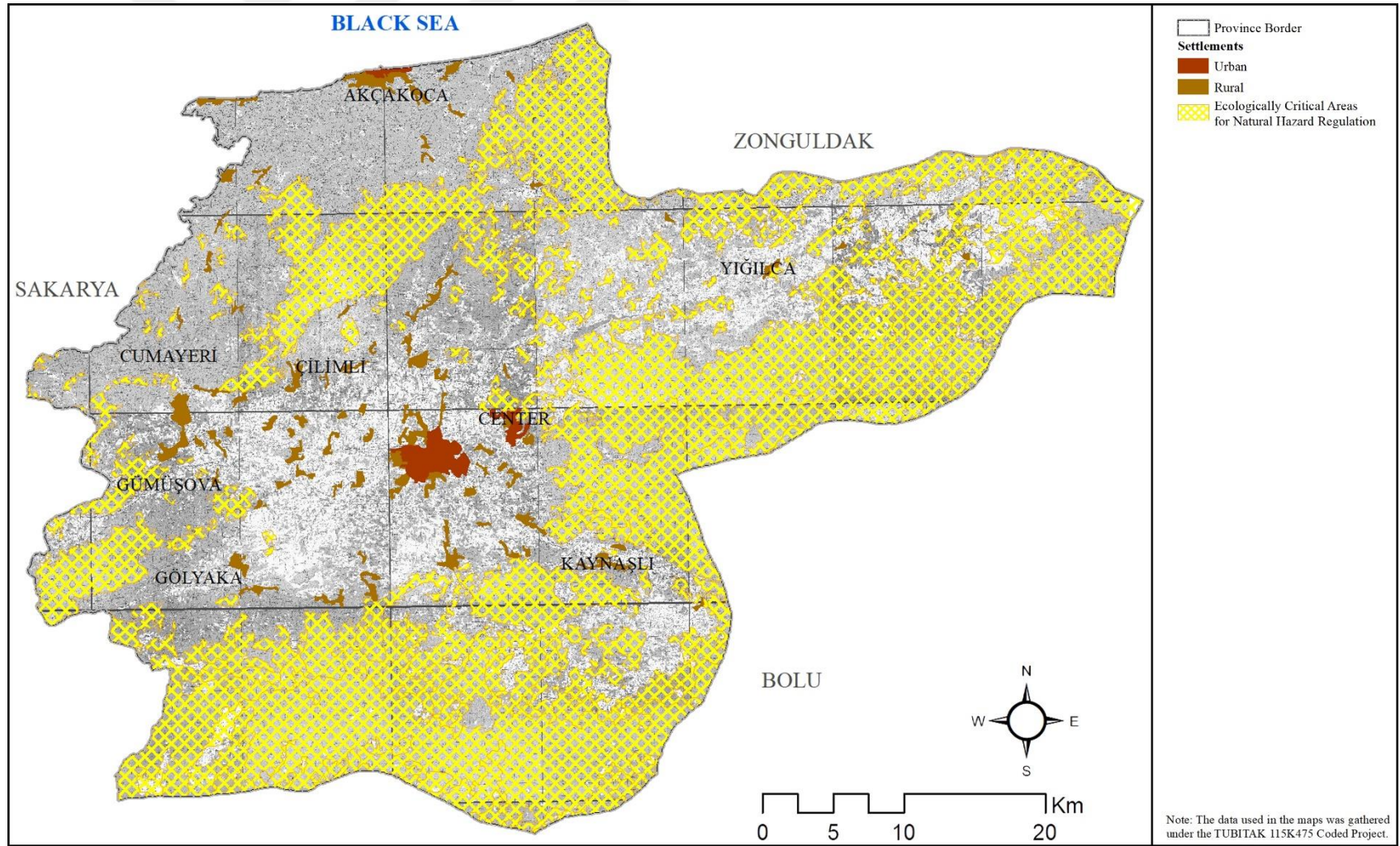


Figure 4. 12: Ecologically critical ES areas for natural hazard regulation.

Table 4. 9: Ecologically critical areas for natural hazard regulation.

Land Cover/ Land Use	ES Capacity	Area (Ha)	%
Broad Leaved Forest	Very High Capacity	68286.67	27.5%
Coniferous Forest	Very High Capacity	6560.947	2.6%
Mixed Forest	Very High Capacity	44077.44	17.7%
Natural Grasslands	High Capacity	1275.754	0.5%
TOTAL		120200.8	48.3%

Ecologically critical areas for natural hazard regulation from the perspective of ES will help to clarify the fundamental hot spots for dealing with natural hazards in province level. Figure 4.11 and Table 4.7 illustrates the ecologically critical areas which consist of forest areas and natural grasslands. Broad leaved forests, coniferous forests and mixed forests are fundamental source of natural hazard regulation services. The size of critical areas covered in 120200.8 hectares and 48.3% of the province. The remaining land cover/land use belongs to no capacity, very low capacity, low capacity and average capacity for natural hazard regulation, because the availability of vast agricultural areas, hazelnut gardens and settlements.

4.7 Comparing 1/100.000 Scale Düzce Environmental Master Plan with Vulnerable Areas to Natural Hazards

1/100.000 Düzce Environmental Master Plan mainly shows the main investments, connections, land use decisions and urban development direction in a comprehensive way. The aim of the plan is to show main tendencies and development pattern with protected land covers; moreover, it is not possible to calculate any size from the plan. When natural hazard prone areas intersect with 1/100.000 scale Environmental Master Plan of Düzce Province, the vulnerable areas to natural hazards in the future planning decisions can be detected. Table 4.10-11 and Figure 4.13 shows the distribution, size and length of hazard prone areas and connections.

As seen from the Figure 4.13, there are connections vulnerable to natural hazards and these connections consist of highway, railway, state roads and other minor roads. Furthermore, urban land use / land cover in natural hazard prone areas are clarified as infrastructure areas, archaeological conservation areas, prison area, pasture-grassland area, agricultural area, forest area, organized industrial area, industrial area, thermal spring area, urban settlement area, administrative infrastructure area, health infrastructure area, quarry area, tourism center and accommodation area, wildlife

conservation and development area, dormitory area, university area and plateau area. Most of the urban land uses located at the center of Center District and under the threat of liquefaction as well as flooding due to lower groundwater level, alluvial soil and location for the intersection of stream web.

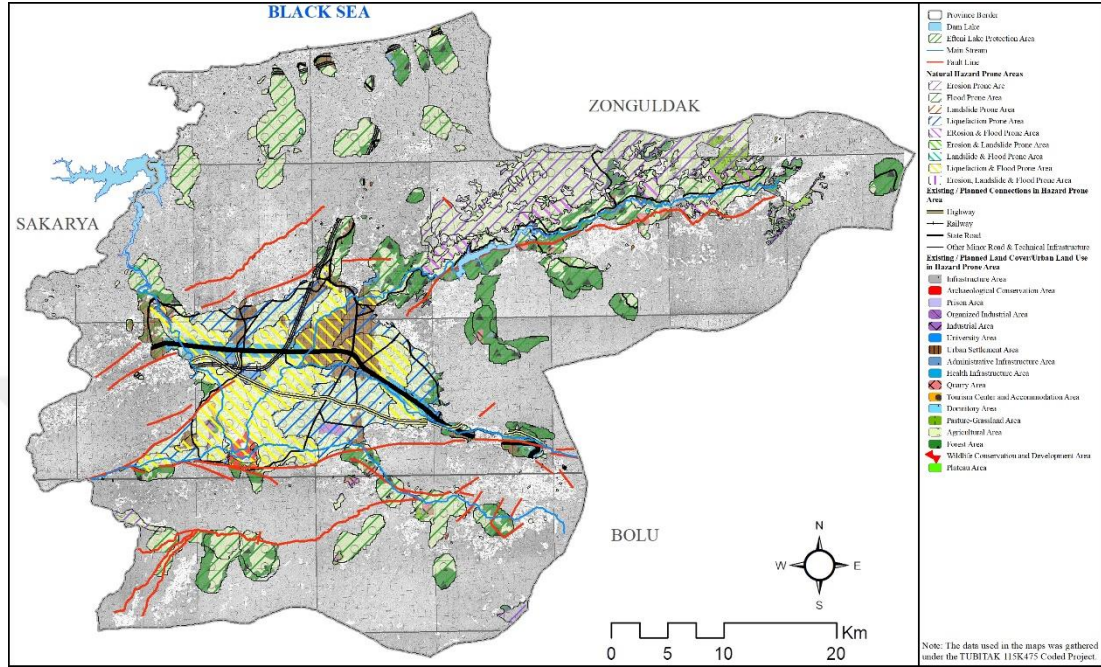


Figure 4. 13: Vulnerable areas in regards to natural hazards in 1/100.000 Düzce Environmental Master Plan.

The highest rate of existing / planned land cover in hazard prone area belongs to agricultural areas with rate of 65.89 while second and third highest rate of existing / planned land cover in hazard prone area belongs to forest area (16.15%) and urban settlement area (8.44%) respectively. Moreover, the highest rate of transportation systems in hazard prone area belongs to the minor roads and other technical infrastructure with rate of 39.5%. All of these hazard prone functions and connections form the vulnerabilities of Düzce province. It is important to know vulnerabilities and available risk to deal with natural hazards in a resilient way. Natural land covers are fundamental for overcoming natural hazards from the perspective of non-structural approaches to resilience building. However, as seen form Table 4.10, fundamental infrastructures such as health and administration have been located natural hazard prone areas. When a disaster strikes a community, these type of infrastructures are basic locations as emergency gathering. If these locations under the risk of hazards, the gathering location decision is not efficient in time of disaster.

Table 4. 10: Existing/planned land cover/land use in hazard prone area.

Existing / Planned Land Cover / Urban Land Use in Hazard Prone Area	Area (Ha)	%
Infrastructure Area	17.11	0.02%
Archaeological Conservation Area	28.73	0.04%
Prison Area	11.55	0.01%
Organized Industrial Area	180.04	0.22%
Industrial Area	118.70	0.14%
University Area	61.72	0.08%
Urban Settlement Area	6926.93	8.44%
Administrative Infrastructure Area	628.81	0.77%
Health Infrastructure Area	1761.85	2.15%
Quarry Area	1285.78	1.57%
Tourism Center and Accommodation Area	242.90	0.30%
Dormitory Area	9.16	0.01%
Pasture-Grassland Area	2553.12	3.11%
Agricultural Area	54048.81	65.89%
Forest Area	13251.52	16.15%
Wildlife Conservation and Development Area	815.99	0.99%
Plateau Area	87.48	0.11%
Grand Total	82030.19	100.00%

Table 4. 11: Existing/planned connections in hazard prone area.

Existing / Planned Connections in Hazard Prone Area	Length (Km)	%
Highway	31.3	7.5%
Railway	93.5	22.4%
State Road	128.3	30.7%
Other Minor Road and Technical Infrastructure	165.0	39.5%
Grand Total	418.1	100.0%

On account of all these explanations, urban land uses which are located in hazard prone areas should therefore be considered in planning process. Table 4.10 reveals the vulnerable functions to natural hazards like organized industrial area and industrial area. These areas are main source of economic activities and employment in province; besides, planning and management of these areas are critical to enhance resilience approach. Because resilience means “*the overcome capability towards a disturbance.*” It is vital to sustain physical, ecological, economic and social structure of the settlements towards natural hazards.

4.8 Comparing Ecologically Critical Areas with Vulnerable Areas to Natural Hazards

In this section, corine land classification system based ES capacity mapping for regulating natural hazards will be evaluated with natural hazard prone areas in Düzce Province. As expressed before, ecologically critical areas which are also very high and high capacity natural hazard regulation ES at the same time consist of forests (broad leaved, coniferous, mixed) and natural grasslands. When ecologically critical areas under the risk of natural hazard is evaluated, most of the broad leaved forest areas located in natural hazard prone locations (Figure 4.14, Table 4.12).

Table 4. 12: Capacity based distribution of ecologically critical areas for regulating ES in hazard prone area.

Land Cover	ES Capacity	Area (Ha)
Broad Leaved Forest		
	Very High Capacity	12115.8
Coniferous Forest		
	Very High Capacity	826.4
Mixed Forest		
	Very High Capacity	7332.9
Natural Grassland		
	High Capacity	104.6
Grand Total		20379.7

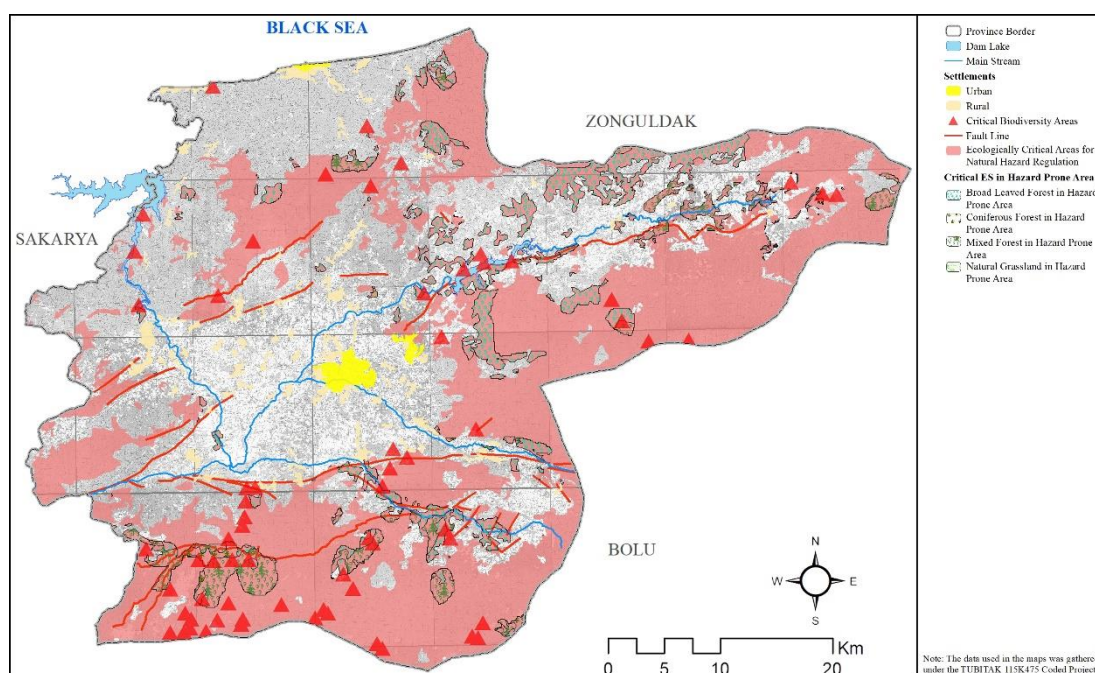


Figure 4. 14: Ecologically critical areas for regulating ES in hazard prone area.

4.9 Spatial Planning System in Turkey and Current Situation of Hazard

Mitigation

Spatial planning system in Turkey consists of several spatial plans in different scales to regulate spatial, social and economic development for regions, settlements and neighborhoods. The planning hierarchy defined in the Law on Land Development and Planning (Law No: 3194) and the Regulation for Spatial Land Development. These two legal documents clearly define the details of plans and how a plan document and report have to be prepared in a comprehensive way. The system starts with the socio economic plans at national level, on the other hand the next level plans are Strategic Spatial Plans which directs physical development and sectoral decisions through integrating ecological, social and economic policies and strategies into spatial environment. The next level plans are Environmental Master Plans which is prepared at province level in general. The plan includes decisions on settlements, development areas, sectors, and directs lower level plans through land use planning decisions suitable with the aim and strategies of Strategic Spatial Plans. The main lower level plans which direct physical development in space are 1/5000 scale Land Use (Zoning) Plan and 1/1000 scale Detailed Implementation Plan. 1/5000 scale Land Use Plans include decisions on transport system, land use and densities while 1/1000 scale Detailed Implementation Plans defines the actual physical development conditions in space. There are also special purpose plans and complementary plans available in the hierarchy of planning (Law on Land Development and Planning, 2985; Regulation for Spatial Land Development, 2014).

According to the hierarchy rule of plans, lower level plans should be compatible with upper level plans. Within general planning rules, planning process expressed in a detailed way. According to the regulation, the planning process consists of preliminary research, stating problems, data and information gathering and analysis, synthesis and planning decisions. After the synthesis stage, the planning process ends with statement of planning decisions. However, there is no system clearly defines the implementation and monitoring system of the plans. The monitoring system can be followed by activity reports of related institutions and organizations (Regulation for Spatial Land Development, 2014). The monitoring and implementation system of plans are not clearly defined in legal documents as seen from the explanation above. Current

developments in planning requires a smarter approach to make easy to monitor process of implementation and effects of planning decisions.

The inclusion of natural hazards and disaster risks into planning also defined in the Regulation for Spatial Land Development. The regulation covers the inclusion of data and opinion of related institutions into plans and planning process; however, monitoring and implementation process of decisions given from the related stakeholders is not clearly defined. The opportunities of smart infrastructures may help to develop the complementary part of the planning process because the planning process does not include only preparation of plan blueprints. Implementation, monitoring and feedback mechanisms are also remaining stages of the planning process.





5. CONCLUSIONS AND RECOMMENDATIONS

Resilient city concept is complementary development concept to live with uncertainty and natural hazards. NHR is the fundamental concept in recent years to adapt changes caused by both climate change and other settlement dynamics; moreover, SSM approach may help to ensure NHR in spatial planning. On account of these facts, this thesis pointed out the conceptual ground for NHR and SSM concepts. The most fundamental outcomes of this research can be grouped into three groups:

1. The statement of the resilience concept and evolutionary way to NHR (This process requires the clarification of resilience, disaster resilience, hazard resilience and attributes of NHR)
2. The statement of the smart city concept and evolutionary way to SSM (This process requires the clarification of attributes of smart cities and evolutionary way to SSM to integrate spatial planning and integration of SMM into ES)
3. The development of NHR supported SSM implementation proposals related with the dynamics and features of the settlement (Figure 5.1).

From Resilience to NHR

Resilience has its roots from mid-19th century in different research areas, however, the idea of resilient city gains importance after hurricanes occurred in US. The idea of being resilience to natural hazards is provided by adaptation and mitigation to them. Brown et al. (2012) expressed that it is fundamental to build resilience in settlements with the help of adaptation measures. Moreover, Beatley and Newman (2013) & Alberti (2005) expressed that from the perspective of resource management meaning natural resources and assets, provision of resilience will be more effective. Although there is a weak balance between hazard mitigation and spatial planning, early hazard mitigation attempts try to decrease vulnerabilities to natural hazard or any stress. However, recent organizations of DRR especially natural hazards clarified the weakness of planning attempts. Even though the results of hazard mitigation process integrated into spatial planning, there is still development in hazard-prone areas. As a

result of this, there is a need to focus more on integration of spatial land management with resource management activities. Recent developments show that the use smart approaches provide more integrated and effective ground for spatial land management.

Smart City to SSM

Early attempts of smart cities aim the sustainable economic development and good quality of life. The concept evolved around the ICT and human behaviors, and according to Kummitha and Krutzen (2017), the evolution process starts with installation of ICT, integration of human element into cities, active use of technology and existence of leading companies. The recent application of smart city examples developed around the last two notions: the leading role of companies and active use of technology to create a living lab experience. All of these developments show the role of people and how people's contribution occurred into a smart city. When the idea of smartness and spatial land development considered, SSM is a new and developing concept in the literature. SSM means basically the use of ICT to identify, monitor, analyze, manage and develop future prospects according to results of process not only in cities but their interaction areas, too; especially when the significance of natural resources input and natural hazard risks to be integrated.

NHR with SSM

Building NHR requires a different approach than regular hazard resilience building approaches. The need for resource management clearly showed that in a NHR building process, it is needed to have an ecological planning approach. In ecological planning, there are two main goals: effective use of resources and mitigating risks. When the system put forwarded for consideration with Newman's (1999) settlement metabolism model, the main goals of planning are increasing livability by utilizing resources and controlling and decreasing effects of externalities by mitigating risks coming from nature and settlement dynamics. Installation of ICT in the structure of ecological planning will provide a SSM-based approach. Moreover, the integration of SSM approaches into NHR building process will act as an activator and a facilitator for identification of natural hazards, vulnerabilities, risks, management of spatial development, providing policies for future development and long-term planning.

Ensuring NHR by SSM in Spatial Planning

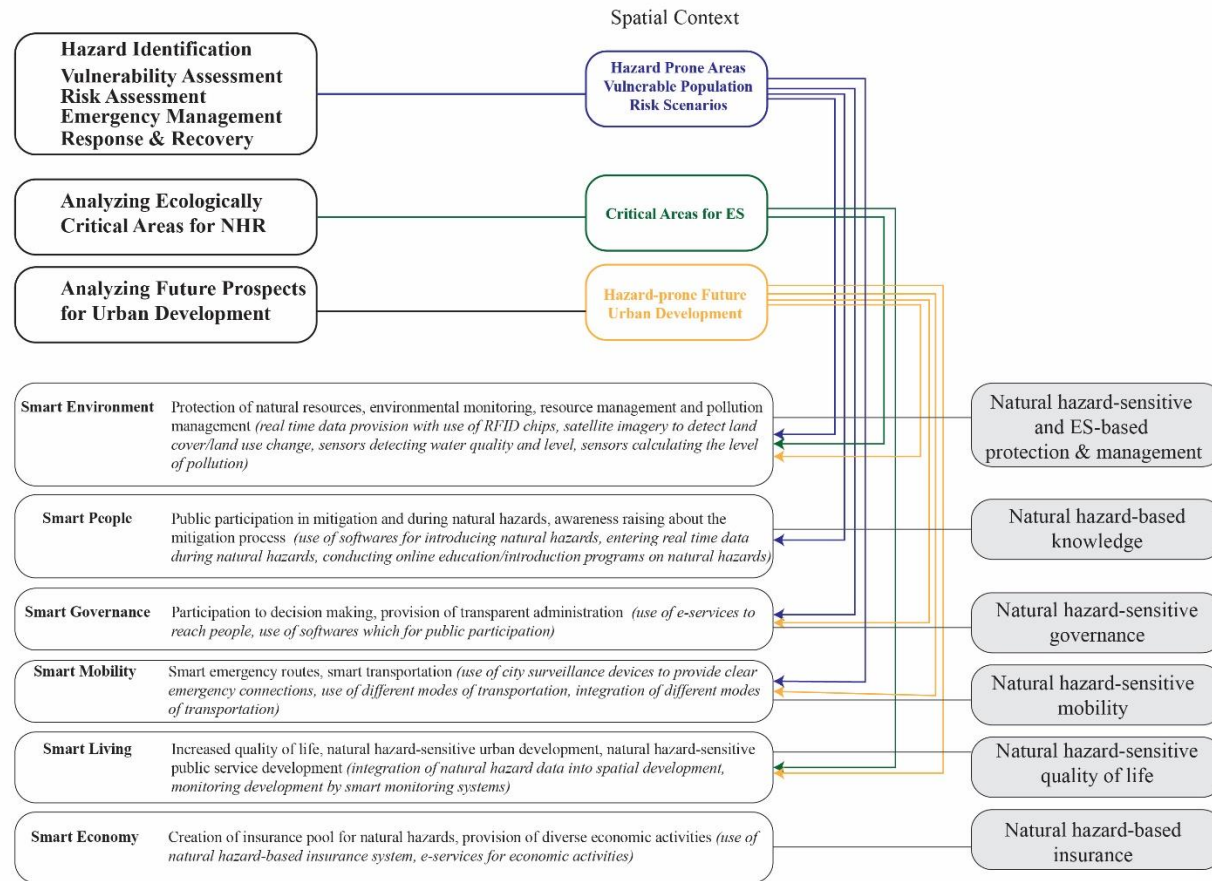


Figure 5. 1: Ensuring NHR by SSM in spatial planning.

SSM proposals are developed with six development axis which is defined before (Figure 5.1). These axes are smart environment, smart people, smart governance, smart mobility, smart living, and smart economy. The aim of the smart environment to ensure NHR is protection of natural resources, environmental monitoring, resource management and pollution management. The aim of the smart people axis to ensure NHR is public participation in mitigation process, awareness raising while fundamental aim of the smart governance is participation to decision making process and provision of a transparent administrative mechanism. The aim of smart mobility to ensure NHR is smart emergency routes and smart modes of transportation. On the other hand, the last spatial axis of SSM is smart living which aims increased quality of life, natural hazard-sensitive urban development and natural hazard-sensitive public service development. Finally, the aim of smart economy to ensure NHR is creation of an insurance pool for natural hazards and provision of diverse economic activities. The relational conclusion of the proposed spatial planning system is shown in Figure 5.1. Provision of NHR, which is developed by SSM approaches, requires related to natural hazard-sensitive and ES-based protection and management, natural hazard-based knowledge, natural hazard-sensitive governance, natural hazard-sensitive mobility, natural hazard-sensitive quality of life and natural hazard-based insurance.

In addition to all of these, analysis for mitigation of natural hazards is the experimental part of the study. The evaluation on hazard identification, vulnerability assessment and risk scenarios conducted to determine future policies, which will be adopted and proposed based on SSM. The main reason for processing NHR by SSM is that there are missing or not clearly defined mechanisms after plan creation in settlements in Turkish legal system, furthermore, SSM will be an efficient tool to complete the missing part of the spatial planning process.

To conclude, developing a NHR can be developed by a SSM concept approach. NHR mitigation is dealing with evaluation of current situation, ecological structure and future development prospects based on hazard prone areas. SSM concept for ensuring NHR helps to minimize or control the externalities of settlement dynamics and to increase livability level in settlements comprehensively. Integration of smart approaches into spatial development provides an integrated and comprehensive planning and management in settlements.

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PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- **Aydın, B , Tezer, A , Türkay, Z , Kutay Karaçor, E , Güler, İ , Uzun, O , Okay, N , Terzi, F , Köylü, P , Satılmış, E , Kara, D .** (2018). Resilience Through Participatory Planning for the Integrated Ecological Risks in Düzce. Resilience, 2 (2), 105-121. DOI: 10.32569/resilience.484946

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