

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING AND TECHNOLOGY

**CRITICAL ASSESSMENT OF ‘STREAM DAYLIGHTING’ AS AN APPROACH
FOR RENATURALIZATION OF RIVERINE SYSTEMS IN URBAN AREAS
CASE STUDY ON: AYAMAMA STREAM**

M.Sc. THESIS

Meltem DELİBAŞ

Department of Urban and Regional Planning

Regional Planning Programme

APRIL 2012

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

**KENTSEL AKARSU KORİDORLARININ YENİDEN
DOĞALLAŞTIRILMASINDA ‘NEHİRLERİN GÜN IŞIĞINA ÇIKARILMASI’
YAKLAŞIMININ İRDELENMESİ: AYAMAMA DERESİ ÖRNEĞİ**

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To my grandmother Nebahat Gürbüz and my family,

FOREWORD

To Assoc. Prof. Dr. Azime Tezer;

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April 2012

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ABBREVIATIONS

ASLA	: American Society of Landscape Architects
CBD	: Central Business District
CIWEM	: Chartered Institution of Water and Environmental Management
Co-MISDAL	: Conceptual Model of Integrated Stream Daylighting
CRSSR	: Center for Riverine Science and Stream Renaturalization
CWA	: Clean Water Act
CWP	: Center for Watershed Protection
DDA	: Downtown Development Authority
DPSIR	: Driving Forces-Pressures-State-Impacts-Responses
DRPC	: Danube River Protection Convention
EEA	: European Environment Agency
EPA	: United States Environmental Protection Agency
EU	: European Union
FAO	: Food and Agriculture Organization of the United Nations
GDP	: Gross Domestic Product
GNP	: Gross National Product
GWP	: Global Water Partnership
IAEA	: International Atomic Energy Agency
IDTM	: World Trade Center
IMM	: Istanbul Metropolitan Municipality
IMP	: Istanbul Metropolitan Planning Centre
ICPDR	: International Commission for the Protection of the Danube
ICWE	: International Conference on Water and the Environment
IDNR	: The Indiana Department of Natural Resources
ILA	: International Law Association
ILC	: International Law Commission
ISKI	: Istanbul Water and Sewerage Administration
IUCN	: International Union for Conservation of Nature
IUGS	: The International Union of Geological Sciences
IWRM	: Integrated Water Resource Management
KSCE	: Korean Society of Civil Engineers
MDGs	: Millennium Development Goals
MEA	: Millennium Ecosystem Assessment
NBI	: Nile Basin Initiative
NGOs	: Non-governmental Organization
NOAA	: National Oceanic and Atmospheric Administration
NRC	: National Research Council
OECD	: Organization for Economic Co-operation and Development
OECD/DAC	: Development Co-operation Directorate
ORSAM	: Center for Middle Eastern Strategic Studies

PCR	: Pressure-Condition-Response Model
RCAA	: Natural Resources Services Division of the Redwood Community Action Agency
SAB	: The Science Advisory Board
SPU	: Seattle Public Utilities
TurkStat	: Turkish Statistical Institute
UCTEA	: Union of Chambers of Turkish Engineers and Architects
UK	: United Kingdom
UN	: United Nations
UNCED	: United Nations Conference on Environment & Development
UNCSD	: United Nations Conference on Sustainable Development
UNECE	: United Nations Economic Commission for Europe
UNEP	: United Nations Environment Programme
UNEP/GPA	: Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
UNESCO-IHP	: The International Hydrological Programme
UNFCCC	: United Nations Framework Convention on Climate Change
UNFPA	: United Nations Population Fund
USS	: Urban Stream Syndrome
WCED	: World Commission on Environment and Development
WFD	: Water Framework Directive
WWF	: World Wild Fund for Nature

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CRITICAL ASSESMENT OF ‘STREAM DAYLIGHTING’ AS AN APPROACH FOR RENATURALIZATION OF RIVERINE SYSTEMS IN URBAN AREAS CASE STUDY ON: AYAMAMA STREAM

SUMMARY

The world’s population is concentrated in urban areas and urbanization became a dominant demographic trend as well as an important component of global land transformation (United Nations, 1993). On the other hand, in addition to its global reach, growing populations, changing consumption patterns, expansion of built-up areas and current unqualified lifestyles of urban contexts are seen as unsustainable development patterns in the long term (Karr, 1999) with a number of documented effects on urban ecosystems.

The ecology of urban areas basically recognizes the city as a legitimate ecosystem that includes the ecological effects of land use change, the spatial distribution of resources (abiotic) or species populations (biotic) and whole system metabolism (energy flow) (Lord et al., 2001). In this context, riverine systems as a key component of urban ecosystems has an important role with not only providing important source of water and material but also have an ecological importance with the riparian areas which are the hotspots of interactions among plants, soil, water, microbes and people. As riverine systems in urban areas occur at the land-water junction alongside the natural waterways, they form unique ecosystems that act as ‘buffer zones’ between upstream and downstreams (Lowrance, 1998). However, the riverine systems as one of the essential components of natural processes are exposed the crisis of ecological deterioration with the acceleration of urbanization. Especially increasing anthropogenic activities in urban areas caused several alterations on riverine systems’ hydro-morphological and ecological structure. Over time, the functions of urban riverine systems have been gradually weakened, the channels were polluted, buried and the riverine characteristics have been lost.

All these negative effects of urban areas on riverine systems emerged the term of ‘Urban Stream Syndrome (USS)’ (Walsh et al., 2005) which is characterized by geomorphic and hydrologic alterations of riverine systems and describes the consistently observed ecological degradation of waterways (creeks, streams, rivers) draining urban land. From this point of view, the health of riverine systems become an important issue and a key concept in terms of system integrity and continuity specially for maintaining ecological processes of aquatic habitats and community of organisms. The term of ‘river health’ requires thinking of a river as an ecological system, not merely a channel that conveys water from one origin to downstream (Changming and Xiaoyan, 2008). On the other hand, the ‘Healthy Rivers’ concept constitutes the basis for renaturalization of degraded riverine systems by several rehabilitation or restoration techniques and directs the practitioners to apply the criteria of river health characteristics not only for its functioning but also to demonstrate resilience in the face of environmental changes, including climate

change, resource exploitation or other kinds of impacts resulted by human activities in urban areas.

In this context, the main aim of the thesis is determined as ‘Renaturalization and integration of damaged and buried riverine systems into socio-economic and ecological systems of urban areas with a focus on providing mutual benefits and sustainability of each system. This process is anticipated as describing the role, structure and functions of riverine systems at global (freshwater systems), regional (watersheds) and local (urban ecosystems) levels and examining the problems of them in terms of ‘Urban Stream Syndrome’. Accordingly, the thesis evaluates the potential for ‘Renaturalization’ of buried riverine systems by using ‘Stream Daylighting’ method as a tool.

‘Daylighting’ describes the implementations that deliberately expose some or all of the flow of a previously covered river, creek, or storm water drainage system (Pinkham, 2000). Although in Pinkham’s definition, it should be underlined that daylighting activities mostly occur in highly urbanized areas, which has numerous negative effects on riverine systems. Therefore, renaturalization-based daylighting efforts help degraded riverine systems in urban areas to go back to their natural status in a naturalistic way and provide the opportunity to integrate those systems with supporting the mutual benefits between riverine systems and urban areas. From this point of view, the research focuses on the definition of healthy rivers in urban environment and develops the criteria for this identification within renaturalization approach. In this process, the methodology of the thesis is based on descriptive analyses and conceptual reviews. These analyses enlighten the research domains that took their form from several research questions. Herein, ongoing threats and challenges from urbanization dynamics together with human activities have been taken in to account for better integration of riverine systems into spatial, social and economic dimensions of urban settlements. Under these perspectives variety of cases from different countries have been assessed under key themes to clarify the potentials of renaturalization process of buried riverine systems in urban areas with stream daylighting method. As a result, the ‘Conceptual Model of Integrated Stream Daylighting (Co-MISDAL)’ is developed for a better understanding and integration of healthy riverine systems within urban areas including different experiences from different countries to guide for future daylighting implementations. The Ayamama Stream Corridor in Istanbul is used as a case study area to test the developed method in the thesis.

**KENTSEL AKARSU KORİDORLARININ YENİDEN
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AYAMAMA DERESİ ÖRNEĞİ**

ÖZET

Tez çalışması, kentsel alanlarda doğal sistemler üzerinde artan baskılara bağlı olarak kentsel akarsu sistemlerinin maruz kaldığı problemlere odaklanmakta ve özellikle kanallar aracılığı ile yer altına alınan akarsu sistemlerinin yeniden doğallaştırılarak kente kazandırılmasını amaçlayan ‘Nehirlerin Gün Işığına Çıkarılması’ (Stream Daylighting) yönteminin etkinliğini sorgulamaktadır. Bu bağlamda, çalışmada literatürde yer alan ve karşılaştırılabilir düzeyde bilgi içeren örnekler değerlendirilmiştir. Yapılan inceleme ve değerlendirmeler neticesinde farklı altyapılara sahip çalışmaların ortak noktada bulunduğu temel kavramlar saptanarak ‘ana temalar’ başlığı altında seçilen örneklerin karşılaştırmalı analizlerine yer verilmiştir. Söz konusu uygulama, akarsu sistemleri üzerinde kentsel baskının yarattığı zararları en aza indirerek, sistemin yeniden kendi doğal yapı ve işleyişine döndürülmesine odaklanır. Bu çerçevede tez çalışması, kent ile bağlantısı koparılmış, ekolojik ve hidromorfolojik yapısı değiştirilmiş, doğal işleyişinden uzaklaştırılarak nehir niteliği kaybettirilmiş olan akarsu sistemlerinin geri kazanımının yanı sıra, bu sistemlerin kente entegrasyonunun sağlanması ve toplum-doğa ilişkisi ile karşılıklı fayda sağlanması adına yeniden oluşturulması amacını taşımaktadır.

Bilindiği gibi, hızlı nüfus artışı ve kentleşme dinamiklerine bağlı olarak dünya nüfusunun çoğunluğu günümüzde kentsel alanlarda yaşamaktadır (Birleşmiş Milletler, 1993). Bu dinamikler, kentsel ekosistemler üzerinde sayısız yan etkiler oluşturmakta ve uzun vadede sürdürülebilir olmayan bir gelişme yapısına neden olmaktadır (Karr, 1999). Kentsel ekoloji, arazi değişimlerinin sebep olduğu ekolojik etkiler ile kaynakların (abiyotik) ve tür sayısının mekansal dağılımını ve etkileşimini içeren bütüncül bir sistem (enerji akışı) olarak tanımlanmaktadır (Lord ve diğ., 2001). Bu çerçevede akarsu sistemleri sahip oldukları su kaynağı potansiyelinin yanı sıra sucul ve karasal ekosistemler arasında geçiş alanı olma özelliği ile de kentsel ekosistemler içerisinde önemli roller üstlenmektedir. Su döngüsünün en önemli bileşenlerinden biri olarak akarsu sistemleri, materyal ve enerji akışı, sucul türler için yaşam alanı oluşturması ve insanlar açısından doğa ile etkileşim halinde olabilecekleri açık yeşil alanlar ve rekreasyon olanakları sağlaması açısından da büyük önem taşımaktadır (Lowrance, 1998). Fakat, artan nüfus ve insan kaynaklı aktivitelerin doğal sistemler üzerindeki etkilerine bağlı olarak, akarsu sistemlerinin hidromorfolojik ve ekolojik nitelikleri bozulmuş ve ya kaybolmuş, özellikle kanallar aracılığı ile yer altına gömülen sistemlerin üzeri yol, bina vb. geçirimsiz yüzeylerle kapatılarak doğal yapı ile bağlantıları kesilmiştir.

Çalışmada, kentsel alanlarda yer alan akarsu sistemlerinde gözlenen tüm bu olumsuz etkiler, ‘Kentsel Nehir Hastalık-Belirtisi’ (Urban Stream Syndrome) kavramı

üzerinden tanımlanmaya çalışılmıştır. Söz konusu kavram, nehir sistemlerinin hidrolojik ve jeomorfik yapısındaki değişimlere bağlı olarak sistem bütününde sürekli olarak gözlenen ekolojik bozulmaları ifade etmekte ve nehir sağlığının sistemin bütünlüğü ve sürdürülebilirliği açısından taşıdığı öneme dikkat çekmektedir (Walsh ve diğ., 2005). Bu noktada ele alınan ‘Sağlıklı Nehir’ (Healty River)’ kavramı, türlerin ve yaşam alanlarının korunması ile temel ekolojik fonksiyonlarının devamlılığını öngörmektedir. ‘Sağlıklı Nehir’ yaklaşımı, akarsuları yalnızca suyun taşındığı kanal sistemleri olarak düşünmek yerine, bütüncül bir sistem olarak algılamayı gerektirmektedir (Changming ve Xiaoyan, 2009). Diğer yandan sağlıklı nehir yaklaşımı, zarar görmüş akarsu sistemlerin yeniden doğallaştırılması için ilgili kriterlerin değerlendirilmesi ve uygulanmasını gerektirmektedir. Akarsuların sağlıklı olma durumlarını ifade eden göstergeler, söz konusu sistemlerin çevresel ve iklimsel değişimler karşısında dayanıklılığının artırılması ve doğal yapı-işleyişlerini devam ettirebilmeleri esasına dayanmaktadır.

Bu çerçevede tezin amacı, kentsel alanlarda artan insan aktivitelerine bağlı olarak zarar görmüş ve kanallar aracılığı ile yer altına alınmış akarsu sistemlerinin yeniden doğallaştırılması ile kent-akarsu entegrasyonunun karşılıklı sağlanacak faydalar doğrultusunda geliştirilmesi olarak tanımlanmıştır. Bu noktada kentin sosyo-ekonomik ve ekolojik sistemleri ile kentsel akarsu sisteminin birbiri ile etkileşimi, sistemlerin sürdürülebilirliği kapsamında ön planda tutulmuş ve bu bağlamda akarsu sistemleri küresel, bölgesel ve yerel ölçeklerde incelenmiştir. Küresel boyutta tatlısu sistemlerinin önemli bir bileşeni olan akarsular, su döngüsü ve doğal yaşamın sürekliliğinde sahip oldukları görevler ile oldukça kritik öneme sahiptir. Tatlısu sistemleri, doğal sınırları ile tanımlanmış olup, politik kısıt ve sınırlardan bağımsız olarak havza boyutunda işleyişini sürdürmektedir. Bölgesel düzeyde ele alınan havza alanları, nehir sisteminin bütüncül olarak korunması ve yönetiminde en önemli yönetim birimi olarak görülmekte ve özellikle birden fazla idari sınır içerisinde yer alan sistemler için bölgesel boyutta bir uzlaş ve işbirliği gerekmektedir. Yerel ölçek çerçevesinde incelenen akarsu sistemleri ise kentsel alanlarda kentin içerisinde geçen ve çoğu zaman insan yerleşimleri için öncelikli tercih edilen alanlar olarak karşımıza çıkmaktadır. Öyle ki, tarihte yer alan önemli uygarlıklar ve ilk yerleşim alanları çoğunlukla akarsu kıyılarında konumlanmış, gelişimlerini suya bağlı olarak sürdürmüşlerdir. Akarsu sistemleri bu süreç içerisinde, tarım, sulama, savunma ve ulaşım gibi çeşitli amaçlar doğrultusunda kullanılmış, sanattan felsefeye kadar birçok alanda toplumsal hayatın içine girmiştir. Zamanla büyüyen ve gelişen bu yerleşim alanlarından bazıları sahip oldukları akarsu sistemlerini koruma ve geliştirme konusunda başarılı olurken, kimi yaşam alanlarında bu sistemler göz ardı edilerek kent yaşamından uzaklaştırılmışlardır. Günümüzde çoğu akarsu sisteminin kentleşme ve nüfus artışına bağlı olarak artan baskılar neticesinde kirlilik, bozulma, nitelik kaybı vb. sorunlar ile karşı karşıya kaldığı görülmektedir. Bu alanlarda akarsu sistemleri, kent sisteminin bir parçası olarak ele alınmak yerine, kentin atık deşarj alanları ya da üzerlerinin kapatılması ile potansiyel gelişme alanları olarak değerlendirilmiştir.

Bu kapsamda akarsu sistemlerinin önem, işlev ve yapılarının farklı ölçeklerde incelenmesine bağlı olarak bu sistemlerin kentsel alanlarda maruz kaldığı problemler tezin çıkış noktasını oluşturmaktadır. Tez kapsamında akarsu sistemlerinin maruz kaldığı problemler ‘Kentsel Nehir Hastalık-Belirtisi’ (Urban Stream Syndrome) kapsamında ele alınmış ve konu, zarar gören akarsu sistemlerinin ‘sağlıklı’ bir nitelik kazanması kapsamında ‘Sağlıklı Nehirler’ (Health Rivers) kavramı ile

desteklenmiştir. Bu çerçevede özellikle doğal niteliği bozulmuş ya da kaybolmuş akarsu sistemlerinin yeniden doğallaştırılmasında (renaturalization) ilgili sisteminin sağlıklı olduğunu gösteren kriterlerin mekana yansıtılması ve korunmasının sistem sürdürülebilirliği açısından taşıdığı önem vurgulanmıştır.

Kentsel alanlarda kanallar aracılığı ile yer altına gömülen akarsu sistemlerine odaklanan çalışma, 1970'li yıllarda Amerika'da kentsel drenaj sistemlerinden kaynaklanan problemlerin çözümüne yönelik olarak geliştirilen 'Nehirlerin Gün Işığına Çıkarılması' (Stream Daylighting) yönteminin doğal nitelikleri zarar görmüş ya da kaybolmuş gömülü akarsu sistemlerinin yeniden doğallaştırılmasındaki önem ve etkinliğini incelemektedir. Söz konusu uygulama, üzeri bir takım sebeplerle geçirimsiz yüzeyler ile kapatılan akarsu koridorlarının tamamı ya da bir kısmının üst örtüsünün kaldırılarak ekolojik ve hidrolojik fonksiyonlarının yeniden kazanılmasını ifade etmektedir (Pinkham, 2000). Söz konusu tanıma ek olarak, stream daylighting uygulamasının genellikle kentleşmenin yoğun olarak görüldüğü alanlarda gerçekleştirildiği görülmektedir. Bu sebeple, kentsel alanlarda nitelik kaybına uğramış ve kentsel sistemler ile ilişkisi kesilmiş olan akarsu koridorlarının doğal yapı ve işlevlerine kavuşturulmasında, sistem sağlığını temel alan yeniden doğallaştırma yaklaşımı, uygulamanın çıkış noktasını oluşturması açısından büyük önem taşımaktadır. Özellikle yer altına gömülü akarsu sistemlerinin üzerindeki geçirimsiz üst örtünün kaldırılması yönünde gerçekleştirilecek uygulamalarda, yeniden doğallaştırmanın 'stream daylighting' uygulaması ile mümkün olduğu ve uygulamanın ekolojik yararlarının yanı sıra kent sistemine sosyal ve ekonomik yönden de olumlu katkılar sağladığı görülmektedir.

Bu çerçevede gerçekleştirilen tez çalışması, kavramsal çerçevenin tanımlayıcı analizlerle geliştirilmesi ve ilgili kavramlar arasındaki ilişkinin ortaya konulmasına yönelik olarak oluşturulan araştırma sorularına dayalı bir yöntem kapsamında geliştirilmiştir. Söz konusu 'gün ışığına çıkarma' yönteminin farklı ülkelerde, farklı altyapı ve amaçlar doğrultusunda gerçekleştirilen uygulama örnekleri tez kapsamında çeşitli analiz ve değerlendirmelerden geçirilmiş, elde edilen bulgular uygulama örneklerinin içerik ve ana hatlarına bağlı olarak geliştirilen sekiz ana tema altında değerlendirilmiştir. Tema başlıkları altında karşılaştırmalı analizlerine yer verilen örnekler, kentsel alanlarda yer altına gömülü akarsuların gün ışığına kavuşturulması ve yeniden doğallaştırılmasında yol gösterici bir nitelik taşıyan 'Nehirlerin Gün Işığına Çıkarılması Bütünleşik Kavramsal Modeli' (Conceptual Model of Integrated Stream Daylighting 'Co-MISDAL')'in oluşumuna zemin hazırlamıştır. Geliştirilen model ile, günümüze kadar gerçekleştirilen ve literatürde yer alan uygulama örneklerinin deneyimlerden yola çıkılarak, uygulamanın başlangıcından bakım aşamasına kadar geçen süreci içeren çerçeve, geniş bir perspektifte karar verici, araştırmacı ve uygulamacılara sunulmaktadır. Çalışmayla geliştirilen modelin, kentsel alanlarda yeraltına alınmış/üzeri kapatılmış akarsu koridorlarının kente entegrasyonu için yapılacak uygulamalarda yol gösterici bir nitelik taşıyabileceği düşünülmektedir.

1. INTRODUCTION

"Take care of the land, and it will take care of you.

Take what you need from the land, but need what you take." - *Aboriginal law*

We are living in a highly urbanizing world. According to United Nations 2009 Revision of World Urbanization Prospects, with 50.5% or 3.5 billion of the people on Earth are living in cities in 2010 and urban population is growing, often at the expense of rural areas, the global population as a whole has become more urban and less rural. Hence, the increase of urban populations is expected to be even more rapid throughout the developing world. On the other hand, the ecological impacts of this growth and population re-distribution are profound. The accumulation of people, their consumption patterns, travel behavior and their urban economic activities have extensive impact on the environment in terms of resource consumption, ecological degradation, waste discharges and pollution. Especially riverine systems as vulnerable water resources in urban areas are exposed to several human intervene with the increasing pressures of urbanization process. Over time, many urban streams were altered hydraulically, chemically and biologically through navigation and flood control projects, wetland dredge and fill activities, water withdrawals, waste discharges, and stream bank stabilization implementations. Portions of most urban streams were ecologically degraded by pollution, low stream flow, channelization, or being buried channel that flows in a tunnel under built-up areas and being forgotten by the city (Platt, 2006).

In this framework, this thesis mainly focuses on threats and problems of riverine systems in urban areas under the renaturalization context. The entire content consists of five main chapters. The first chapter, 'Introduction' describes the research problem, its aim and the general structure of the study under four sub titles: Problem Statement & Hypothesis, Aim & Methodology of the Study, Research Questions & Structure of the Study, Justification of Research & Literature Reviews.

1.1 Problem Statement & Hypothesis

The modern era has not been kind to urban streams.

With the acceleration of urbanization, urban rivers are exposed the crisis of ecological deterioration, the functions of urban rivers are gradually weakened; the river channels are polluted, buried and the urban characteristics are lost. Because of that disturbance of human activities during the process of urbanization, urban rivers have become one of the zones where human activities and natural processes have mutual effects (Lei and Guanghe, 2008).

As humankind has enlarged agricultural areas, built roads, and clustered into cities, they have polluted streams, diverted them, straightened them, confined them in concrete channels, put them into pipes, filled their associated wetlands, and otherwise used and abused them, often beyond recognition (Pinkham, 2000). These all cause riverine systems to be lost especially in highly urbanized areas with the services they provide and the aquatic ecosystem itself. Over the time, these alterations make riverine systems to be forgotten by changing from their historical and original situation during the urbanization process.

From this point of view, the hypothesis of study states that:

The hydro-morphologically altered and buried riverine systems in urban areas which are disregarded, separated from social & ecological urban systems and damaged by human activities can be turn back to their natural functioning within the integration with spatial, social , economic and ecological mechanisms of urban areas through the ‘Conceptual Model of Integrated Stream Daylighting Method’. The model can be used as a tool for a better understanding the functioning of riverine systems in urban areas and serve as a guideline for future studies and practices related to retrieval of lost and damaged riverine systems especially in highly urbanized areas by considering their integration with the social, ecological and economic systems of the city. The model also constitutes a common platform for facilitating the communication among different disciplines and determining the drivers and mechanisms within the main framework including the set of indicators, which are essential for a successful implementation.

1.2 Aim & Methodology

The main aim of the study is to examine the integration of renaturalization process of buried and damaged riverine systems in to socio-economic and ecological systems in urban areas with a focus of providing mutual benefits and supporting sustainability and integrity of each system with the case of Ayamama Stream in Istanbul. Meanwhile, several sub-objectives are determined in order to identify the highlights and the scope of the research. In this framework, each sub-objective constitutes key steps for developing the research process and provides the formation of related chapters. Each objective directs the research to investigate more about the riverine systems both in environmental and socio-economic contexts within a relevant systematic design of research flow (Figure 1.1).

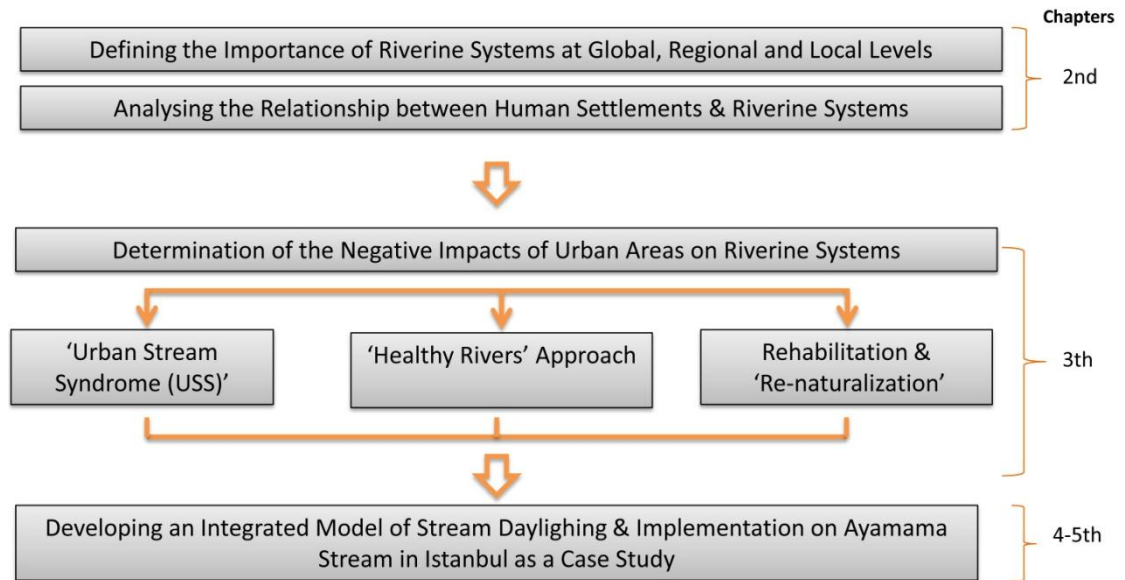


Figure 1.1 : Schematization of main aim and objectives of the research.

Within the scope of the contradiction between consumption and conservation of water resources in urban areas, the research begins with defining the role and functions of riverine systems at different levels (global, regional, local) and continues by analyzing and understanding the relationship between human settlements and riverine systems through historical perspective. The reasons that make people to prefer living in these areas will enlighten the basic drivers of human interventions on these vulnerable systems. These two sub-objectives constitutes the second chapter of the thesis that provides the theoretical background for a better understanding of human & nature & riverine system relationship. The third sub-objective aims to

investigate and analyze the negative effects of urban areas on natural systems and resources through the urbanization process. From this point of view, it also searches for the solutions to create healthy riverine systems through a comprehensive rehabilitation approach including renaturalization of damaged riverine systems. All of these sub-objectives provide a basis for developing the theoretical knowledge with spatial analysis and case study assessments to reach an integrated conceptual model including relevant indicators to guide for the possible implementation in the case study area of Ayamama Stream, Istanbul and as well as for future studies.

Development process of the thesis starts with problem definition and intends to reach the main aim defined above. This task requires a well-organized set of methods which will constitute a route map for research and provide a theoretical and practical background to analyze. Herein, the methodology of the study has taken its form from three main stages including conceptual literature reviews, conceptual model development and case study application (Figure 1.2).

Research Methodology

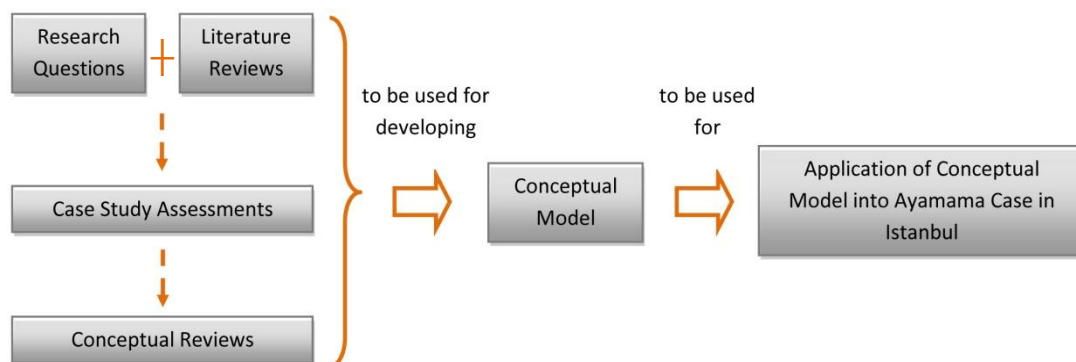


Figure 1.2 : Schematization of the research methodology.

Conceptual reviews as the first part of the research process, consists of several research questions, which conducts the organization of data along the whole research. Under the light of research questions, literature reviews and several case studies from different countries as variety of experiences are used to analyze conceptual stage after a conceptual model to be followed. At the second stage comprehensive approach for the integration of urban areas & riverine systems in a sustainable way. The model not only indicates to have mutual benefits for each system but also aims to integrate them under spatial, socio-economic and ecological dimensions. The third and the last stage of the research methodology consists of case

study application and determination of problems for selected case study area to develop relevant solutions according to the improved model for renaturalization of riverine systems in urban areas. As a result, an outline will be produced for the possible future projects for this area and it takes the role as a guideline for decision-makers to consider about complexity of factors and drivers that identify main structure of renaturalization efforts.

1.3 Research Questions & General Structure

The general framework of the study is organized in the context of several research questions. Each question has a role of constituting a basis for defining and analyzing the data through linking the theoretical knowledge with practical experiences. First, understanding the importance and the role of riverine systems at global, regional and local scales is examined. In this framework, all riverine systems are essential components of freshwater resources as part of aquatic biomes on earth and these systems play an important role within dynamic natural systems. Accordingly, river basins are important hydrological and territorial units at regional level that requires a comprehensive management approach from a multidisciplinary perspective. Although, watershed boundaries, as natural units, encompasses an area of land which is surrounded by highest elevations and generally do not overlap with national administrative boundaries they may overlay on a geographic area of different countries. Therefore, the requirement of international cooperation among different riparian countries becomes essential for an integrated management of riverine watershed systems. On the other hand, although these systems flow through both rural and urbanized areas, herein, urban areas are taken into consideration because of major threats for their health and assets are more related to urban areas where the pressure and negative effects caused by human activities are generally taking place. From this point of view, the relationship between human settlements and riverine systems is examined for a better understanding of this contradiction with determining the importance of riverine systems within urban ecosystems and the data generated from the analyses is used to reach an effective and comprehensive method for renaturalization of damaged riverine systems. The overall structure of the study takes its basis from answering of each question. The main questions are highlighted with

bold characters including sub-questions, which direct organization of the study in relevant chapters (Figure 1.3).

The research questions are:

1. **What is the importance and role of riverine systems in nature as a part of freshwater sources?**
2. How should we categorize riverine systems (such as creek, stream or river)?
3. How can we define the borders of a riverine system including its tributaries?
4. What can be done if the entire riverine system is shared by different regions or countries including different institutional, social, economic and legal backgrounds?
5. What is the relationship between ‘human settlements & riverine systems’?
6. What is the importance, role and services of riverine systems within urban ecosystems?

2nd Chapter:
Riverine
Systems in
Urban Areas

7. **What are the negative effects and pressures of urban areas on riverine systems?**
8. What is the concept of ‘Urban Stream Syndrome (USS)’ and how can we define its symptoms?
9. What is the concept of ‘Healthy River’? How can we revitalize degraded riverine systems to a ‘healthy river’ status?
10. How the rehabilitation of riverine systems should be Within the concept of renaturalization?

3rd Chapter:
Environmental
Conflicts and
Rehabilitation
of Riverine
Systems

11. **How could it be possible the ‘Renaturalization’ of riverine systems by ‘Stream Daylighting’ Method?**
12. How can we assess implemented Stream Daylighting projects in terms of their goals, drivers, stakeholders and results?
13. What kind of a conceptual model should be developed including relevant indicators from social-economic-environmental-legal aspects?
14. How Ayamama Stream Case can be interrelated with other Case studies in regard to implementation criteria?
15. How can we integrate this model for case study area: Ayamama Stream-Istanbul (suggestions)?

**4th and 5th
Chapters:**
Stream
Daylighting:
The Second
Chance to be
‘Natural’

The thesis consists of five chapters. Excluding the 1st Chapter, which is Introduction, the logic of rest four chapters is schematized and described in detail below.

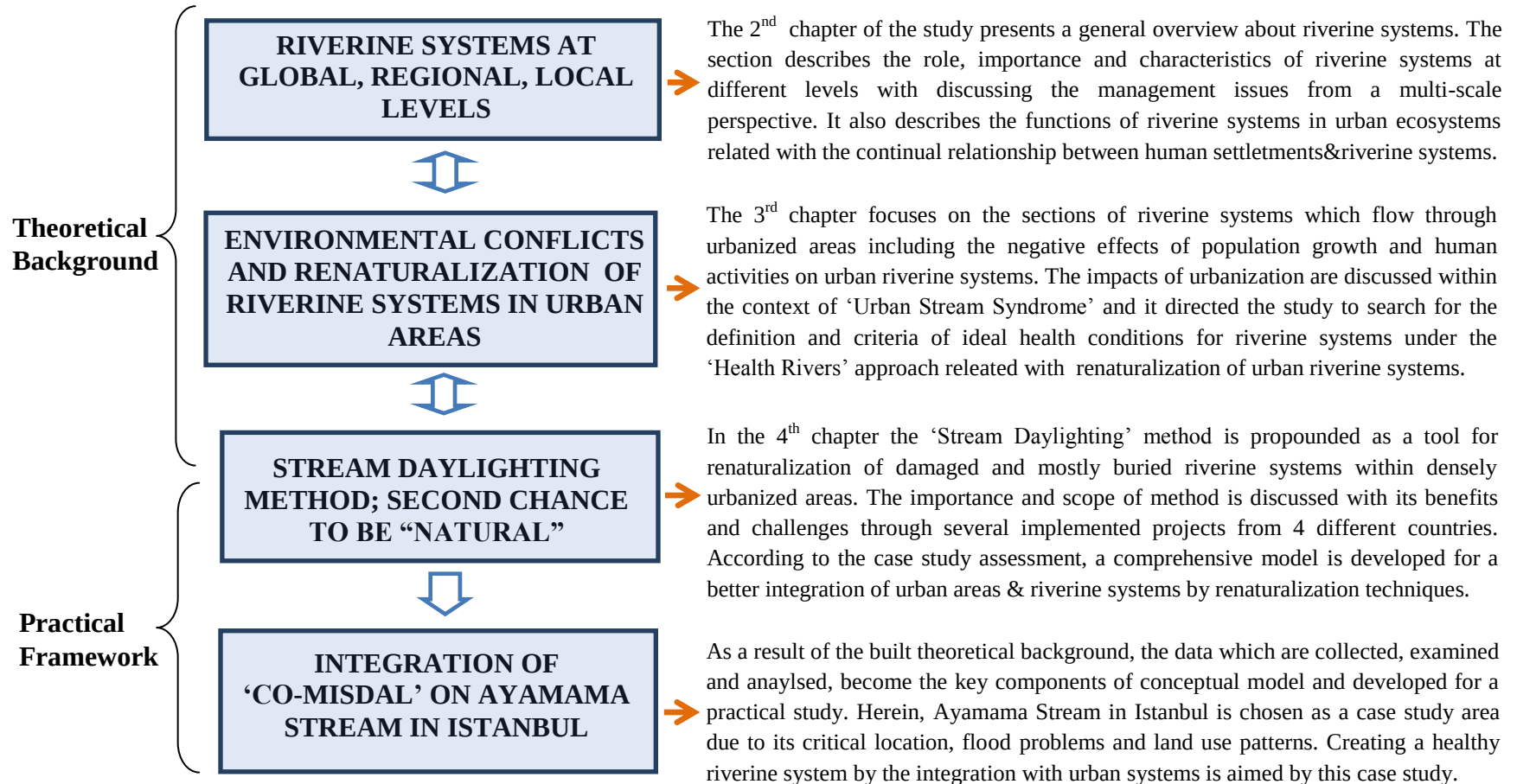


Figure 1.3 : General structure (flow chart) of thesis content.

1.4 Justification & Literature Reviews

Human alteration of Earth is substantial and growing. Between one-third and one-half of the land surface has been transformed by human actions; especially from the beginning of the ‘Industrial Revolution’ more than half of all accessible surface fresh water is under use of humanity. According to this observation, it is clear that we live on a human-dominated planet (Vitousek et al., 1997).

Urban areas are primarily sites of consumption, which create multi-dimensional conflicts with their natural systems. These conflicts and interferences on biophysical environment make cities as an important field to be studied comprehensively because of their rapidly changing features and the impacts on natural systems. However, most of the studies on this conflicting relationship have generally been developed without considering the comprehensive relationship among social, ecological and economic features of sustainable development in regard to urban riverine systems management. These exercises also act like snapshots of current conditions for a specific area disregarding ecosystem functioning, social aspects, spatial integration or mitigating the effects of development. Herein, lack of the consensus about riverine system rehabilitation indicates the importance of a multidimensional and comprehensive approach including the interactions between the drivers of sustainability (Environmental Health, Social Wellbeing, and Economic Benefits). Therefore, the research focuses on an integrated approach among the components of urban riverine systems considering ecosystem services and socio-economic benefits.

According to the literature reviews about riverine systems and their conservation & integration issues in urban areas, literature research has been completed by diverse scientific resources including M.Sc & Ph.D thesis, proceedings&reports, scientific articles, electronical journals and e-books. Specifically, ‘Stream Daylighting’ method and implementation experiences of this approach are searched in terms of renaturalization of riverine systems in urban areas. All in these resources, thesis that are written in Turkey were the only materials, which these subjects are broadly discussed. However, during the evaluation process of each thesis, it is determined that the subject is discussed under three main titles which are; Recreation & Aesthetics Issues, Green Infrastructure, Urban Areas & Riverine Systems Interactions.

Many of these works assess riverine systems as coastal recreational parts of urban areas and mainly focus on enhancing their human-use potentials. Some others, which discusses the interactions between urban areas and riverine systems, varies from each other according to their context. One of the M.Sc thesis with the title of: “Impact of Planning Institutions on Urban Water Management: Case Study Ankara” by Pınar Aypek Türker from Middle East Technical University focuses on the role and the importance of institutional tools on urban water management whilst another one with the title of: “Assessment of Watercourses’ interactions within urban renewal process with a case of Izmir” by Çiğdem Kılıçaslan from Ege University discusses about interactions between riverine systems and urban areas in the context of urban renewal process. In the same category (Urban Areas & Riverine Systems Interactions), a Ph.D thesis with the title of “An approach to urban river rehabilitation for coexistence of river and its respective city: Porsuk River case and city of Eskişehir” by Gül Şimşek from Middle East Technical University rethinks about the urban physical environment within ecological planning perspective and indicates the importance of ecocity approach considering the relationship between river rehabilitation and urban pattern. Similarly, the M.Sc thesis with the title of “Water component in Urban Space: Streams flowing to Boğaziçi” by Gülcemal Alhanlıoğlu from Istanbul Technical University focus on improving the city identity in relation with river rehabilitation practices from an aesthetical perspective. Distinctively, it indicates the revitalization of buried river and compiles several streams flowing to Bosphorus but it does not suggest a rehabilitation framework for these buried systems.

In this framework, a gap is determined about the rehabilitation, revitalization and integration of riverine systems in to urban areas with the lack of a comprehensive approach including a clear management basis for these vulnerable systems. Therefore, this thesis aims to develop an applicable approach for riverine systems to strengthen the integration and the relation between these systems in urban areas.

Although, in order to improve the knowledge about this field and learn about former implementations a literature review is completed with 10 case studies from different countries are selected from various scientific resources. During this process, case studies are selected only from the ones to be scientifically relevant and cited works.

As a result, according to the literature reviews and scientific information search the need for a common language within a comprehensive approach including all drivers of sustainability in urban areas can obviously be seen as an integral part of the research. In brief, justification of this thesis can be summarized as below:

1. Riverine systems are integral parts of both natural systems and human populations in urban areas.
2. However, human activities in urban areas play a major role on the devastation of natural systems with the growing impact of urban dynamics. This conflict states a basic reason enough to investigate on them.
3. In addition, the interactions between riverine systems and urban areas are so weak to integrate ecological and social systems on these riverine systems in urban areas.
4. Decline in biodiversity is also an important problem in urban areas and riparian corridors are the habitats for rich variety both aquatic and terrestrial species that need to sustain their existence and their functioning.
5. Disregarding of urban riverine systems as natural drainage canals and combining with underground sewer systems can cause major flood risks in combination with the unsustainable growth of urban areas.
6. The studies and rehabilitation techniques on these systems mostly focused on the hydro-morphological and ecological alterations of aquatic systems and solely work on stream channel design. A holistic approach for stream renaturalization including social, ecological, economic and legal integration is already missing.
7. In Turkey, riverine systems in urban areas are exposed to several impacts and pressures as a result of human activities. Many rivers or streams are put in to channels, culverted in pipes, buried, and hence river bed morphologies are altered and they lost with built infrastructures on them.
8. In addition, natural restoration issues are mainly disregarded or very limited and the efforts are handled mostly from a recreational/ aesthetical perspective.

Hence, this study intends to improve an integrated approach for *working with nature (riverine systems), rather than to be against to it* and to serve as a guideline for renaturalization of buried riverine systems as a binding value in between these urban systems.

2. RIVERINE SYSTEMS IN URBAN AREAS

‘Urban’ has been defined as vaguely as ‘built up’ (Erskine, 1992) to as precisely as ‘an area with >2500 people (620 individuals/km²), depending on the context in which the term is being defined (McIntyre et al., 2000). In general, an urban area is a continuously built up land mass of urban development (Demographia, 2011). Such that, throughout the history many urban centres have developed around rivers due to the resources that they provide including food, water, power, flat land for development and transport (Grimm et al., 2001). However, especially with the effect of industrialization process, growth of urban population due to rapid urbanization had extensively affected the environment and especially biodiversity patterns in urban areas by enhancing biological invasions mainly on riverine systems. Consequently, many of the world’s rivers are impacted by urbanization; 50% of the global population lives in urban centers and this is predicted to increase (UNFPA, 2007). Since there is not one common term to define ‘urban’ the following definition will be used to describe the term of ‘urban stream’. ‘A stream where a significant part of the contributing catchment consists of development where the combined area of roofs, roads and paved surfaces results in an impervious surface area characterizing greater than 10% of the catchment’ is defined as “urban stream” (Findlay and Taylor, 2006).

From this point of view, second chapter describes the importance, role and functions of riverine systems from a broad perspective. Firstly, it begins from the global level that investigates natural functioning and structure of riverine systems as freshwater ecosystems and their role as part of water cycle. Accordingly, it continues to analyze the integrity of riverine systems itself and to focus on the watershed perspective, which constitutes a management unit for these systems even if the watershed area located in a cross-border location between different regions or states. That situation brings the necessity of international cooperation in the context of watershed management. Finally the chapter narrow down its scope and focus on specifically

urban areas and their early relationship with riverine systems with analyzing the role and functions of riverine system as part of urban ecosystem.

2.1 Riverine Systems at Global Level

Riverine systems are essential components of freshwater systems as a part of aquatic biomes. The biomes are defined as "The world's major geographical areas of ecologically similar communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment" (Campbell, 1996). Biomes are classified in various ways. According to Campbell (1996), the categorization can be made in five major groups: aquatic, deserts, grasslands, forests and tundras (Figure 2.1).

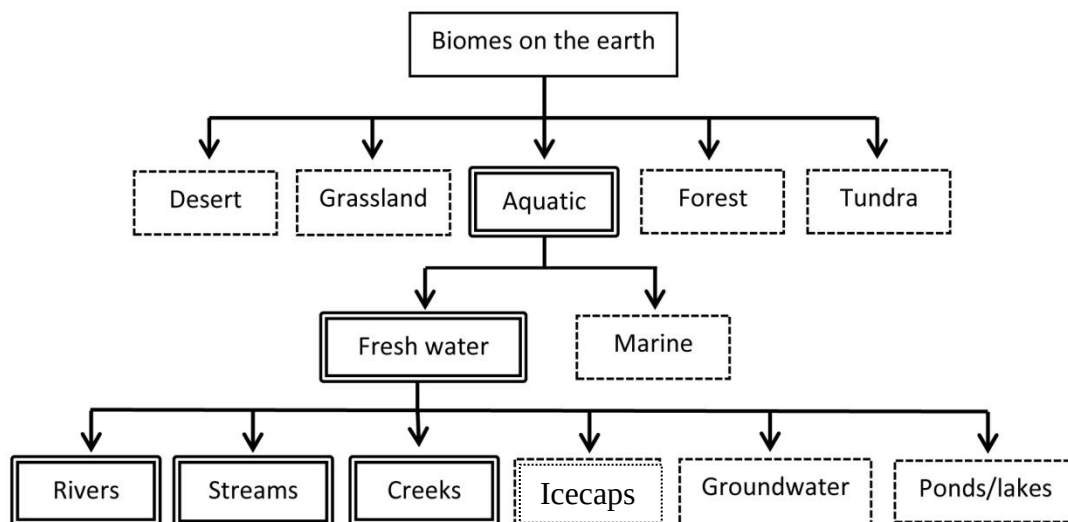


Figure 2.1 : Relationship of riverine systems as the components of aquatic biomes on Earth (Campbell, 1996).

The aquatic biome groups into two major categories: Fresh water (water with little or no salt in it in ponds, rivers, streams, wetlands) and Marine or salt water (ocean). The freshwater and marine biomes are probably the most important of all biomes. Their medium, water, is a major natural resource as it is the basis of life. Without water, most life forms would be unable to sustain themselves and countless species live in it for all or part of their lives. Moreover, water represents the common link among all biomes and it makes up the largest part of the biosphere, covering nearly 97% of the Earth's surface (Url-1, 2011).

More importantly, only 3% of the water on Earth is fresh water in nature and about 2/3 of this amount is frozen in glaciers and polar ice caps. Most of the rest is underground and only 0.3% is surface water (EPA, 2011). In other words, only 3% of the water on the planet is fresh and just a third of that is accessible to humans. Also, rivers make up 2% of all freshwater on Earth (Figure 2.2).

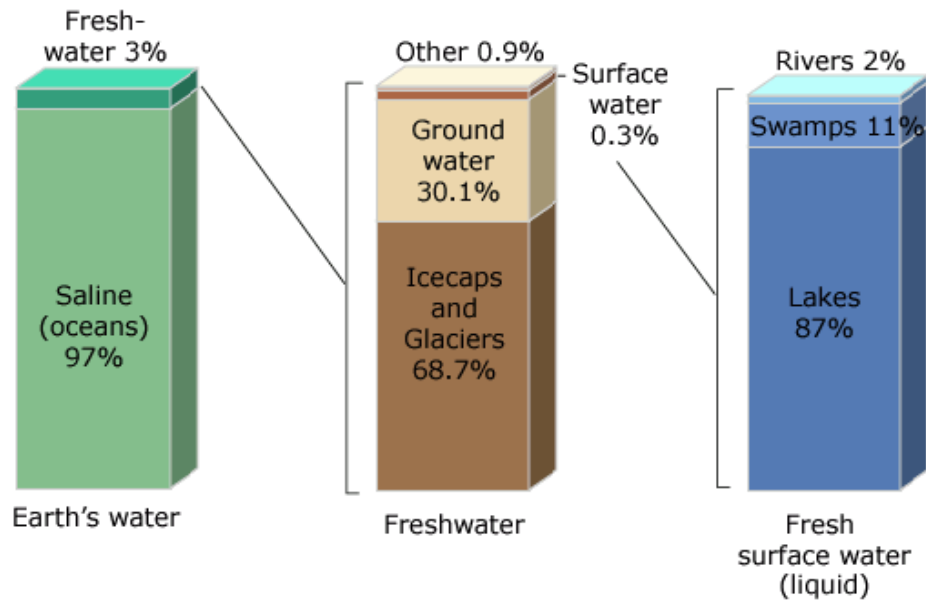


Figure 2.2 : Distribution of Earth's water (Gleick, 1996).

Freshwater systems encompass a wide range of habitats including rivers, streams, lakes, ponds, groundwater, reservoirs, cave water, springs, floodplains, and wetlands (bogs, marshes, and swamps). These systems are created by water that enters the terrestrial environment as precipitation, having a low salt concentration -usually less than 1% - and flows both above and below ground towards the sea (EPA, 2011).

Nevertheless, more recently, human activities have drastically altered these communities. Freshwater biomes have suffered mainly from pollution. Runoff containing fertilizer and other wastes and industrial dumping enter into rivers, ponds, and lakes and tend to promote abnormally rapid algae growth. Especially, rising human population and levels of socioeconomic development have led to a rapid rate of water resource development and the replacement of naturally occurring and functioning systems with highly modified and human-engineered systems. Meeting human needs on the freshwater provisioning services such as irrigation, domestic water use, hydro power, and transport has come at the expense of inland water ecosystems - rivers, lakes, and wetlands- that contribute to human well-being through

recreation, scenic values, maintenance of fisheries and biodiversity, and ecosystem function (Url-2, 2011). Consequently, the physical integrity of the world's freshwater ecosystems is now an important issue and supported by many international, national and regional programs and legislations (Findlay and Taylor, 2006).

Although rivers constitute 2% of all fresh surface water on Earth, it plays a very important role. Rivers are like roads that carry water, organisms and important gases and nutrients to many areas. They also help drain rainwater as such a dynamic system providing wide range of ecological niches supporting diverse flora and fauna. Rivers are also travel routes for people and provide recreation opportunities in connection with nature (White and Greer, 2005). In addition to their important role of carrying materials and providing niches to species, rivers are also important components of the 'Water (hydrological) Cycle' which is essential for existence of freshwater resources on the land surface (including of all sizes of rivers, streams, creeks, ponds, lakes, reservoirs and canals, and freshwater wetlands).

The water cycle (hydrological cycle), is the continuous exchange of water between land, water bodies, and the atmosphere. By this way, the water is continually being recycled between the earth, the atmosphere, rivers, lakes, oceans, and living things in a complex process called as 'water cycle' with its main components as precipitation, evaporation/transpiration, condensation and collection (Figure 2.3). In this successive process, rivers have important role with collecting run-off from precipitation and transmitting towards surface water bodies and oceans.

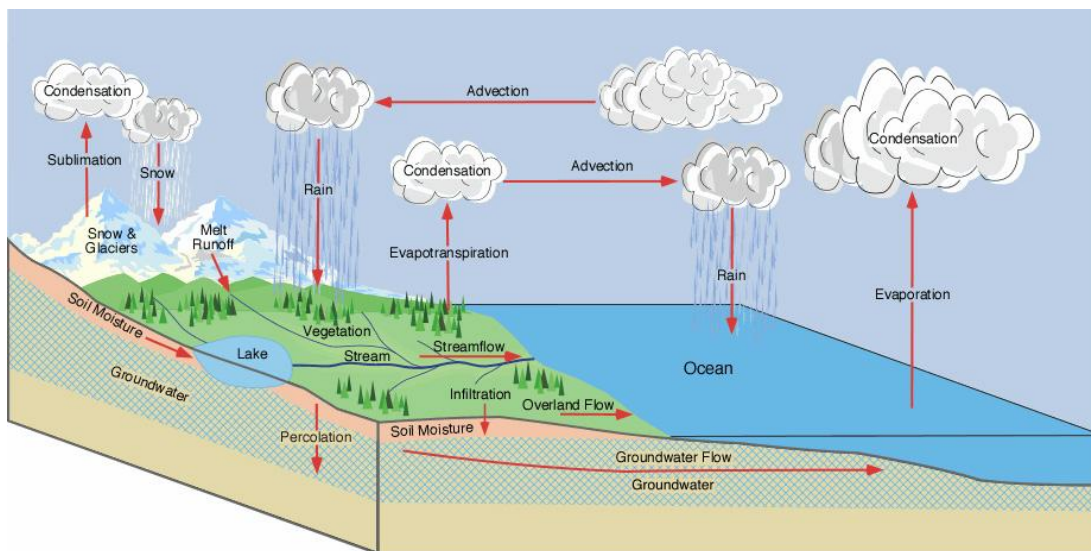


Figure 2.3 : Diagram of water cycle (Url-3, 2011).

Through their catchment areas, rivers are central actors of environmental transport and as the water flows down, it may pick up more water from other small streams, springs or from rain or snowmelt. Such that, rivers and streams are types of open channels, i.e., conduits of water with a free surface. According to Martin (1999), in contrast to canals, ditches, aqueducts and other structures designed and built rivers and streams are the products of natural geological processes and, as a consequence, are quite irregular. These complex systems can be called as ‘riverine systems’ including creeks, streams and rivers. They consist of linear aquatic communities of flowing, non-tidal waters with a discrete channel, with persistent emergent vegetation sparse or lacking. But they may include areas with abundant submerged or floating-leaved aquatic vegetation. The riverine communities in this classification are distinguished primarily by position of the stream in the watershed and water flow characteristics (Beitel, 1976). The whole process of water cycle should be re-defined in order to understand the logic behind of this classification according to the size range of flowing waters as riverine systems (Url-4, 2011).

According to Ward et al. (2008), many stream order classifications have been developed, but no single system has been universally accepted. One of the earliest methods developed, and arguably the most commonly used method today, was developed by Strahler in 1952 (Figure 2.4). In this system, first-order streams are perennial streams, which carry water all year and when two first-order streams come together, they become a second-order stream (Strahler, 1952).

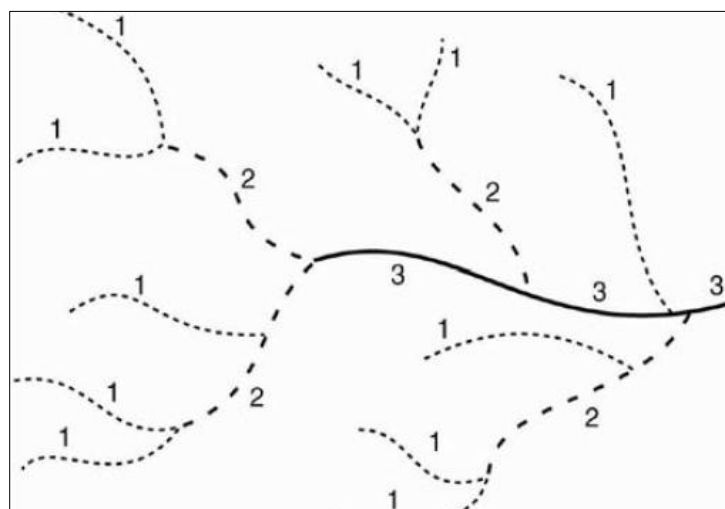


Figure 2.4 : Strahler stream order classification method (Ward et al., 2008).

The characteristics of a river or stream change during the journey from the upstream to the downstream. The temperature is cooler at the source than it is at the mouth. The water is also clearer, has higher oxygen levels, and freshwater fish such as trout and heterotrophs can be found. Towards the middle part of the stream/river, the width increases, as it does for species diversity numerous aquatic green plants and algae populations. Toward the mouth of the river/stream, the water becomes murky from all the sediments that is picked up from the upstream, decreasing the amount of light that can penetrate through the water (Ruby, 2006). Since there is less light, there is less diversity of flora, and because of the lower oxygen levels, plant and fish species that require less oxygen can be found.

Consequently, stream ordering provides a measure of system complexity. Also, it is an important characteristic of stream systems because it can be related to drainage area, stream size and expected ecological function of a stream system (D'Ambrosio and Ward, 2008).

2.2 Interactions of Riverine Systems at the Regional Level

‘Everyone lives in a watershed’ (EPA, 2010).

Each water body is part of a watershed system where their border is defined by nature itself including the interconnectedness between territorial and aquatic systems. At the regional level, river basins represent the integrity of both social and ecological structures with its natural resources and inhabitants that it encompasses.

Physically, a river basin represents a natural area of collection and concentration of surface and ground water and therefore has an essentially volumetric and hydrological connotation (Dourojeanni, 2001). Accordingly, it is the drainage area contributing water, organic matter, dissolved nutrients, and sediments to a stream, lake, wetland, or other water body. Each stream has its own watershed and topography is the key element affecting this area. Because, the boundary of a watershed is defined by the highest elevations surrounding the stream (Url-6, 2011) In this framework, a watershed can be defined as an area of land that waterfalls with precipitation and flows across as it moves toward a common body of water, such as a stream, river, lake or coast (Figure 2.5).

WWF-International defines river basins as ‘the land area between the source and the mouth of a river, including all the lands that drain into the river. Some river basins may terminate at lakes and/or inland deltas, with no exit to the sea’ (Ramsar COP8 DOC., 2002). Watersheds come in many different shapes and sizes. According to Molle (2007), river basins are the geographic area contained within the watershed limits of a system of streams and rivers converging toward the same terminus, generally the sea or sometimes an inland water body.

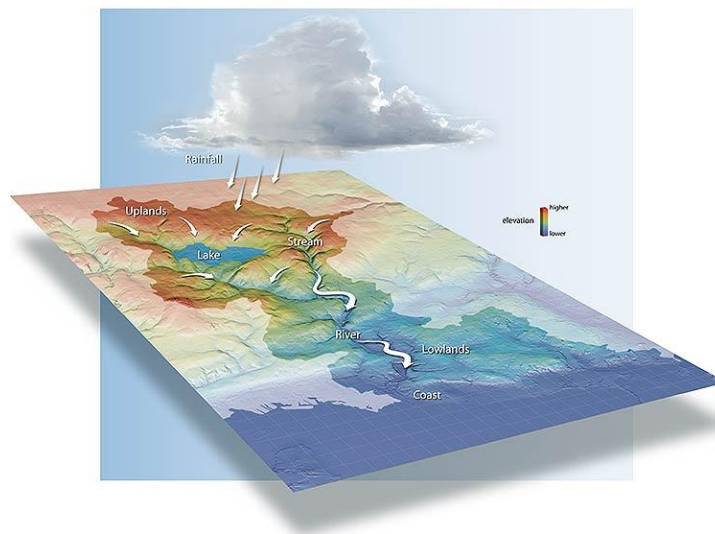


Figure 2.5 : Water drainage in the watershed (Url-9, 2012).

Although not everyone lives on a stream, we all live in a watershed (Url-7, 2011). According to MacQyarrie et al., (2008), there are over 263 international river basins in the world, covering almost half of the Earth’s land surface, nearly 40 percent of the world’s population, and 60 percent global river flow. Over 145 nations are riparians to one or more international basins in the world and there are over 300 international agreements on international basins. Some basins, such as the Danube, share up to many countries.

According to ICPDR (2012), Danube River Basin is the second largest river basin of Europe (after Volga River Basin) with a total area of 801,463 km². It includes the territories of 19 countries (Austria, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Serbia, Slovakia, Slovenia and Ukraine) which make it the world’s most international river basin (Figure 2.6).



Figure 2.6 : Danube River Basin District (ICPDR, 2012).

As Europe's largest remaining natural wetland, the Danube Delta is one of the continent's most important habitats for wetland wildlife and biodiversity. Those ecosystems of the Danube River Basin are highly valuable in environmental, economic, historical and social terms, but they are subject to increasing pressure of human activities. As it is home to 83 million people with a wide range of cultures, languages and historical backgrounds, the increasing human impacts, pressure and serious pollution from agriculture, industry and municipalities affect the water supply for communities, irrigation, hydropower generation and industry, as well as opportunities for transportation, tourism and fishing. (ICPDR, 2012).

The International Commission for the Protection of the Danube River (ICPDR) is created in 1998 with an aim to ensure the sustainable and equitable use of waters and freshwater resources in the Danube River Basin. It is also indented to provide a basis to coordinate the implementation of the Danube River Protection Convention (DRPC), which came into force in 1998 signed by the Danube countries in Sofia, Bulgaria, in 1998. The work of the ICPDR is based on the “Danube River Protection Convention”, as the major legal instrument for cooperation and transboundary water management in the Danube River Basin (ICPDR, 2012).

Similarly, the Nile River Basin Initiative (NBI) is another example of inter-governmental organization that was established in 1999 by ten member states as

Sudan, South Sudan, Burundi, Rwanda, Democratic Republic of the Congo, Tanzania, Kenya, Ethiopia, Uganda and Egypt to promote cooperation among all Nile riparian countries (Figure 2.7).



Figure 2.7 : The Nile River Basin (NBI, 2012).

The goal of NBI is determined as ‘to achieve sustainable and socioeconomic development through the equitable utilization of and benefit from, the common Nile Basin water resources’ (Cascao, 2011). The River Nile is the world’s longest river in the world that flows northward from the lakes of Central Africa to the Mediterranean Sea with an estimated length of over 6800 km and extending for more than 3 million square kilometers including 10 riparian in African continent (NBI, 2012). Some countries, such as Zaire, have only a small part of their total area in the Nile Basin. Others, like Burundi, Egypt, Rwanda, Sudan and Uganda, are nearly completely integrated into the Nile Basin. The countries in the basin rely heavily, and sometimes exclusively, on the waters of this resource for drinking water, agriculture, power generation, tourism and industry. Egypt is dependent on the Nile for 98 per cent of its water needs, while 77 per cent of Sudan’s water resources come from the Nile (IAEA-Water Resource Programme, 2011).

As Danube River is home to 83 million people including four capital cities it flows through (Vienna, Budapest, Bratislava, Belgrade) also in the Nile River Basin about 300 million people live. Approximately 160 million of those people depend on the Nile including the major cities that are located on the edge of the Nile like Cairo, Gondokoro, Khartoum, Aswan, Thebes/Luxor, Karnak, and the town of Alexandria lies near the Rozeta branch (NBI, 2012). The activities of those people within the catchment area affect the environment of the basin leading to problems with water quality and quantity, and significant reductions in biodiversity. Especially major cities and urbanized parts of the basin with high density of individuals and human activities are the foremost causes and the drivers of environmental problems. Such as, in Austria, the Danube is a major economic, geographical and cultural force and home to 7.7 million people but point-source discharges, sewerage and organic pollution, hydro-morphological pressures and alterations on land use are the main problems of river system in the capital, Vienna.

To conclude, it is clear to emphasize that the health of a watershed is dependent on the health of the relationship between urbanized area and the basin. In this sense, the environmental, social and economic dimensions of single-family residential land, new development, commercial areas, agricultural land, wetlands, and upland forests in critical headwaters and confined valleys have to be taken into account carefully and in the long-term watershed health should be related with community-wide engagement to be sustainable especially starting from urban areas.

2.3 Riverine Systems in Urban Areas: Local Level

The interaction between human and water is associated with the control mechanisms and dominance of human activities on these natural systems. Throughout the history, the land around riverine systems has always been a suitable and preferred place for human beings. Water constitutes the mainspring of civilization and it was recognized at the dawn of civilization especially in Mesopotamia and in Egypt.

2.3.1 Relationship between human settlements & riverine systems

As it can be seen from the early civilizations such as the Egyptian, Indian and Mesopotamian Civilizations, they all developed in the close vicinity of major rivers and water has always played a central role in human societies. Throughout the

history, it has been recognized that water is an essential requirement for the survival of humans and ecosystems (Biswas, 2008).

These civilizations were all founded on their access to water which provided the key not only to supplying freshwater, but also to agriculture, trade, transport and defense. Importance of water also has incorporated into culture of society and become a resource for inspiration about religion or art by the physical and aesthetic properties of water. This early recognition of the link between water management and civilization made human societies to be constrained indirectly by the influence of water on food, energy, transportation, and industry. Throughout the history, human societies have found new means to secure availability of water where they settled. They have devised ingenious methods to harvest, transport, and store rainwater, spring water, groundwater, and even air moisture (UNESCO-IHP, Hassan, 2003). According to Postel (1999), such as the great Egyptian civilization in the Nile River valley has sustained itself for some 5,000 years without interruption. The Egyptians practiced a form of water management called basin irrigation, a productive adaptation of the natural rise and fall of the river. They constructed a network of earthen banks, some parallel to the river and some perpendicular to it that formed basins of various sizes. For nearly 1,500 years, Egyptian farmers cultivated about 800,000 hectares under this system of basin irrigation. The shaduf, the water-lifting device already in use in Mesopotamia appeared in upper Egypt sometime after 1500 BC (Figure 2.8a). This technology enabled farmers to irrigate crops near the riverbanks and canals during the dry summer. A similar increase might have been afforded by the waterwheel, introduced sometime after 325 BC (Figure 2.8b). Therefore, those 1 million hectares of land were effectively under cultivation in the course of a year in Egypt (Postel, 1999).



Figure 2.8 : a) A shaduf was used to raise water above the level of the Nile.
b) Anoria, buckets attached to a waterwheel (Url-10, 2011).

Also canals are used in Egypt (reigned 2332–2283 BC), to bypass the cataract on the Nile for irrigation. Such that, the oldest known canals were irrigation canals, built in Mesopotamia. In ancient times, canals were an important part of human life in terms of supplying water for farming and for transportation. Also in ancient China, large canals for river transport were established as far back as the Warring States (481-221 BC). Because in the Middle Ages, water transport was cheaper and faster than transport overland (Url-11). By far the longest canal was the Grand Canal of China, still the longest canal in the world today (Figure 2.9).

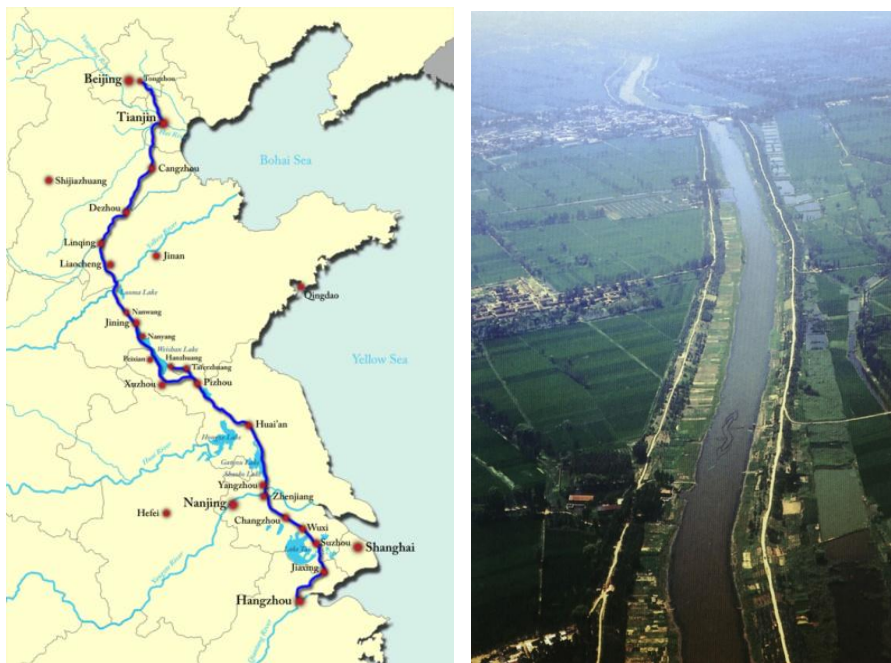


Figure 2.9 : The Grand Canal in China (Url-11, 2011).

The first artificial canal in Europe was the Fossa Carolina built at the end of the 8th Century. In the early 13th century, canals were also built in the Netherlands and Flanders to drain the polders and assist the transportation of goods. Canal building was revived in this age because of commercial expansion from the 12th century AD. River navigations were improved progressively and they were important for industrial development. The greatest stimulus to canal system building came from the Industrial Revolution with its need for cheap transport of unprecedented quantities of raw materials and manufactured items (Url-11).

The canal systems differ according to their structure and functions (Figure 2.10).

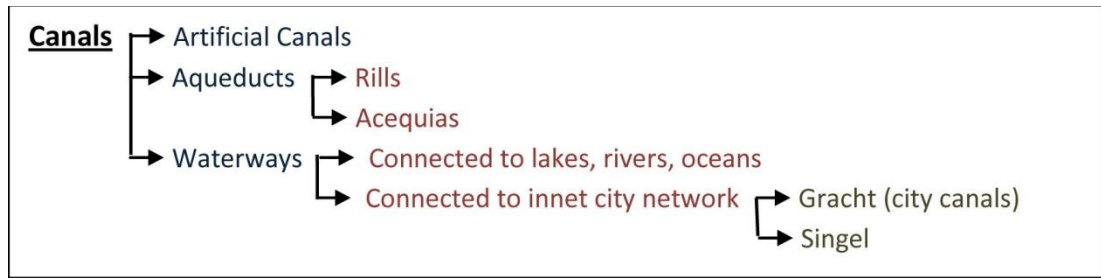


Figure 2.10 : Types of canal systems.

Mainly, there were three types of canals. First, artificial canals that subject to the ebb and flow of the tide. Second, aqueducts that are used for the conveyance and delivery of potable water for human consumption, municipal uses, and agriculture irrigation. Third, are waterways navigable transportation canals used for carrying ships and boats shipping goods and conveying people. As known, a canal is a man-made watercourse, usually in the countryside but gracht is a city-canal in the city with streets on both sides of the water (Figure 2.11a). The gracht, (plural: grachten) as a typical Dutch term, were used for many purposes: transportation, draining, water collecting and as sewers, all at the same time. In addition, a single by origin is a water-filled moat that surrounds a city for defense purposes (Figure 2.11b) (Url-12). Each system itself has its own main functions.

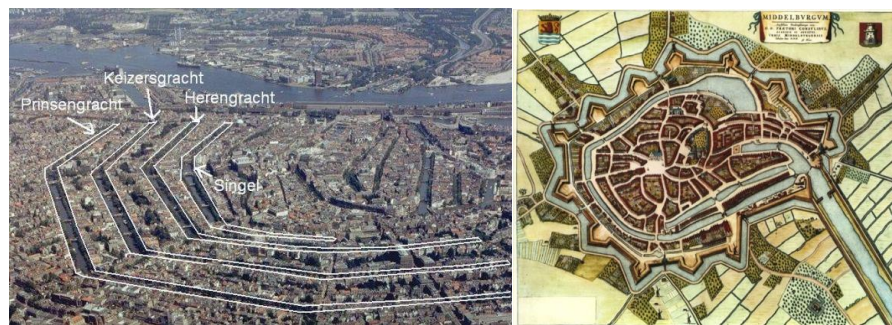


Figure 2.11 : a) Concentric half-circles of canals in Amsterdam b) Old map grachten & singels for defense in Middleburg, The Netherlands (Url-12, 2010).

Herein, riverine systems in urban areas have continued their role to be the interaction zones between human and nature over centuries. In addition to the importance of their ecological functions, they also can integrate the history with modern city features and provide a social cohesion among generations. So that, in some riparian cities, mutual benefits between these systems are considered as an integral part of the settlement life. As an illustration, the Seine River has always been a main component of Paris city serving as a transportation route for trading and a recreational area for

inhabitants in early times (Url-14). Moreover, an inner-city transportation system is established which connects many pedestrian roads and squares to the riverbanks through main arteries of roads (Figure 2.12). Similarly, Danube River in Budapest, Hungary as one of the four capitals Danube flows has an important role for history whereas it divides the city in to two parts. Budapest became a single city occupying both banks of the river Danube with a unification on 1873 of west bank Buda and Óbuda with east-bank Pest. The river is still an important attraction point of the city with the seven islands it contains (Figure 2.13) (Url-15).



Figure 2.12 : a) Seine River in Paris b) George Seurat's painting 'Sunday Afternoon on the Island of La Grande Jatte-Seine' (1884-1886) (Url-14, 2012).



Figure 2.13 : a) Danube River in Budapest b) Margaret Island (Url-15, 2012).

However, during the earlier times, the clusters of the human population were small, the ranges of the human activities were very limited and generally water was plentiful and of reasonably good quality. On the other side, the human population steadily increased over the centuries, and the range of the human activities expanded, especially after the Industrial Revolution, water resources, both in terms of quantity and quality, started to come under increasing stress in many parts of the world ever than before (Biswas, 2008). The world population and the associated economic activities have continued to increase very significantly since the post-war period. This has meant that not only have humans needed an increasing quantity of water for

various uses, but they have also produced enormous quantities of wastewater, which have been discharged to the environment, mostly to the water bodies such as rivers, lakes, and oceans, with limited or generally without treatment (Biswas, 2008). Accordingly, because of the continued indiscriminate discharges of the inadequately treated wastewater, the water quality of the rivers, lakes and the coastal areas had declined steadily by the late 1960s. On the other hand, the efforts to control and manage rivers under the concepts of planning, developing, and managing have emerged in the late 19th and early 20th centuries.

River basin development was boosted by technological changes in dam construction at the beginning of the 20th century. During the second half of the century multipurpose development of river basins focused primarily on the construction of large dams for hydropower generation, flood control and water storage for irrigation (Teclaff 1996). Over time, many streams and river basins in urban areas were altered hydraulically, chemically and biologically through navigation and flood control projects, wetland dredge-and-fill activities, industrial activities and waste discharge.

In 2010, 'Ajka alumina plant accident' as an illustration of a recently happened industrial disaster in Europe, had shown the critical situation of riverine systems against the threats of human activities. On the 4th October 2010, corner of the dam of reservoir in an alumina factory in Hungary collapsed and the toxic red sludge including heavy metals flow through three villages and creeks that flow into waterways connected to the Danube with a high pH value and alkaline content (Figure 2.14). At least nine people died, and 122 people were injured. About 40 square kilometers of land were initially affected. The spill reached the Danube on 7 October 2010. The industrial accident, triggered by the collapse of walls at the factory reservoir, has been described as an ecological disaster and threatened the entire ecosystem of the Danube as the Europe's second longest river flowing through 19 countries (Url-13).



Figure 2.14 : Toxic sludge spill in Hungary (Url-13, 2010).

This case showed clearly that, urban watersheds and riverine systems are under the pressure of dense human activities. Therefore, under like larger river basins in nature, the watersheds in urban areas also must be viewed as integrated physical systems whose proper functioning depends upon the interplay of hydrologic, chemical, and ecological elements as part of urban ecosystem functioning (Platt, 2006). In this framework, the role and importance of riverine systems in urban areas should be defined in the context of urban ecology and the ecosystem services generated by riverine entire watershed systems for urbanized areas.

2.3.2 The role and functions of riverine systems in urban ecosystems

There are many ways to describe cities. However, even with all of the ways we have to describe cities we do not normally think of them as in any way related to the ‘natural’ environment (Light, 2003).

In this context, Eugene Odum (1953), states that: “Any unit that includes all of the organisms (i.e., the “community”) in a given area interacting with the physical environment so that a flow of energy leads to clearly defined tropic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and nonliving parts) within the system is an ecosystem”. In this framework, there are two distinct meanings of urban ecology in the literature. One is a scientific definition, and the other emerges from urban planning. In ecology, the term urban ecology refers to studies on the distribution and abundance of organisms in and around cities, and on the biogeochemical reserves of urban areas. In planning, urban ecology has focused on designing the environmental amenities in cities for people while reducing their impacts on the environment (Pickett et al., 2001).

According to Lord et. al., (2001), understanding the city as an ecosystem began with understanding following four perspectives: First, human activities are concentrated in urban settlements. Even for those living outside of metropolitan centers in what are classified as rural landscapes, the productive activities of these people are often linked to resource requirements in nearby or distant areas. Second, humans as a species dominate each of the earth's ecosystems, whether they are heavily populated or not. Third, any modern model of ecology must include considerations of human impact in order to be of use as a predictive tool. Finally, developing an understanding of the ecological processes that occur within urban landscapes can be of great utility to those professionals in charge with dealing the social problems inherent in the city life.

As biophysical components of urban ecology, research on urban ecology highlights the nature of the physical environment, including urban climate, precipitation, hydrology, vegetation structure & biodiversity and soils. They can be called also terrestrial components of urban ecological systems. The main principles of this approach are balance, competition, and the ecological processes of invasion, succession, and dominance. In addition, hierarchies, patchiness, and perturbation are some other underlying principles of ecology including resilience, resistance, persistence, and variability (Picket et al., 2001). On the other hand, Lord et al., (2001) states that, ecology of research topics that recognize the city as a legitimate ecosystem include the ecological effects of land-use change, the spatial distribution of resources (abiotic) or populations (biotic) and whole system metabolism (energy flow). However, standard ecological models suggest three biophysical forces or drivers that stimulate and modulate the nature of any ecosystem:

- 1) The flow of energy,
- 2) The cycling of matter
- 3) Information flow among humans.

These forces lead to five major processes in ecosystems; primary production (energy captured by plants through photosynthesis), population growth and decline, organic matter (the raw “stuff” of food), nutrients (available food) and disturbance (climatic, geological or human induced). Consequently, human factor is a key element of urban

ecology and should be considered in any planning process for ecological functioning in the environment.

As socio-economic components of urban ecology, social scientists mainly focus on interactions between humans and their environments with indicating the integrity of social sciences with ecology. Because human behaviors are the basic element of each system in urban areas. According to Picket et al. (2001), these components are socio-cultural hierarchy, access and allocation of resources, wealth, power, status, social identity, security, GDP, institutional system, administrative system, health services etc.

Ecological studies of terrestrial urban systems include many contrasts between economic development, social wellbeing and ecological conservation in urban areas. However, if the integrity of each system is succeeded then the urban ecology can be a linkage between these three components of sustainable development. Such that, sustainable development recognizes social and economic progress, which should be simultaneous and integrated with supporting ecosystems (World Commission on Environment and Development, 1987). However, the integration of such principles in to practice have some challenges and requires scientific & pragmatic tools. One such pragmatic approach to apply this principle in to practice is that of ‘ecosystem services’, which describes the multiple benefits provided to people, both directly and indirectly by ecosystems and biodiversity (Daily, 1997). In April 2000, Millennium Report to the United Nations General Assembly, in recognition of the growing burden that degraded ecosystems are placing on human well-being and economic development and the opportunity that better managed ecosystems provide for meeting the goals of poverty eradication and sustainable development. These were grouped by the UN Millennium Ecosystem Assessment Report (MEA) (2005) into four categories: ‘provisioning services’ (extractable resources), ‘regulatory services’ (processes that regulate the natural environment), ‘cultural services’ (culturally-valued benefits) and ‘supporting services’ (processes essential to maintenance of the integrity, resilience and functioning of ecosystems). Ecosystem services collectively underpin human wellbeing, including health, economic activities and enjoyment of life, exposing the complexity and diversity of interactions between society and natural systems (Everard and Moggridge, 2011).

According to Egoh et al., (2007), evaluations of ecosystem services in urban environments exist in the scientific literature but there is not a widely accepted methodology for applying the ecosystem services approach. However, environmental authorities, policy-makers and practitioners increasingly recognize the value of the ecosystem services approach and are beginning to adapt this in practice.

Urban areas are primarily sites of consumption including urban built up areas and connecting infrastructures, which are agglomerations of people and their activities. Although it is the concentration of humans, urban areas are also home to many natural units such as, forests, wetlands or grasslands as well as connecting coastal areas and riparian corridors. These ecosystems provide services to humans, such as recreation in urban parks and freshwater from nearby watersheds (Figure 2.15) (Marcotullio and McGranahan, 2005).

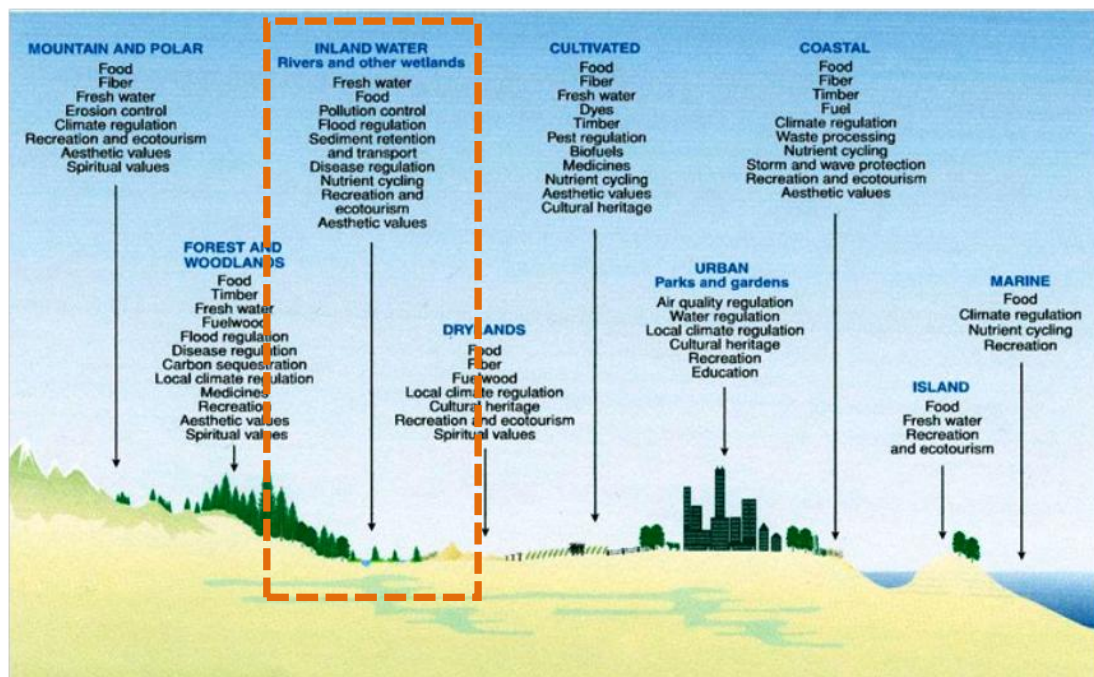


Figure 2.15 : Potential ecosystem services in urban areas (MEA, 2010).

These watershed areas including headwater streams provide important ecosystem services, including clean drinking water, habitat for aquatic life, and rapid processing and uptake of nutrients, which can reduce delivery of nitrogen and phosphorus to downstream coastal waters. Streams in urban areas, as another component of this system, serve as a variety of functions: urban drainage and flood management, aquatic habitats and material carrying, public and community amenity (including linkages to open space). They can include special cultural and community

significance (Elmore and Kaushal, 2008). In this context, river systems are key components of surface water cycle and the main channel for mass and energy exchange (Table 2.1).

Table 2.1 : Ecosystem services of riverine systems in urban areas.

Ecosystem Services of Riverine Systems in Urban Areas	
Provide :	Freshwater, Food, Fibre, Aquatic Habitats, Energy Production
Regulate :	Flood Management, Disease Control, Water & Air Pollution Control, Urban Drainage
Cultural Services:	Public & Community Amenity , Recreation, Aesthetic Values, Ecotourism
Support :	Soil Fertility, Water Cycle, Material Carring (Water & Sediments Carring), Mass & Energy Exchange

As a conclusion, “Urban Rivers” refer to those that originate from or flow through urban settlements, including some artificial canals and canal systems, which have had the characteristics of natural rivers through their evolution.

Urban rivers not only provide important source and material transportation channels but also play an important ecological role (Lei and Guanghe, 2008). These riparian areas are hotspots of interactions between plants, soil, water, microbes and human beings. Because they occur at the land-water junction alongside the natural waterways. They form unique ecosystems that act as ‘buffer zones’ between up-streams and down-streams (Lowrance, 1998). Therefore, riparian zones are foci for human-nature interactions and can serve as catalysts for ecological and socioeconomic revitalization in urban systems (Groffman et al., 2003).

2.4 Summary of the Chapter

The chapter examined the role, importance and functions of riverine systems from three different perspectives.

Accordingly, as it is indicated from all these different levels, water has always been one of the fundamental resources utilized by human societies. Daily (1997) states

that, freshwater ecosystems are degraded and destroyed worldwide, human society will lose the wealth of ecosystem services those healthy freshwater ecosystems provide.

Therefore, management and conservation of these natural resources located within the area of a river basin is a valuable option for guiding and co-coordinating processes of management for development in the light of environmental variables (Dourojeanni, 2001). Such that, river basins are the units, which are defined by natural boundaries carry water and contribute runoff to a particular water body consist of different ecological units including woodlands, agricultural lands, wetlands rural & urban areas. In addition, they are independent forms of administrative boundaries, which may require an international perspective for the management of river basins including a collaborative approach of all riparian's. Therefore, watershed boundaries should be the planning units for management of natural resources at regional level. Meanwhile, it would be obvious and easy to observe the negative effects of human actions on the environment, especially in the form of water pollution at watershed level. At that point, the perspective which is required by watershed level management unites social, economic, and environmental concerns in a landscape where upland forests and rangelands, wetlands, agricultural and urban areas are integrated even from different states.

From a local perspective, urban areas constitute the key problematic points for the riverine systems that flow in within the whole basin itself. Because, urbanization is a dominant demographic trend and the cities are key to the promotion of global sustainability, yet we are only beginning to understand the ways in which their activities impact the local, regional, and global ecosystems (UNU/IAS Report, 2003). The negative impacts of urbanization and increased levels of social and economic activities cause chain alterations on these systems. Therefore, urban areas become the most vulnerable zones for the interaction between human activities & natural integrity. On the other hand, the areas including riverine systems have always been important sites for human beings to settle and live with the utilities of essential water sources for transportation, defense, irrigation or recreational amenities. As can be seen from many cities both from ancient times and today's settlements, urban rivers are always the foundation for city's existence, containing city's rich history and culture and embodying modern city's peculiar features and beautiful scenes.

However, as a result of rapid urbanization and industrialization in early 19th century, particularly urban ecological systems are largely exposed to several problems caused by human activities and indicate the requirement of understanding the city as an entire ecological system. According to Grimm et al., (2001), the perspective of understanding the city as an ecosystem starts as viewing the city as an organism in itself. As riverine systems are limited resources of freshwater systems has an important role for natural processes on Earth, riverine systems also have an important role as a part of urban ecology. They are the riparian areas, which are hotspots of ecological function in many landscapes that occur at the land & water junction alongside natural waterways, and they form unique ecosystems act as "buffer zones" between uplands and streams (Lowrance, 1998). At local level, riverine systems provide many ecological service functions for cities such as water supply, biological protection and landscape amusement. It also promotes urban development with its social, economical and environmental values. Briefly, riverine systems in urban areas are: 1) habitats for a potentially diverse and productive biota, 2) carriers of water and processors of the materials in that water, and 3) important social and cultural foci for the human inhabitants of their catchments (Changming and Xiaoyan, 2008).

However, with the urban size expansion and increasing disturbances of human activities, such waterways were managed as a resource for human benefit including water supply, flood mitigation, disposal of wastewater and minimization of disease (Paul and Meyer, 2001).

3. ENVIRONMENTAL CONFLICTS AND RENATURATION OF RIVERINE SYSTEMS IN URBAN AREAS

The world is becoming ever more urban (Roy et. al., 2009).

More than 50% of the global population currently lives in cities, and this percentage will rise more in coming decades. In another way, all of the population growth expected in the next 25 years (2000 and 2030, approximately two billion people) will be concentrated in urban areas and the world's urban population will reach more than 60 percent (4.9 billion) by the year 2030 (United Nations, 2005). As human population has been increasing as such our species' impact on the global ecosystems, humans are becoming the dominant species in urban ecosystems on the pace of environmental change (Lord et al., 2001).

In the context of third chapter, riverine systems and urbanization relations are examined in detail with discussing the results of increasing human activities on these systems. All the contradictions between consumption centers (cities) and conservation concerns (urban ecological systems) which overlapped in the same area are called with the word of 'Environmental Conflicts'.

Herein, the concept of conflict encompasses a broad spectrum of empirical phenomena ranging from disputes between individuals and wars between states. Meanwhile, environmental conflicts manifest themselves as political, social, economic, ethnic, religious or territorial conflicts, or conflicts over resources or national interests, or any type of conflict (Libiszewski, 1996). Also, they are characterized by the principal importance of degradation in one or more of the following fields:

- Overuse of renewable resources,
- Overstrain of the environment's sink capacity (pollution),
- Impoverishment of the space of living.

In this framework, environmental conflicts of urban riverine systems can be count under each degradation field including overuse and pollution of aquatic systems with

spatial expansion of urban areas among riverbanks that causes chain problems within the ecological and socio-economic structure. At that point, after analyzing the importance and functions of riverine systems in urban areas related with their global and regional interactions (in chapter 2), the following chapter (3rd chapter) discusses about the changes, threats and impacts of urbanization process on these vulnerable and vital systems. Furthermore, rehabilitation approaches for urban riverine systems are discussed to reach a better integration between urban & riverine systems under the concept of 'renaturalization'.

3.1 Impacts of Urbanization on Riverine Systems

Widespread urbanization is a recent phenomenon in 1900 just 15 percent of the world's population lived in cities. The 20th century transformed this picture, as the pace of urban population growth accelerated very rapidly in about 1950. Sixty years later, it is estimated that half of the world's people lives in cities (Buckley et al., 2009). The rapid urbanization in many developing countries over last half century seems to have accompanied by excessively high level of concentration of the urban population in large cities.

According to Population Division Report of United Nations Department of Economic and Social Affairs (2001), the world's urban population reached 2.9 billion in 2000 and is expected to rise to 5 billion by 2030 (Figure 3.1).

Whereas 30 percentage of the world population lived in urban areas in 1950, the proportion of urban dwellers rose to 47 percent by 2000 and is projected to attain 60 percent by 2030. In addition, in 1950, one third of the world people lived in cities and just fifty years later, this proportion have risen to one half and will continue to grow to two thirds, and 6 billion people, by 2050. According to the report, population growth is projected to be particularly rapid in the urban areas of the less developed regions, averaging 2.2 per cent annually during 2005-2030. As a consequence, the urban population in the less developed regions will increase from 2.3 billion to 3.9 billion by 2030 (Figure 3.2).

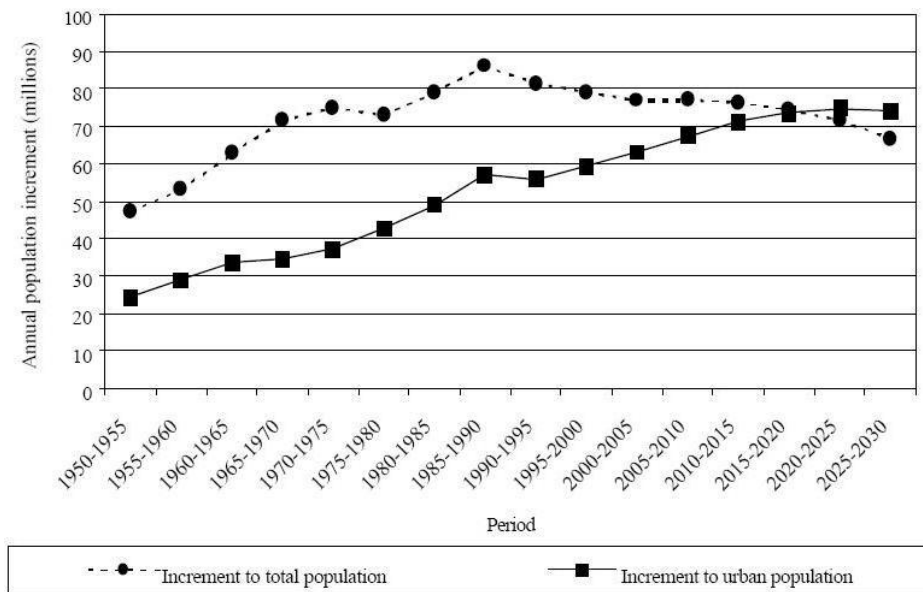


Figure 3.1 : Annual increment of the world population and the world urban population, 1950-2030 (UN Population Division, 2001).

As a result of increasing population densities, spatial distribution of urban areas, economic activity and social attitudes of the society, the world has become urbanized and this rapid change became the major cause of most environmental problems in urban areas mainly on aquatic resources. Because according to Maksimović and Guilbert (2001), these growing cities have been the engines of economic growth, vital centers of human activity and the requisite infrastructure for industrial activity. However, their fast growth, contaminants released by their large populations and industrial activities has created new problems of both quantity and quality of water.

During much of the 20th century, the water needs of growing populations were met through the construction of infrastructure to increase water withdrawals from rivers and aquifers. Water was perceived to be abundant, and impacts on the environment were incremental and little noticed at first. Today, water resources in many river basins are fully or almost fully committed to a variety of human uses, water quality is degraded, river-dependent ecosystems are threatened, and expanding demand for water is leading to intense competition and even at times to strife (Molle, 2007).

Under the discussion about negative effects of urban & riverine system relations, also there is no need to elaborate the interdependence of water and urbanization. Because as known, cities owe their early existence to availability of good quality water and the historical roots of settlements are to be found in the riverine regimes of our

world. In addition, the evolution and welfare of cities have been connected to both quality and quantity of their water supplies (Maksimović and Guilbert, 2001).

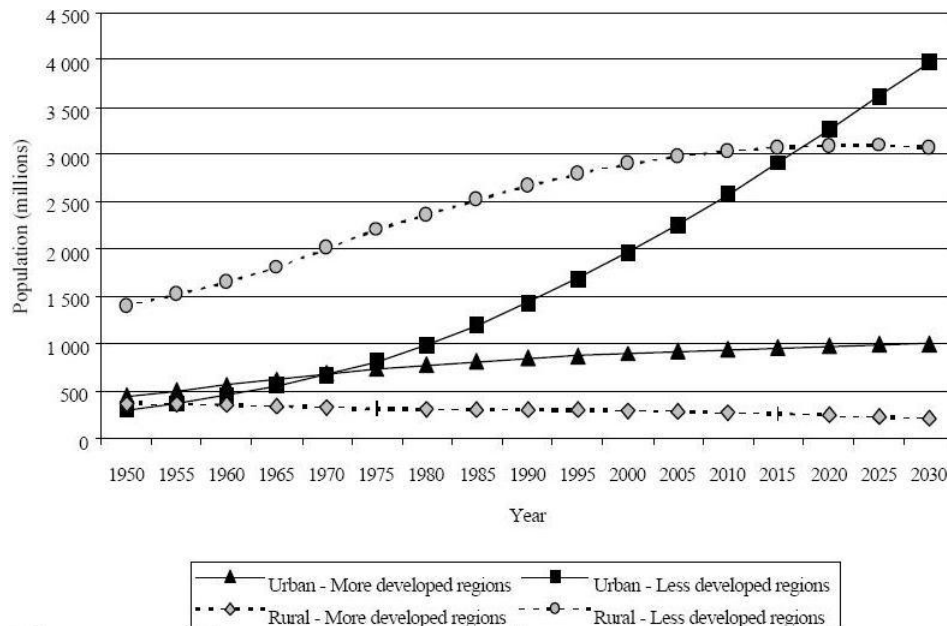


Figure 3.2 : Annual increment urban & rural population of more and less developed regions (Source: UN Population Division, 2001).

However, the ‘World Water Vision’ Hague declaration of March 2000 underlined that there is undeniable evidence that freshwater ecosystems have been declining in some parts of the world for hundreds of years. The problem has been getting more serious and it threatens the economic, social and environmental security of human society. Therefore, in order to understand and analyze the negative effects, results and interactions of urbanization process with riverine systems it is crucial to analyze this process from both socio-economic and environmental perspectives. It is also important to understand the ongoing debates and cooperation between different groups both national and international agenda.

3.1.1 Impacts of urbanisation from socio-economic & legal perspectives

As urbanization is accepted as a social, economic and territorial process, it put a considerable stress on socio-economic structure. In other words, urban development changes the spatial organization of economy and society in a remarkable way (Alpopi, 2005). As a key driver of this process, migration of people from rural to urban areas (especially in developing or under-developed countries) causes several congestion problems in cities those results with the agglomeration of settlements,

industries, infrastructure and several human activities. Hence, as city grows, the need for housing, infrastructure and other services also grows. Therefore, as one of the main characteristics of urbanization, population growth in cities promotes the growth of consumption and at the same time also brings the problem of unemployment with increasing crime rates. Besides, of these socio-economic effects of urbanization, the most remarkable and damaging effects of this process can be seen on natural systems. Because, growth of consumption brings overuse, degradation and pollution of natural resources including depletion of forests and agricultural lands, loss of biodiversity, water scarcity and sanitation problems. In addition, each type of wastes (domestic, industrial, medical, nuclear etc.) with sewage facilities and disposals causes water pollution whilst, transportation and industrial activities causes air and noise pollution. According to Platt (2006), especially, riverine systems are exposed to several impacts and pressures including waste discharges, riverbed alterations, channelization or burial in tunnels.

All these problems are perceived as major threats for the sustainability of coexistence of human societies (within ongoing urbanization process) and limited natural resources (which are essential for the existence of life) at global level. Thus, several conventions, legislations, organizations and acts are performed and added to the international agenda.

With the emergence of awareness and increase of international recognition of the need to manage human activities that have an effect on natural ecosystems, the first global step is taken by United Nations Conference on the Human Environment in Stockholm, 1972 with a published book called 'Limits to Growth' as an outcome of the conference. Mainly pollution problems all over the world are indicated with propounding the potential crises about depletion of natural resource because of uncontrolled consumption pattern. In addition, the concept of 'Carrying Capacity' is put forward with this declaration. In 1987, the importance of the balance between economic development and environmental conservation is stated by Brundtland Report - Our Common Future including emergence of a new term of 'sustainability'. Following to these steps, especially in the last decade, many international conferences, including the Rio Earth Summit in 1992, UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes in 1992, The UN Convention on the Law of Non-Navigational Uses of International

Watercourses in 1997, EU Water Framework Directive (WFD) and UN Millennium Declaration in 2000, and the World Water Forum seminars (started in 1987 in Morocco and, The Netherlands-2000, Japan-2003, Turkey-2009, France-2012), workshops and all kinds of meetings (including those of UNEP/GPA, UNCSD, WWF, and OECD/DAC) have all reiterated the urgent need to give due importance to ecosystems in water management policies and practice (Table 3.1).

Table 3.1 : Water-related legislation and conventions.

Name & Location	Year	Important Outcomes
1.The Helsinki Rules on the Uses of the Waters of International Rivers, Finland	1966	- An international guideline regulating how rivers and their connected ground waters that cross national boundaries may be used, adopted by the International Law Association (ILA)
2. Ramsar Convention, Iran	1971	- An intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (1822 wetland sites)
3. Declaration of the United Nations Conference on the Human Environment Stockholm, Sweden	1972	- The first document in international environmental law to recognize the right to a healthy environment. - ‘Carrying Capacity’ concept & Limits to Growth - influenced legal and institutional developments (creation of the United Nations Environment Programme- UNEP)
4. United Nations World Commission on Environment and Development (WCED)	1987	- Publication of Our Common Future (Brundtland Report) - ‘Sustainability’ concept is put forward - Influenced strongly the Earth Summit in Rio de Janeiro in 1992
5. International Conference on Water and the Environment (ICWE) in Dublin, Ireland	1992	- Dublin Statement on Water and Sustainable Development (Dublin principals) - The emphasis on the economic value of water & increasing scarcity of water

6. United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, Brazil (known as Rio Conference or Earth Summit)	1992	- (UNFCCC) which led to the Kyoto Protocol in 1997 - Rio Declaration on Environment & Development, Convention on Biological Diversity, Forest Principles - Agenda 21 action plan is developed
7. UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Helsinki, Finland	1992	- Provide a basis for several bilateral or multilateral agreements between European countries (DRPC-1994 & WFD-2000) - Conservation and protection of ecosystems & public information
8. The UN Convention on the Law of Non-Navigational Uses of International Watercourses	1997	- The first global water law - Influenced by Helsinki Rules in 1966 document that was approved by a vote of 103-3 (Turkey voted against) - The law proposed by the International Law Commission (ILC)
9. EU Water Framework Directive (WFD)	2000	- A legal framework for the protection and restoration of clean waters across the European Union - By 2015, Member States are to achieve "good water status" on surface waters - Based on 'River Basin's and provide a form of IWRM planning.
10. United Nations Millennium Declaration (Millennium Summit), New York City, USA	2000	- Its purpose was to discuss the role of the United Nations at the turn of the 21st century - Eight Millennium Development goals are derived from (MDGs) Millennium Declaration
11. The 2005 World Summit	2005	- follow-up summit meeting to the UN-2000 Millennium Summit - World Summit Outcome Document mainly on security and human rights
12. EU Directive on the assessment and management of flood risks	2007	- Directive on the assessment and management of flood risks - More emphasis on the role of flood plains and sustainable land use practices
13. World Water Forum Declarations	1987-2012	- Organized by World Water Council - Marrakech, Morocco - 1987 - The Hague, Netherlands - 2000 - Kyoto, Japan – 2003 - Mexico City, Mexico - 2006 - Istanbul, Turkey - 2009 - Marseille, France - 2012

Specifically, the Ramsar Convention in 1971, International Conference on Water and the Environment (ICWE) and UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, in 1992 have the role as an important stepping stone for management and protection of surface waters in international agenda (Ramsar COP8 DOC., 2002).

In this context, watershed management is increasingly viewed by environmental policy specialists. Because, river systems are in many cases not confined to one country. Activities in a river catchment may therefore have a direct effect in other countries. Co-operation between countries concerning these activities is thus crucial for sustainable management of the river resources and cross border activities include water abstraction, pollution, river siltation, catchment deforestation, etc., but also include the introduction of aquatic species (FAO, 2008).

In the context of UN Conventions and EU Legislations, Integrated Water Resource Management (IWRM) and European Union Water Framework Directive (WFD) are discussed in detail in terms of integration of spatial planning approaches to legal framework at basin scale.

“UN Convention” and IWRM:

The United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses is a global instrument to promote the equitable and sustainable development and management of river basins shared by two or more states. The convention was passed by the UN General Assembly in 1997 by a 103-3 vote. Also, WWF has embarked on an initiative to facilitate dialogue among governments, UN bodies, NGOs, and other actors to promote further ratifications (Clarke et al., 2011).

In the context of UN-Water Task Force, the traditional fragmented approach is seemed as no longer viable and a more holistic approach to water management is essential. Therefore, Integrated Water Resources Management (IWRM) approach has developed as an empirical concept, which is built up from the on-the-ground experience of practitioners. The concept was made the object of extensive discussions as to what it means in practice. The Global Water Partnership's (GWP) definition of IWRM is widely accepted. It states: 'IWRM is a process which promotes the coordinate development and management of water, land and related

resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.' This statement now has been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands' (UNEP, 2009).

Integrated Water Resources Management is a cross-sectoral policy approach, designed to replace the traditional, fragmented sectoral approach to water resources and management that has led to poor services and unsustainable resource use. IWRM is based on the understanding that water resources are an integral component of the ecosystem, a natural resource, and a social and economic good. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of ecosystems for future generation (GWP, 2012). IWRM is a step-by-step process and takes time. By responding to changing social, economic and environmental needs or impacts, one can gradually achieve better and sustainable water resources management as if moving up a spiral, through such means as progressively developing water resources in the basin, building a more integrated institutional framework, or improving environmental sustainability. The set of IWRM Guidelines illustrates the dynamic and evolving process of IWRM in a river basin using a conceptual 'IWRM Spiral' model as shown in (Figure 3.3) (IWRM Guidelines, 2009).

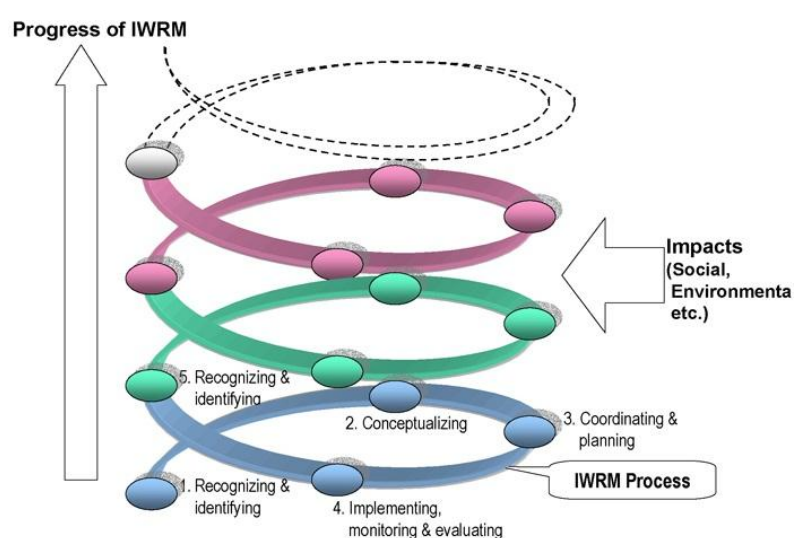


Figure 3.3 : IWRM Spiral (Source: IWRM Guidelines, 2009).

The spiral evolutionary model reflects progressive positive changes in historical water resources development and management which permits immediate action, builds understanding, develops local capacity and creates ownership (IWRM Guidelines, 2009).

“European Union (EU)” and WFD:

Most EU countries are heavily reliant on water resources flowing from out with their territory, and it is therefore not surprising that there is a long tradition of conflict and cooperation of Europe’s transboundary waters. Such history has resulted in the adoption of numerous bi-lateral and basin-specific agreements. At the regional level, the 1992 UNECE Helsinki Convention seeks to implement integrated water resources management (IWRM) throughout Europe’s transboundary waters. Adopted in 2000, the EU Water Framework Directive (WFD) aims to prevent further deterioration of water resources in the EU and to reach adequate water quality and quantity status in all of the member states inland and coastal waters by 2015 (Clarke et al., 2011).

The framework covers groundwater and all surface waters including rivers, lakes, coastal waters and ‘transitional waters’, such as estuaries that connect fresh and saltwater. It sets a less ambitious objective ‘good potential’ for artificial and ‘heavily modified’ bodies of water such as canals and reservoirs, or industrial ports. The Framework Directive is built on four main pillars (EU, 2010).

1. Coordinated action to achieve ‘good status’ for all EU waters, including surface and groundwater, by 2015.
2. Setting up a water-management system based on natural river basin districts, crossing regional and national boundaries.
3. Integrated water management, bringing different water management issues into one framework.
4. Active involvement of interested parties and consultation of the public

The EU defines ‘WFD’ as a holistic approach to water resources management that encompasses “environmentally-sound water management; food security especially for the poor; private sector involvement; reduction of subsidies; decentralization of decision-making to the lowest appropriate administrative level; user participation in services; institutional reform and regulatory frameworks; and cost recovery and

pricing”. This holistic approach requires balancing the competing demands on the resource domestic, municipal, agricultural, industrial and environmental. Also the EU Water Initiative stresses the need for integration between health, livelihoods, and economic development, peace and security considerations like The Convention on Wetlands (Ramsar, 1971) and Agenda 21 (Ramsar COP8 DOC., 2002).

As the WFD sets out a timetable for the implementation of requirements for EU member countries also the candidate countries like Turkey will also adapt the directive and prepare an individual implementation plan. In this context, The Ministry of Environment is assigned as the responsible institution for co-ordinating the implementation of the WFD in Turkey. Also, the main players are determined as the General Directorate of Environmental Pollution Prevention and Control and the General Directorate of Environmental Protection of the Ministry of Environment (Moroglu and Yazgan, 2008).

Within the context defined by the Helsinki Summit, beginning from early 2000’s, a number of steps have been taken by Turkey in order to facilitate the harmonization process with the EU Water Framework Directive and its related EU-level legislation WFD harmonization process in Turkey have contributed to changes in three dimensions of Turkey’s water policy:

- 1). Pilot projects, which includes projects supporting harmonization in a specific location such as MATRA Project focusing on Büyük Menderes Basin.
- 2) Legislation changes in order to move Turkish water legislation closer that of the Union’s.
- 3) Provisions that official legal documents and independent official studies or initiative entail with respect to water management policy area. (ORSAM, 2011). Although, EU reported that limited progress on the implementation of WFD is observed in Turkey according to ‘2006 Progress Report of Turkey’, because of the complex legislative and institutional structure, technical challenges and costs, the adaptation process seems complicated and long run for Turkey (Moroglu and Yazgan, 2008) .

3.1.2 Environmental perspective of urbanization impacts and urban stream Syndrome (USS)

Clearly, it can be seen that human actions dramatically alter the functioning of ecosystems of which humans are also a part (Grimm et al., 2000).

Major human impacts on the environment probably go back as far as 12,000–15,000 years ago, when Siberian hunters first entered the Americas. These hunters may have played an important role in the extinction of many species of large mammals (Grimm et al., 2000). The introduction of agriculture transformed human–environmental relations in virtually all parts of the world, leading to, in addition to the obvious benefits, localized but intense episodes of deforestation, soil erosion, disease, and region wide degradation of vegetative cover long before the modern era. Today, urbanization is a dominant demographic trend and an important component of land-transformation processes worldwide.

From this point of view, the ‘ecosystem approach’ is adopted by the Convention on Biological Diversity (CBD) in 2000 which has a broad scope that goes beyond ecosystems themselves to encompass social, cultural and economic factors that are fully interdependent with biodiversity and ecosystem services. For the last decade, ecosystem approach based management is becoming the dominant paradigm for resource managers. Such that, ‘The Convention on the Law of the Non-Navigational Uses of International Water Courses’ stresses the need to utilize international watercourses in an equitable and reasonable manner taking into account all relevant factors within ecosystem approach including: (a) geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character; (b) the social and economic needs of the watercourse states concerned; and (c) the population dependent on the watercourse in each watercourse state (Ramsar COP8 DOC., 2002). IUCN defines an ecosystem-based approach as a strategy for integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable fashion. The specific aims are to: (1) maintain ecosystem functions and services; (2) support livelihoods; (3) ensure equitable sharing of benefits amongst shareholders; (4) promote adaptive management, to enable people to make informed choices; (5) decentralize management, to empower people to manage their own resources; and (6) foster intersectoral cooperation, to achieve greater effectiveness through partnerships.

On the other hand, human alteration of Earth is substantial and increasing. As the human population has grown and the power of technology has expanded, the scope and nature of modifications on environment has also changed drastically. Due to the growing demands of rapid population increase, the loss of forests and agricultural lands, changes on local climate (heat islands) and air quality, solid wastes and soil pollution, water sanitation and pollution problems and declines on biodiversity are seem as the results of urbanization impacts on environment.

Hence, ecological impacts of population growth and urbanization process on riverine systems are profound (Platt, 2006). Because, as the level of human activity increases and the ability to change the nature also enhances. As running waters occupy the lowest-lying areas on the landscape, they integrate the effects of land-use change and thus are very sensitive to urbanization. As land is cleared of vegetation and replaced with a large amount of impervious surface such as asphalt, concrete and rooftops, the amount of run-off entering streams increases; the hydrology and geomorphology of receiving streams are fundamentally altered; and the consequences for ecological changes can be severe and complex (Bernhardt and Palmer, 2007).

These negative urban impacts on riverine systems include increased flooding, increased stream velocity, erosion, sedimentation and loss of habitat. But, according to Bernhardt and Palmer (2007), the most obvious and immediate consequences are an increase in impervious surface area with resultant increased runoff to receiving streams, higher peak discharges, greater water export and higher sediment loads during the construction phase. Over time as the catchment is built out (new construction slows or ceases), the hydrologic alterations remain but sediment delivery to streams decreases dramatically leading to channel erosion and sometimes dramatic increases in channel width and depth.

According to 'Impervious Cover Model' which has been supported by over 200 studies and developed by Center for Watershed Protection, aquatic system's health is related with percentage of impervious cover in its contributing watershed. The Model is based on the average percentages of impervious cover at which stream quality declines, and classifies those impacts into three categories: Sensitive, Impacted and Non-supporting streams (Figure 3.4).

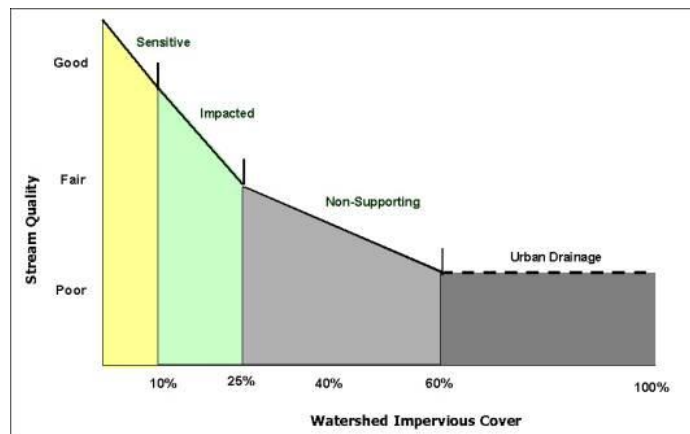


Figure 3.4 : Impervious cover model (Source: CWP, 2009).

Sensitive streams have watersheds that are below a 10% impervious cover including excellent water quality and habitats. Impacted streams have water quality and habitat impairments, which are found in watersheds between 10 and 25% impervious cover. Non-supporting streams have severe water quality and habitat degradation in watersheds with over 25% impervious cover. The impacts are so significant that they are not considered suitable for restoration (CWP, 2012)

As a result of increasing impervious cover in developing catchments, evapotranspiration and soil infiltration are reduced, peak discharges and flashier stream flows increase. In most cities, urban stormwater drainage systems exacerbate the problem of high peak flows, with piped storm drainage networks efficiently routing stormwater directly into stream channels (Walsh et al., 2005). These changes in channel morphology disconnect the stream from its flood-plain, decrease sinuosity, and homogenize stream profiles. Therefore, an altered hydrograph with high peak flows and reduced baseflows is the most obvious and consistent effect of catchment urbanization on stream hydrology. This desire for physical channel stability has led to highly simplified urban stream channels in the most extreme cases urban streams are confined in concrete channels or routed through underground pipes.

In general, negative effects of urbanization on riverine systems can be categorized in four groups including land cover changes & imperviousness, modifications on stream morphology, pollution problems & discharges, groundwater pumping & droughts. The interactions of these impacts create several impacts and pressures on

riverine systems and alters their hydrological & morphological structure including chemical and physical features (Figure 3.5).

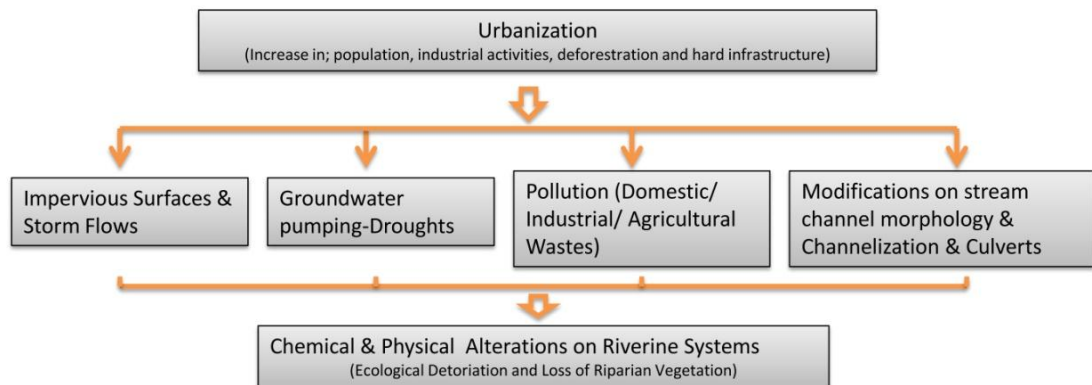


Figure 3.5 : Impacts of urbanization on riverine systems.

There are numerous urban impacts on local watersheds and aquatic resources, including the following:

- Flood hazards in metropolitan scale watersheds are intensified by increasing flashiness (the tendency to flood) and magnitude of peak discharge from storm events due to the spread of impervious land cover, grading the land surface, removal of vegetation and natural storage, and proliferation of artificial drainage networks (CWP, 2004).
- Increased impervious cover (IC) in urban watersheds alters stream hydrology and degrades stream habitat, water quality, and aquatic diversity.
- Rapid fluctuation in streamflow due to increased stream flashiness or deliberate intervention (cause erosion, sedimentation etc.)
- Urban streams are contaminated by point sources such as combined sewer overflows, sanitary sewer overflows, and industrial discharges and nonpoint sources such as failing septic systems and storm runoff. Farm and landscape fertilizers contribute phosphates and nitrogen to local drainage systems, causing algal blooms and reduced dissolved oxygen downstream, which leads to fish kills.
- Public access to and enjoyment of urban surface waters is widely impaired and seperated from urban ecosystem by physical & chemical problems.

All these negative effects of urban areas on riverine systems made the term ‘Urban Stream Syndrome’ emerge in scientific field and discussed as a tool to understand and define the multiple impacts on aquatic ecosystems.

The most critical challenge facing this generation is how we reduce our impact on the environment. Minimizing the environmental impact of urbanization on stream and river ecosystems is a major part of this challenge. Over the past two decades, myriad research has shown that streams and rivers in close proximity to urban areas are degraded chemically and ecologically that often referred to the ‘Urban Stream Syndrome (USS)’ which describes the consistently observed ecological degradation of streams draining urban land. It is also used to describe a consistent pattern of hydrological, physical, and biological conditions seen in aquatic ecosystems downstream of urban inputs (Walsh et al., 2005).

The term ‘urban syndrome’ was adopted at the symposium workshops as a way of communicating the changes that may be expected with increasing urbanization of catchments. Urbanization results in four broad interrelated forms of disturbance or degradation that can affect stream ecology, for example by altering hydrology, geomorphology or ecological processes such as energy transfer, nutrient cycling and the breeding or recruitment of flora and fauna. (Cottingham et al., 2003).

However, these urban-impacted stream ecosystems are degraded due to complex and multiple factors, and where the mechanisms of cause and affect are not always understood. Although, most impacts can be ascribed to a few major large-scale sources, primarily urban stormwater runoff delivered to streams by hydraulically efficient drainage systems. Other stressors, such as combined or sanitary sewer overflows, wastewater treatment plant effluents, and legacy pollutants (long-lived pollutants from earlier land uses) can obscure the effects of stormwater runoff (Walsh et al., 2005). Moreover, the symptoms of the urban stream syndrome include hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species. According to Walsh et al. (2005), these symptoms of the urban stream syndrome that appear to occur consistently across regions are predominantly driven by urban storm water runoff, which, in almost all urban areas of the world, has traditionally been managed for flood control by direct piped connection between impervious surfaces and streams.

Other anthropogenic impacts that may or may not be associated with urban land use may obscure the relationship between stream condition and imperviousness. Deforestation, particularly in the riparian zone, is often identified as an important driver of urban impacts to streams (Figure 3.6).

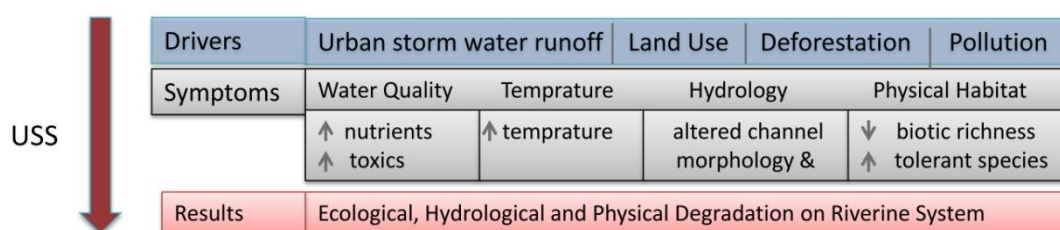


Figure 3.6 : Impacts of urbanization on riverine systems within USS framework.

Symptoms of the urban stream syndrome include a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species, which result ecological, hydrological and morphological alterations and degradations on riverine system structure (Walsh et al., 2005).

As a consequence, the first step to minimize the urban impact on stream ecosystems should be reducing the volume of storm water runoff reaching these important ecosystems and the second step should be reducing the nutrient loads. By focusing our efforts on reducing the volume and improving the water quality of urban runoff and wastewater discharges, we can begin to minimize the ecological degradation of stream ecosystems and allow them to heal. In this framework, efforts for rehabilitation of riverine systems are discussed within the context of renaturalization concept as a newly developed and accepted remediation approach for riverine systems.

3.2 Renaturalization of Riverine Systems

Over the last couple of decades, river restoration has grown an important endeavor to overcome the long-term deleterious effects of human manipulation of rivers (CRSSR, 2012). Also, the importance of streams as drivers of the biodiversity and ecological systems has been recognized recently and several efforts have been undertaken to restore streams, their fishery and floodplains. Work to date, however, has focused solely on stream channel design and mechanics with focusing on a

specific area with a narrow scope. Therefore, a holistic approach to stream renaturalization including groundwater exchange, geochemical cycling, establishment of appropriate ecological processes and systems including integration with urban systems (ecological and socio-economical systems) is missed.

From this point of view, following the first part (3.1) of the chapter with defining and analyzing the negative impacts of urban areas on riverine systems, the second part (3.2) discusses about the best solution to improve the damaged conditions of these systems with an integrated approach and containing a comprehensive framework both for urban and riverine systems. At that point, the study compares and discusses traditional efforts versus a newly developed term of 'renaturalization'.

3.2.1 From rehabilitation to renaturalization: evaluation of the approach

Although, streams in urban areas serve a variety of functions: stream habitat, urban drainage and flood management, public and community amenity (including linkages to open space), and can include special cultural and community significance, urban streams are usually highly modified from their natural, pre-urbanized state, with significant differences in stream and riparian habitat, stream flow and water quality.

Initially, such waterways were managed as a resource for human benefit including water supply, flood mitigation, disposal of wastewater and minimization of disease (Paul and Meyer, 2001). These anthropogenic activities due to modernization of society and the growth of urban areas have led to a subsequent damages and declines in quality and functioning of urban watersheds and riverine ecosystems. However, more recently, communities and government are recognizing that urban streams are degraded and neglected, and that 'restoring' them can provide multiple benefits from reconnecting communities with urban streams to improved stormwater performance.

In recent decades, the world has witnessed many reforms in the way the environment is viewed. So that the physical integrity of the world's freshwater ecosystems is now an important issue and supported by many international, national and regional programs and legislation (Findlay and Taylor, 2006). Especially with the emerging of water management policies such as the European Water Framework Directive (WFD), water managers have to take measures to improve the ecological functioning and quality of rivers and lakes towards 'good or high quality status'. In order to achieve those ecological objectives, measures must be taken to improve water quality

and to restore the natural hydro-morphodynamic conditions. Therefore, a stream restoration project should be integrated in a suite of urban catchment management efforts that may include acquiring or protecting streamside land, preventing or reducing peak stormwater flows, improving and maintaining sewer and stormwater infrastructure, and upgrading sewage treatment facilities (Bernhardt and Palmer, 2007).

The earliest river restoration projects are launched in Europe. The US started the activities in 1976, and later in China. In Europe, the US, Japan and many other countries, there have been many restoration practices for small river ecosystems with mature restoration technology. In great river ecosystems, such as Mississippi, Rhine, etc., there also has been much restoration work. (Zhao et al., 2007).

The term “restoration” has been defined in a variety of ways. It is frequently suggested that restoration means returning an ecosystem to its pre-disturbance state (NRC, 1992); however, in many situations this goal is unrealistic. Such that, the main purpose of river restoration is to eliminate constraints to river’s natural patterns or biodiversity, which from human activities (Ebersole, 1997), but not necessarily to rehabilitate certain natural structures and conditions of river ecosystem, such activity should concentrate on rebuilding a kind of state which can make river’s natural process regenerated and drive river ecosystem go back to the track of natural succession, keeping a state of ecological balance.

On the other hand, there has been considerable discussion in the restoration ecology literature of different terms such as recovery, enhancement, remediation, restoration / reclamation, rehabilitation and renaturalization, and what each seeks to describe (Kaufman et al., 1997, Palmer et al., 1997, Platt et al. 2000). Whatever the ‘R’ word used, the general intention of waterway managers is to ‘make things better’ by maintaining or improving the condition of streams and protecting the values assigned to them. According to Mendiondo (1999), each of these family concepts has slightly but important differences. ‘Recovery’ is the process of species returning to normal population levels after disturbance, in a normally way. In other hand, ‘enhancement’ means to improve the current state of the ecosystem without reference to its initial state. The terms of ‘remediation’ and ‘reclamation’ are also describes a set of activities that help improve the environmental health of a river or stream. However, ‘restoration’ is a process that involves management decisions and manipulation to

enhance the rate of recovery. In this context, river restoration is a recovery enhancement and considers a technique to enable disturbed river ecosystems to stabilize at a much higher rate than through natural and biological recovery processes of habitat development and colonization. Also, the term ‘rehabilitation’ is probably a mixture of enhancement and recovery which refers to the reinstatement of features of the stream ecosystem (structural or functional) that may have been impaired or lost due to urbanization, rather than a complete return to ‘natural’ or pre-disturbance conditions implied by the term restoration. Furthermore, if a natural condition could be defined, the measures that help a system to back to nature in a naturalistic way are usually referred as ‘renaturalization’. The aim of renaturalization has therefore evolved towards the concept of bringing watercourses ‘close to a natural state’ rather than creating a truly natural state. The relationship between these family concepts is schematized in the (Figure 3.7).

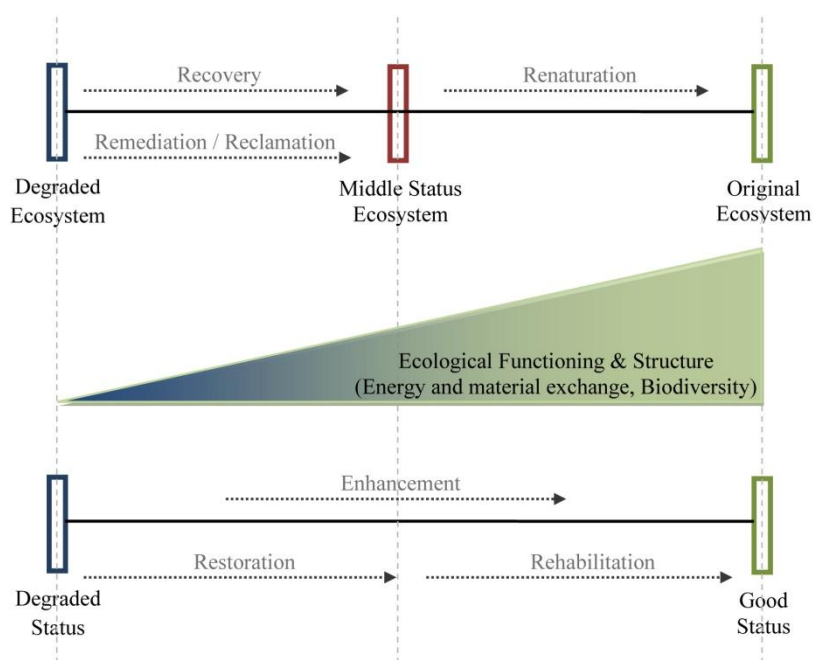


Figure 3.7 : Schematic diagram of improvement concepts on riverine systems.

According to the relationships between different concepts for degraded riverine ecosystems, a gradual structure can be viewed in order to reach the original systems functioning status from two different types of lands. For the first condition, which the riverine system located in a natural area, including rural and semi-urban lands, improvement of the system requires rehabilitation techniques with recovery and the enhancement of the current status. On the other hand, it is necessary to involve

management decisions for the riverine systems that are in urban areas within the concept of restoration. In addition to those stages, the approach of ‘renaturalization’ constitutes a complementary role to reach beyond the ‘good-status’ to original ecosystem. Especially the riparian habitats in highly urbanized areas need a holistic management approach including the interactions within the catchment area and the urban systems together.

Because of the suffering of the rivers in urban areas, about the serious disturbance from human activities, urban river restoration planning should be the trade-off of consideration in river ecology, applied restoration technology measures, socio-economical supporting conditions, etc. (Zhao et. al., 2007).

However, the restoration & rehabilitation practices to date mostly focused on place-based solutions including the measures and objectives, which vary by site-by-site according to the specific requirements of the land instead of an integrated approach with strategical planning. They also generally worked on the improvement projects on natural sites while the eco-hydrological and morphological status of riverine systems in urban areas are worst than these.

Therefore, especially for the recent years, recognition of the importance of river status improvement efforts and the complementary concepts for an integrated development is increased. Also, it is realized that successful stream rehabilitation requires a shift from narrow analysis and management to integrated understanding of the links between human actions and changing river health (Table 3.2) (Booth et al., 2004).

This also can be explained by ‘Connectivity’ approach. It is a key concept for riparian and landscape ecologists and hydrologists, who use it as a measure of natural integrity in a river ecosystem. From this perspective of landscape ecologists and conservation biologists, the landscape is made up of patches of different habitats with transition zones between them (ecotones). Connectivity is the strength of interactions across ecotones; it is “an ecological term that describes the natural habitat continuum throughout the landscape: the antithesis of fragmentation” Therefore, rivers and riverbanks are connecting elements (or landscape corridors) between patches and serve as paths along which animals can move and plants can spread (Harrison, 1996).

Table 3.2 : The shift from rehabilitation/restoration approach to renaturalization.

From Rehabilitation & Restoration	► To Renaturalization
• Solely focuses on stream morphology or channel design • Considers precautions for flood damages • Causes changes & relocation of river bed morphology. • Aesthetic concerns are mainly prioritised • Lack of historical data usage (original situation & original status of the river)	• Holistic approach • Includes a broad framework of integration between ecological, social, economic systems • Considers connectivity between aquatic variables within ecosystem structure and functions • Aims to be ‘Close to nature’ in urban, semi-urban, rural, natural landscapes

On the other hand, urban designers and politicians use the same term to promote human access to riverfronts and most importantly there is a strong emphasis on connecting humans to rivers. According to this perspective, ecosystems include the interactions among all organisms in a given habitat and people are part of the systems that cannot be excluded especially from the river ecosystem (Harrison, 1996). Humans are also the dominant species in urban ecosystems, so connectivity of all kinds must include a connection between humans the system as a whole. If the values of ecological and hydrological connectivity do not fit into human’s established ideas of how cities engage with rivers, then what is needed is a new way of communicating and understanding those values. Many recent urban river restoration projects should recognize this perspective to interact these ‘buffer zones’ with social needs and natural structure. This new paradigm also seeks to maximize opportunities to make nature an ally in the strife to stabilize water levels and prevent flood especially the countries, which experienced risky high waters from rivers (Boer and Bressers, 2011). In this context, a true case of renaturalization can be viewed in the Regge River, The Netherlands.

The Netherlands is a geographically small country with a land surface totaling only 41,546 square kilometers and a population of sixteen million people. The people however are not evenly dispersed throughout the country, the majority of population living in the Randstad (including Amsterdam, Rotterdam and Utrecht) which a horseshoe-shaped urban configuration area and the economic powerhouse in the western part of the country (Figure 3.8a). On the other hand, with approximately 23.9% of the land area below sea level includes most part of the Randstad (Figure

3.8b) and three main rivers running through it. Therefore, flooding issues have long been an important matter for Dutch society (Boer and Bressers, 2011). About the critical situation of the Netherlands, IPCC 4th assessment report (Climate Change-2007) states that: “The Netherlands is an example of a country highly susceptible to both sea-level rise and river flooding because 55% of its territory is below sea level where 60% of its population lives and 65% of its Gross National Product (GNP) is produced.” (Url-16, 2010).

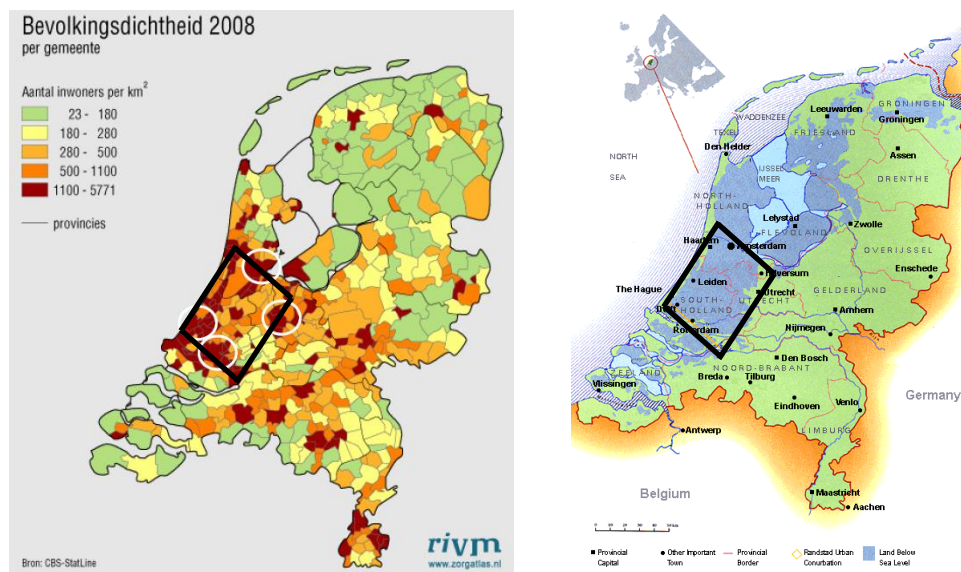


Figure 3.8 : a) Population densities in the Netherlands b) The land below sea level (blue part) and the Randstad (Meijles, 2010).

Therefore, over the past decades, the Dutch people have been confronted with severe water-related problems. Being a river-delta and having 23.9 % of land beneath sea level, the Dutch have a century-long tradition of fighting the water and trying to control it. In this way, much of the water system is canalized and the surrounding area protected by dams, dikes and polders. However, in 1993 and 1995, the Netherlands experienced two major floods of the rivers Meuse and Rhine where the country lie at the downstream end of the catchments of these major rivers. These floods followed by high levels of regional waters in 1998. The sudden water related problems led parliament to question current water management practices. Also, European Water Framework Directive (WFD) on respecting ecology and natural river basins has contributed a shift in water management (Meijles, 2010). On the other hand, in densely populated cities of Netherlands, little space is available for living, working, transport and recreation, while at the same time there is the need to

preserve or even enlarge natural coastal and deltaic habitats. This is where the principle of Building with Nature has emerged. Consequently, the new paradigm is accompanied by slogans such as 'space (room) for rivers', 'living with water' and 'building with nature'. The goal of the Dutch Room for the River Programme determined as to give the river more room to be able to manage higher water levels. The program will be completed by 2015 and at more than 30 locations, measures will be taken that give the river space to flood safely (Url-17, 2010).

The Netherlands is investing large amounts of resources (hundreds of millions) into the construction of an ecological main structure and in the renaturalization of rivers and creeks. With respect to this, it can be seen that the Regge has been classified under the Water Framework Directive as heavily modified, and it has the goal of returning the river to a naturally functioning stream system. A major factor in the project is also the presence of flooding concerns and the desire to use portions of the watershed for water storage in times of high water levels (Boer and Bressers, 2011).

The Room for the River project site encompasses four rivers: the Rhine, the Meuse, the Waal, and the IJssel. Measures in the plan include displacing of dykes, depoldering of forelands, creating and increasing the depth of flood channels, reducing the height of the groynes, removing obstacles, and the construction of a "Green River" which would serve as a flood bypass (Figure 3.9).

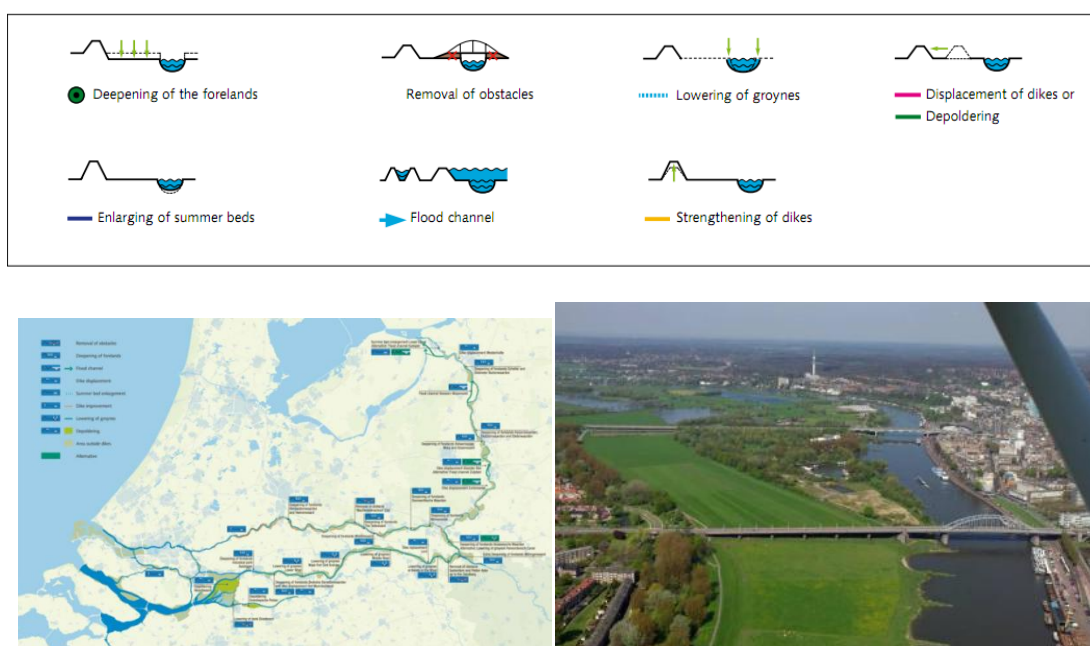


Figure 3.9 : a) Measures in the Room for Water Plan b) Location of measures and alternatives c) Floodplains of Rhine River (Url-17, 2010).

As a result of the Dutch government breaking away of 20 years of policy continuity, the renaturalization projects are supported in the country. Thus, the traditional strategy for flood protection with being in a fight with water (constructing of dikes, storm barriers, canals, dams etc.) shifted to give more place to water and provide the protection by natural techniques. According to Boer and Bressers (2011), Dutch Regge River Renaturalization Project is in many respects a fairly typical example in a country where renaturalization projects abound. Renaturalization in the Netherlands is done as much as possible in conjunction with any and all other related land use and policy opportunities.

In this context, the Regge renaturalization can be characterized as multi-sectoral and long term and is thus a complex and dynamic implementation process. River renaturalization is also seen as the best way to achieve more water buffering capacity given the future climate expectations.

Hereby, according to theoretical background and the implemented projects about this new paradigm, the management issues of renaturalization in terms of riparian zones can be summarized below Mendiondo (1999):

- Focus attention of riparian areas as “hot spots” with opportunities to sustainability and as ecotones for living
- Preserve river ecotones and habitat integrity
- Re-integrate the fragmented riparian corridors
- Recover the riparian and floodplain forests, especially the indigenous species
- Renaturalize floodplains in a way to filter and mitigate the rapidly sediment and nutrient migration from headwaters to the main rivers
- Provide environmentally flood protection

3.2.2 Measures of healthy rivers approach

The idea of ‘river health’ requires us to think of a river as an ecological system, not merely a channel that conveys water from the uplands to the sea (SRA, 2012).

The word ‘Health’ shorthand for good condition (e.g. healthy economy, healthy communities) is grounded in science yet speaks to citizens. Applying the concept of river health to rivers is a logical outgrowth of scientific principles, legal mandates, and changing societal values. Success in protecting the condition or health of rivers

depends on realistic models of interactions of landscapes, rivers and human actions. Urban ecology also plays a critical role in this interaction (Karr, 1999).

According to Norris and Thoms (1999), there is debate over the meaning of 'health' when applied to ecosystems. Rapport (1989) suggested three approaches that might differentiate 'healthy' from 'sick' ecosystems: (i) the absence of distress defined by measured characteristics or indicators; (ii) the ability of an ecosystem to handle stress, or bounce back to its resilience; and (iii) the identification of risk factors such as industrial or sewage effluents. As an overall definition: 'a healthy river is a system whose social and natural functions can be balanced or compromised in terms of the socio-economic, ecological and environmental values associated with the river'. In this context, the river health criterion should reflect the river's natural function status, which includes the riverbed, water quality, river ecosystem and runoff. However, the variety and quantity would be different for different rivers depending on different natural features and social background. The standards to be adopted for a healthy river should be determined according to the requirements for maintaining river's normal natural functions and the key factor of river health should be the enough and clean flow (Changming and Xiaoyan, 2008). Healthy aquatic systems are also described at regional level. The Science Advisory Board (SAB) of United States Environmental Protection Agency (EPA) has developed a "Framework for Assessing and Reporting on Ecological Condition" (EPA, 2002). This framework was developed as an organizational tool for reporting on information about the health of ecosystems through an assessment of essential ecological attributes. The health of watersheds assumes watersheds as integrated systems that can be understood through the dynamics of essential ecological attributes. According to definition of EPA the 'Healthy Watersheds' approach is: 1) identifying healthy watersheds on a state-wide basis and healthy components of other watersheds; and 2) conserving healthy watersheds and protecting healthy components of other watersheds. It is an approach that will protect the remaining healthy watersheds and prevent impacts to aquatic ecosystems (and, thus, water quality impairments) from land use changes and other perturbations (e.g., invasive species) in other watersheds (Figure 3.10).

Recently, consideration of river health or integrity rarely entered decision making by societies who are bent on conquering some frontier. Water was simply there, a liquid to be used but not to be allocated, to be consumed and to be discarded as likely as not

carrying with it society's unwanted wastes. This attitude has threatened and continues to threaten the tenuous balance between water and human society, between rivers and the people who depend on rivers (Norris and Thoms, 1999).

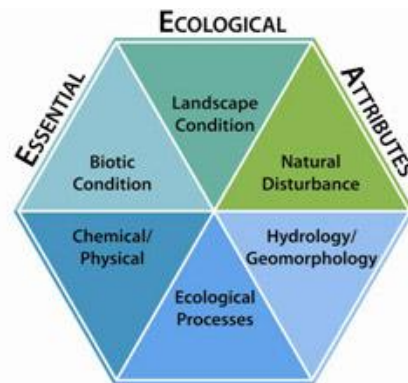


Figure 3.10 : Dynamics of Essential Ecological Attributes (EPA, 2011).

As human activity changes biological systems, they move along a gradient, ultimately to state where little or nothing is left alive with severe disturbance and at the end a biological integrity due to no or minimal disturbance. During the continuum of human influence on riverine systems, a threshold can be defined for each systems' characteristics within the conditions or activities, which are no longer healthy or sustainable in terms of supporting living systems (Figure 3.11).

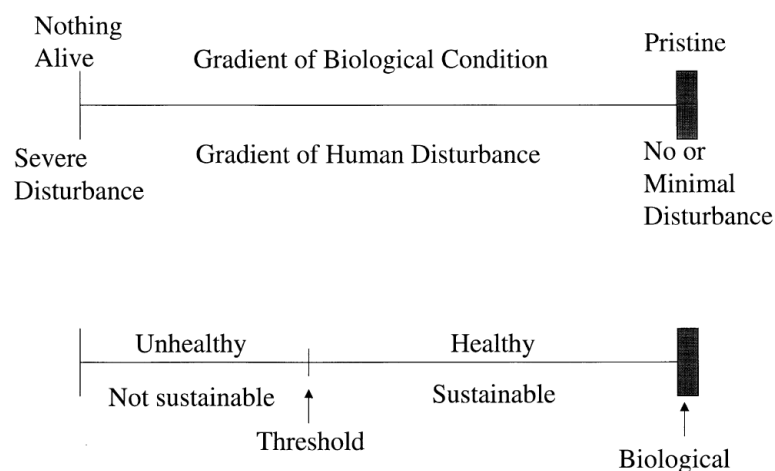


Figure 3.11 : Continuum of human disturbance on riverine ecological system (Norris and Thoms, 1999).

Over time, humans alter the biological and chemical systems of rivers by altering physical habitat, modifying river/stream bed and water flow, changing the interactions among stream organs and contaminating the water with chemicals. However, according to the Karr (1999), the 'aquatic ecosystem' includes the flora and fauna and their habitats, linkages between the river and its catchment, the

dynamics of water flow and the transport and transformation of nutrients. It demonstrates good health by being resilient in the face of environmental changes, including changes in climate, resource exploitation or other impacts of human activity. Also, it implies a long-term balance whereby the integrity of the natural system is preserved while meeting human needs and provides a system whose social and natural functions can be balanced or compromised in terms of the ecological, socio-cultural, and economic values associated with the services generated by riverine systems (Figure 3.12).

Ecological	Riverbed	Water Quality - River Ecosystem	Flow Regime/Run off
(Balancing social-natural functions)	Favorable riverbed Energy exchange function Transportation function	Acceptable water quality & Ecosystem Purifying water Nourishing river ecosystem	Compatible run off
Socio-cultural	Water Supply/Clean Potable Water - Flood Control - Recreation		
Economic	Flood Control - Land Use Patterns - Infrastructure - Navigation		

Figure 3.12 : Health riverine systems in terms of ecological, socio-cultural and economic services.

Measurements of rivers made within the metaphorical 'health' framework share many of the objectives and practices of ecological research, such as the identification of spatial and temporal patterns and their underlying processes, and the use of indicators for detection and identification of patterns and processes. Indicators are crucial to many socio-political schemes for portraying environmental influences of society (Fairweather, 1999). The river health indicators should reflect the river's natural function status, including the riverbed, water quality, river ecosystem and runoff. But, the variety and quantity would be different for different rivers because of different natural features and social background. There are many possible indicators of river health, including measures of structure and function both of the biotic and of the physical components.

Indicators of river health may represent spatial scales ranging from local to catchment, temporal scales from instantaneous to long-term, and may be direct or explanatory measures (Norris and Thoms, 1999). The International Union of Geological Sciences (IUGS) recently constructed a list of 27 geoindicators, within 16 fields, that assist with the assessment of the condition of abiotic components of the environment. Seven of the 27 geoindicators are directly related to the condition of river systems (Table 3.3).

Ecological indicators for riverine systems are also different for different rivers. For instance, for rivers with good ecological diversity and rare species (fish) are present, the ecological indicators should include not only the normal parameters such as biological diversity and ecological integrity but also probably the living conditions for the rare species (Changming and Xiaoyan, 2008).

Table 3.3 : Physical indicators of riverine system condition (IUGS, 2012).

Indicator	Components
Sediment sequence and composition	• Rate of accumulation • Sediment calibre • Mineralogy • Geochemistry
Soil and sediment erosion	• Rate of erosion • Source of sediment • Mode of transport
Stream flow	• Total annual flow • Variability
Stream channel morphology	• Slope • Pattern • Cross-sectional dimensions
Stream sediment storage and load	• Sediment flux • Mode of transport
Surface water quality	• Turbidity • Total suspended solids
Floodplains/wetlands structure and hydrology	• Wetting and drying regime • Connectivity with the river area

In addition, river health criteria are restrictions for the management, development, utilization, and protection of rivers, and action objectives of all the stakeholders in the river basin and relevant regions, therefore, the river's healthy criteria should be not only scientific, but independent, applicable, and acceptable by public (Changming and Xiaoyan, 2008).

Also, for each riverine system, the evaluation and indicators of being 'healthy' should differ according to the condition and structure of the system.

3.3 Summary of the Chapter

In the context of third chapter at first, the conflicts between natural and urban systems are discussed and analyzed under socio-economic, legal and environmental perspectives with a focus on urban riverine systems. Secondly, the solutions are searched for a better integration between damaged riverine systems within urban systems. In this context, the growing population and their agglomeration in urban areas are examined with the growing demands of human societies and their increasing damage on natural systems. Such that, streams and rivers, as the low-lying points of the landscape, are especially sensitive and profoundly impacted areas by the changes associated with urbanization and suburbanization of catchments.

Hence, due to over consumption patterns of aquatic resources, the world primarily faced with water crisis problems. In this process, unsustainable management of water resources led the decision makers, scientists, related sector members to think on a sustainable future. As a result of several meetings, symposiums, conventions and conferences a holistic river/lake basin and ecosystem approach is developed for protection of aquatic resources including human utilization in terms of ecosystem services. In addition, they are supported by UN Documents or EU Legislations for better integration, evaluation and recognition of the values and functions of water-related ecosystems. According to the situation of Turkey as a candidate of EU membership, the adaptation of Turkish national water legislation in to EU regulations is also accelerated in this process. Besides, of socio-economic and legal reflections of urbanization, there are significant impacts of this process on environmental systems also. As rural lands surrounding urban areas are converted to urban land uses, nearby freshwater systems experience increased stresses with a variety of consequences for biodiversity and ecosystem functions. As a result of urbanization process, the properties and functions of riverine systems can change both chemically and physically. Especially, large areas of impermeable surfaces in urban areas can increase the frequency and magnitude of storm flows. On the other hand, groundwater pumping and reduced recharges can base flows reduction and it can exacerbate the effects of droughts. Most importantly, modification of stream hydrology and flood management practices can alter the sediment regime, with subsequent effects on streambed composition, and stream channel morphology. In

addition, loss of riparian vegetation can increase water temperatures as stream shading is reduced (Brown et al., 2005).

These changes in physical habitat and water quality have been linked to changes in aquatic biota and land use changes associated with urbanization can cause chain problems in the whole system (urban watershed area). Therefore, understanding the effects of these stresses on aquatic assemblages will be extremely important in preserving, rehabilitating, and managing these ecosystems as urbanization proceeds.

Since the Middle Ages, many small rivers were of prime importance for the population and used for a variety of purposes such as power generation, irrigation, transport, fish farming, defense etc. They were therefore altered significantly to fulfill these purposes and created anthropogenic changes. The respective river environments were once centers of activity but today, many of the remains of such activities are hidden in a seemingly little touched and sparsely populated environment (Müller and Koll, 2004). Therefore, restoration projects are important in terms of integration of this cultural heritage with riverine systems and provide the mutual benefits between social and natural systems.

From this point of view, traditional and separated restoration/rehabilitation methods are discussed and compared with 'renaturalization' approach, which brings broader catchment management strategies for an effective urban stream restoration. Similarly, Platt (2006) states that, urban watershed management depends upon creative institutional arrangements, combinations of federal and state mandates and incentives, regional partnerships, municipal awareness of externalities, and grassroots sense of community including improving the essence of the ecological structure and function characteristics of each riverine system. Because for a healthy riverine system, natural functions show the life signs of the system and ultimately determine the sustainability of human societies.

4. STREAM DAYLIGHTING; THE SECOND CHANCE TO BE “NATURAL”

In this rapidly urbanizing world, riverine systems are exposed to several impacts by human actions. They are polluted, covered by concrete covers, channelized, culverted in to pipes and several alterations are made on riverbeds. These anthropogenic interferences mostly caused chain alterations on their ecological and hydro-morphological systems and resulted with a system failure including damaged & fragmented aquatic ecosystems.

Therefore, related with the first three chapters, this section of thesis focuses on a newly developing approach for renaturalization of riverine systems in urban areas. Mainly, densely damaged and buried systems are discussed under the title of ‘Stream Daylighting’ approach, which constitutes a radical change on river restoration context. In this framework, ten case studies are compiled and discussed under eight themes in order to develop a comprehensive conceptual model for’ renaturalization of buried riverine systems in urban areas by using ‘stream daylighting ‘approach.

4.1 Historical Background of the Method

The link between human settlement and the control of water flow in those settlements dates back at least 4,000 years. Even in two millennia BC, the Greeks and Egyptians had adequate supplies of drinking water for their cities, drained streets, had bathrooms in their houses and water flushing arrangements for toilets. Earthenware pipes were used before 1500 BC and some pipes in Mesopotamian cities from that era are still in working order (Buchholz and Younos, 2007).

In European and American cities prior to the mid-1800’s, small neighborhood grids allowed for the management of water with a localized supply and treatment approach that included collecting rainwater in cisterns and designing useful channels in narrow roads and alleys. However, when the industrial revolution came to full force and it was no longer possible to manage city water flow using pre-industrial methods. As rapid urban expansion took place, also concerns about pollution in public drinking

water led to placing millions of miles of creeks and rivers into pipes (Figure 4.1) (Buchholz and Younos, 2007).



Figure 4.1 : Wingohocking Creek Sewer Construction in 1909 (Buchholz and Younos, 2007).

Many riverine systems are culverted in to pipes, buried and covered with concrete or asphalt covers and so the development of cities continued over these forgotten underground ecosystems. Human societies and decision makers thought that they took the control of these natural systems to take the precautions for future threats (pollution, diseases, floods etc.) According to the explanations of National Park Service (U.S. federal agency that manages all national parks), “Once the streams were buried underground, the towns also found it easier to grow. They built streets, housing, and industrial plants over the buried streams. And the public health problems also disappeared at least for a while”.

However, with the beginning of the twenty-first century, the traditional view of urban streams not the only vision available for community leaders for America that is approaching a turning point in its urban storm water management system. This turning point is precipitated by the deterioration of industrial-era pipes that were built to capture storm water runoff and contain streams and creeks that interrupted the dense development patterns of the 19th century. In addition to that, with the emerging trends in environmental awareness and stewardship, it became possible to imagine and ultimately build a more holistic future for American cities and their invisible waterways (Buchholz and Younos, 2007). This awareness of the problems associated with culverts has increased significantly over the last decade and reflected by the development of policy to prevent culverting or to promote the removal of

these structures and to restore urban rivers back to a more natural condition. Because culverts can have several effects on local river and wetland habitat by modifying substrate, altering flow, reducing algal and plant growth and dissociating the stream from the surrounding terrestrial environment (Macdonald and Davies, 2007). In addition, in many urban areas, local communities may be completely unaware of the existence of a riverine system running beneath streets, buildings or open spaces while these invisible systems were fragmented, separated from the whole catchment system, physically, chemically and ecologically damaged and left to be lost in underground with cutting the connection with daylight and air. Accordingly, Bucholz and Younos (2007) indicates the importance of the system integrity between social and natural systems and they state that, at the turn of the century, famous landscape architect Frederick Law Olmsted held a vision of community development that was supported by wildlife biology and landscape ecology experts. Plants, animals, and ecosystem processes must be part of a network of protected natural areas in order to thrive. Today, it is considered an interconnected network of green space that protects natural ecosystem values and functions, and provides associated benefits to human populations. It is a post-industrial conservation approach that considers ecological needs within the context of human activities. Urban stream “daylighting” is one manifestation of green infrastructure. It attempts to address the complex and dynamic aquatic processes at work in streams surrounded by human development. Herein, the ‘daylighting’ activity has steadily increased especially across the United States, and it is even more widespread in parts of Europe. In just the city of Zürich, Switzerland, over nine miles of brooks and storm drains have been brought back to the surface since 1988 (Figure 4.2).



Figure 4.2 : One of the Daylighting Projects in the city of Zurich, Switzerland. (Before/After) (Pinkham, 2000).

Also, a significant development in relation to deculverting in the United Kingdom over recent years has been the CIWEM (Chartered Institution of Water and Environmental Management) Policy Position Statement on deculverting of watercourses, which highlights considerable problems associated with culverts (CIWEM, 2007). Broadly, CIWEM (2007) calls for: (1) active promotion of deculverting in national and regional Government planning guidance, and by public bodies and local planning authorities; and (2) active identification and promotion of opportunities to restore urban watercourses, no matter how small, to realize benefits for the local community and environment.

In this process, policy makers, engineers, and builders increasingly recognized the value of maintaining natural drainage patterns and stream channels in new development. In this context, “Daylighting” as a new phenomenon, became perhaps the most radical expression of this change in attitudes and approaches to surface waters (Pinkham, 2000). The term ‘daylighting’ is often unfamiliar to most people, who confuse it with bringing daylight into the interior of a room or building. According to Pinkham (2000), “Daylighting describes projects that deliberately expose some or all of the flow of a previously covered river, creek, or storm water drainage”. In addition, they liberate waterways that were buried in culverts or pipes, covered by decks, or otherwise removed from view. In short, daylighting projects usually remove a stream from an underground pipe and restore the waterway to open air. Also they generally re-establishes a waterway in its old channel where feasible, or in a new channel threaded between the buildings, streets, parking lots, and playing fields now present on the land. Pinkham (2000) states that, daylighting is never straightforward activity both technically, institutionally, and socially. Therefore, it can provide multiple benefits besides causing many challenges during the planning and implementation processes.

In this context, removing culverts and daylighting projects has a high potential to improve aquatic and marginal habitats. However, the recovery of riparian vegetation may take longer than expected if planting along the river ‘suffered from disturbance’. Moreover, ecological improvements are important for addressing water quality problems that are crucial to the recovery of aquatic habitats. Deculverting also could therefore significantly improve fish passage by removing migration barriers (Wild et al., 2009). In addition, it could provide aesthetics values with recreational

opportunities and a new open public space for city dwellers and educational opportunities (outdoor laboratory for the students) as social outcomes. Also, it provides to give a place a sense of identity as in the example of Arcadia Creek, where the daylighted river is now the centerpiece of a successful festival site, providing opportunities for recreation in what was a declining urban area. Examples demonstrate that daylighted rivers reconnect people with their local environment (Pinkham 2000) and the larger living system (Buchholz & Younos 2007), with the potential to add understanding and value to natural systems and to reinstate the importance of the presence of water in the urban environment. In general sense, the benefits of these removal & improvement projects in terms of socio-economic perspective is reported in several cases which were located in areas suffering from crime and a 'near-silent, pedestrian (and cycling) environment is provided after daylighting the riverine system. Other reported economic benefits include rising nearby property values and leveraging private investment (Pinkham, 2000) or attracting new business (Hoobyar, 2002). For instance, Pinkham (2000) suggests that deculverting has 'increased property values' and 'can motivate investments in nearby properties and businesses, which may see an increase in number of people who come to enjoy the reopened stream'. An impressive case where detailed economic analysis has been undertaken is at Cheong Gye Cheon in Seoul. Kang and Cervero (2009) conclude that deculverting delivered new benefits to both residential and nonresidential land markets. Often, the economic effects of deculverting are closely linked to flooding impacts, covered in subsequent sections. As Buchholz & Younos (2007) note, 'Depending on the economic viability of the community, flood damage can exacerbate urban decay. Stream daylighting projects have therefore been undertaken to reduce urban flooding and to promote subsequent urban revitalization and redevelopment efforts'. About the key contrast between deculverting and culvert replacement, there are many discussions but Smith (2007) concludes that although the costs of deculverting projects vary widely according to geography, project scope and community or volunteer support, deculverting can be cost-comparable with conventional infrastructure- and material-intensive engineering solutions to flooding and combined sewer overflow problems. Also, some studies highlights that the projects have been successful in reducing flood risk. According to Wild et al., (2009), Projects can vary from the simplest form removing the 'roof' of a culvert and retaining existing bank walls and natural bed material to the major reconstruction of

both bed and banks using soft-bioengineering measures and river restoration techniques. More complex projects are likely to require detailed feasibility studies, site investigations, hydraulic modeling and advanced engineering design. Furthermore, social and ecological effects are likely, and so careful consideration should be given to engaging communities and assessing environmental impacts.

4.2 Assessment of Implemented Stream Daylighting Projects under Key Themes

“We have a problem in river restoration. The problem is lack of communications and trading of experiences. As a result, successes in field restoration are little known, while mistakes are repeated indefinitely. What is needed is a gradually accumulating file of case studies describing with text the illustration of the original condition, an assessment of the basic cause of the problem, the techniques and construction details of treatment, and an objective analysis of the result” (Leopold 1997).

According to the statement of Leopold (1997), it is important to collect data from each experience to create a databases and trading of knowledge for a specific field of research. In order to reach a common and base information platform about rehabilitation/restoration of riverine systems a basis should be created including basic terms, experiences, faced problems and reached results. According to Jenkinson et al., (2006), the databases could also demonstrate the value of improving the integrity of stream ecosystems to funders and policymakers. Costs could be assessed and evaluated against reported social and environmental successes. Such evaluations could provide greater information for making annual budgetary recommendations for programs that fund restoration projects. Information contained within databases also could aid the prioritization of how and where to allocate limited restoration (e.g., a particular stream reach that could link existing projects or a critical but underfunded program area). Improved accessibility and exchange of information on specific restoration projects will increase the scientific understanding of stream ecosystems along with the collective ability to conduct successful projects. Otherwise, without coordinated data tracking of restoration projects, the people will be limited in their ability to draw conclusions about restoration effectiveness in different perspectives. In order to maximize the cost-effectiveness of restoration efforts as components of watershed and basin management strategies, the cumulative

impacts of restoration projects should be examined from different aspects (socio-economic & ecological).

In recent decades, environmental degradation on urban riverine systems is taken in to account seriously within the development process of urban areas. The recognition of unsustainable living styles and the growing pressure on natural systems have led decision makers, scientists, organizations and other related groups (NGO's etc.), to think on the problems, drivers, dynamics, results and solutions from socio-economic and environmental perspectives. These searches are resulted with several meetings and actions both at local and international level. In this framework, it is realized that aquatic systems are one the most vulnerable and threatened systems in urban areas in terms of their low resilient structure against dense and multiple impacts of human activities. Therefore, several studies and researches are made for protection, improvement and remediation of these systems in order to minimize the effects of damaging activities. These practices began in the beginning of twenty-first century, primarily in America, which is precipitated with deterioration of industrial-era pipes. The mistakes of previous control mechanisms and strategies about riverine systems including urban storm water management in early times are realized and a radical shift is began from re-opening the cover of buried riverine systems from underground surfaces to the daylight. Therefore, the new approach is called as 'Daylighting', which provides a second chance for, culverted and lost riverine systems in urban areas. This approach is adopted by many European countries such as Switzerland and Germany and also by UK. Over time, many implementations are completed all over the world and .miles and miles of riverine systems are turn back to their natural status (the closest status to river's original ecosystem functioning). However, as Leopold (1997) indicated above, the need for communication and trading of experiences among these implementations are the key components for future practices and constitutes an essential step for developing new approaches to improve degraded status of another riverine system in another part of the world. For this reason, according to the literature reviews, several scientific sources (thesis, e-books, articles, proceedings etc.) are overviewed and ten implemented daylighting projects are selected due to their approval by scientific databases (Table 4.1).

Table 4.1 : Literature review of case daylighting studies.

Case Studies Sources	Napa Creek, San Francisco Bay Area	Strawberry Creek, Berkeley	Zurich, Switzerland	Jolly Giant Creek, Arcata	Arcadia Creek, Michigan	Taddle Creek, Toronto, Canada	Cheong Gye Cheon River, Seoul	Dunes Creek, Indiana	Castro Valley Creek, California	Thornton Creek, Seattle
M.Sc. / Ph.D Thesis	-	Da1housie University, Canada, 2001	-	Da1housie University, Canada, 2001	Da1housie University, Canada, 2001	Da1housie University, Canada, 2001	-	-	-	-
Books	Stream Daylighting, Pinkham R., 2000	Stream Daylighting, Pinkham R., 2000	1. Stream Daylighting, Pinkham R., 2000 2. Enhancing Urban Environment by Environmental Upgrading and Restoration, Marsalek,et.al.2004.	1. Stream Daylighting, Pinkham R., 2000 2. Urban Stream Daylighting Case Study Evaluations, Buchhold & Younos, 2007	1. Stream Daylighting, Pinkham R., 2000 2. Urban Stream Daylighting Case Study Evaluations, Buchhold & Younos, 2007	Stream Daylighting Pinkham R., 2000	-	-	-	-
Databases and E- Journals	Scholarship, University of California (Assessing Feasibility of Creek Daylighting in San Francisco, Ray, B.S., 2007)	EBSCOhost (Environ- mental Complete) - Journal of Watershed Protection Techniques 1(4), 184-187	1. eScholarship, University of California 2. Springer Link 3. Taylor& Francis (The Zurich Daylighting Program)	-	-	- Web of Science (Article: Once and Future Creeks, Botelho Z., 1999)	1.Scopus 2. Web of Knowledge -Springer Link (Journal of Landscape and Ecological Engineering)	EBSCOhost (Environ- mental Complete) (Daylighting, Brzozowski C., 2010)	1. Scopus Daylighting Castro Valley Creek, Ackerman & Modrell, 2008) - Journal of Water Planning and Management	1. Science Direct 2. eScholarship, University of California 3.EBSCOhost (Environmental Complete) 4. Scopus
Reports / Proceedings	-	Water and Environment Journal	Switzerland National Report	Water and Environment Journal	Water and Environment Journal	-	1. Seoul Development Institute 2.University of Korea	16th National Nonpoint Source Monitoring Workshop, Ohio, 2008	Alameda Country Flood Control& Water Conservation	ASLA National Conference, Chicago, 2009

The cases are selected from four different geographical regions (US, Canada, Europe-Switzerland and Korea) including different social, economic, legal and environmental backgrounds with various circumstances and results they face off. Six of the projects are selected from USA where this approach is emerged. The selected case implementations are indicated below (Table 4.2).

Table 4.2. Selected 10 case studies from implemented daylighting projects.

Location	Name of the River/Stream/Creek
USA (6 cases)	1.Napa Creek- San Francisco Bay 2.Area Strawberry Creek- Berkeley, 3. Jolly Giant Creek- California, 4. Arcadia Creek- Michigan, 5. Dunes Creek- Indiana, 6. Castro Valley Creek- California, 7. Thornton Creek- Seattle,
Switzerland (the programme)	8. Zurich Daylighting Programme
Canada (1 case)	9. Taddle Creek- Toronto
Korea (1 case)	10. Cheonggyecheon River- Seoul,

The projects include different types of constraints, challenges, drives, feasibility conditions and supportive backgrounds (institutional, legal and public support), starting with different goals and resulting with various impacts both in positive and negative aspects. Therefore, this assessment of different practices from different countries and backgrounds provides a broad spectrum of implemented daylighting experiences including different contexts and led to understand the details of each implementation process with their challenges and benefits for the future practices, which will be held in various conditions (both the urban area and riverine system conditions). It also presents the lessons that should be learned from each case. The assessment consists of two steps. First, the projects are analyzed under six main and 12 sub-titles including the general data about each project, technical details, economic, social, legal, institutional backgrounds and the results of the implementations. This stage provides an overview for each implementation including the details of projects (Table 4.3). The second step compiles the projects under eight key themes, which are determined according to the highlights of implemented cases, and constitutes a route for understanding the key components of daylighting practices. Under each theme, the projects are discussed according to their characteristic features and results.

Table 4.3. General overview of implemented daylighting projects.

PROJECT			TECHNICAL		ECONOMIC		SOCIAL	LEGAL & INSTITUTIONAL		RESULTS	
Project Location	Year Completed	Primary Objective(s)	Length of Daylightened	Type of Implementation	Total Cost	Funding	Land Characteristics	Legal Support	Stakeholders	Challenges	Benefits
1 Napa Creek-San Francisco Bay, US	1970's	Re-Explosion of a Hidden Stream (as a part of Urban Renewal Project)	Unavailable	Remove the concrete channel (only)	Un available	Un-available	Napa valley and settlement areas (densely populated area)	Unavailable	- Local Firms & Groups: - Urban Creeks Council - Wolfe Mason Associates	- Identifying the channel geometry, - Dealing with the problems of older urban infrastructure.	- Urban infrastructure benefits (expensiverepair costs). - Allows an increase in storm flow capacity.
2 Strawberry Creek-Berkeley, California, US	1984	Create a park and urban creek amenity by ecological restoration	200 feet + 4 acres for park area	Naturalization	\$50 000 (US) + \$580 000 park cost	City of Berkeley	Dense, mixed use area (near central business district) rail yard and university campus	Unavailable	-The city of Berkeley - Berkeley Youth Alternatives - University of California	Early model of a challenge that must be faced in nearly all daylighting projects: fear	- First example of daylighting, inspired many others - Shows the importance of public support - Property values increased
3 Zurich, Switzerland	Started in 1988	Seperating stream from sewage pipes	Over ten miles of project since 1988 to 2007	Naturalization	\$5,000 (annual costs)	Zurich City Council	Densely populated urban areas	Swiss Water Protection Law and Citywide Policies	-Zurich City Council - The Stream Daylighting Group	- Citywide projects need different estimates for each implementation	- Significant reduction in loading to the combined sewer system - Flood mitigation

Table 4.3 (continued): General overview of implemented daylighting projects.

4	Jolly Giant Creek-Arcata, California US	1997	Habitat Improvement, education	160 feet	Naturalization	\$120 000 (US)	-Urban Stream Restoration - The city of Arcata - The National Tree Trust	Residential, Institutional area (school)	Efforts have helped shaped city policy and prepared a new drainage master plan	- Biologist Lewis Armin-Hoiland and 2 graduate students - RCAA	- Establishing the channel geometry in a floodplain - Trucking chunks of concrete cost a lot - finding a disposal site for the spoils	- Created a valuable new public space in the city - Provide the outdoor classroom
5	Arcadia Creek, Michigan, US	1995	Stormwater Management and aesthetics	472m	Canalization	\$7.5 million (US)	-Downtown Development Authority - Private Organization	Dense urban area (near central business district)	The city formed a Downtown Development Authority to coordinate and fund the project.	- STS Consultants Ltd. - Downtown Development Authority	- Contaminated soils - Structural and environmental measures cost a lot - Aged infrastructure under downtown	- Protection from a 500-year flood - Redevelopment in Kalamazoo's downtown for private investment
6	Taddle Creek, Toronto, Canada	1997	Stormwater management and aesthetics	230 feet of Vivian Creek	Naturalization	Unavailable	Unavailable	Dense, mixed-use areas	Unavailable	-Grassroots alliance of residents' associations -Local groups	- Need for expensive treatment facilities	- Creating multi-purpose parks - Separation from sewer systems
7	Cheong Gye Cheon River, Seoul, South Korea	2005	Preserving the unique identity of the natural environment and the historic resources in the CBD of Seoul	6 km	Naturalization	\$384 Million (US)	- NOAA - Federal Emergency Management	Dense urban area (near central business district)	Unavailable	- The Seoul Metropolitan Government - Citizen's Committee for Cheonggyecheon Restoration - Cheonggyecheon Restoration Research Corps	- Safety problems due to the deteriorated concrete construction - Some Korean environmental organizations have criticized the project for its high costs and lacking ecological and historical authenticity	-Air quality & temperature reduction -Restoration of the historic centre - Biological Diversity - Recreation area - Cheonggyecheon became a centre for cultural and economic activities.

Table 4.3 (continued): General overview of implemented daylighting projects.

8	Dunes Creek Indiana, US	2006 (1 st Phase) 2009 (2 nd phase)	Water Quality Improvement and Restoring the creek to its natural bed (connect the two open parts of the stream)	500 feet	Naturalization	\$141.400 (US)	- NOAA American Recovery and Reinvest -met Act - Federal Emergency Management Agency funding	State park, public beach and parking area, connected to Lake Michigan	Unavailable	- The Indiana Department of Natural Resources (IDNR) - Private Firm, The Troyer Group and Gariup Construction Company	- Dune Stabilization - Parking Lot Collapsed after flooding in 2009	- Showed that it takes about two years for the bio logical systems to develop enough to improve the water quality - Open channel to fish migration - Won several awards - Flood mitigation
9	Castro Valley Creek, California, US	2007	Flood mitigation and Restore native vegetation with natural stream functions	300 feet And Enhanced 600 Feet More	Naturalization	\$500.000 (US)	Union City, Redevelop-ment agency	Library site	Clean Water Act (CWA)	-City of Union -Alameda County Flood Control&Water Conservation District	- Limited amount of space for stream restoration	- Maximizing Public Enjoyment - Native riparian landscaping - Contained 100-year Storm Flows
10	Thornton Creek, Seattle, Washington, US	2009	Revitalization of creek as a part of a redevelopment project of an old parking lot.	Unavailable	Naturalization	\$14 Million (US)	Thornton Creek Legal Defense Fund	Parking lot, trade centre and settlement area	- Urban Creeks Legacy Program - Seattle Public Utilities	- Thornton Creek Legal Defence - Fund Urban Creeks Council	- Developed plans failed and legal process took 4 years	- Facilitated development of 530 housing units and commercial centre - Refuge for fish migrating

4.2.1 Primary goal (s) and scope of the projects

Daylighting practices took their roots from the second half of the 20th century. First efforts started in California's San Francisco Bay Area, which became the highest concentration land of daylighting activity in the country over time. Daylighting began in the Bay Area when the city of Napa removed a cover over a channelized portion of Napa Creek in the 1970s (Pinkham, 2000). While this project did not re-naturalize the stream, it may have been the first North American project to re-expose a previously hidden stream without environmental concerns. Additional daylighting projects followed in Bay Area. Berkeley completed the path-breaking and Strawberry Creek project in 1984 constructed as an archetype of daylighting projects. Although Strawberry Creek was a heavily impacted urban stream, the goal of ecological restoration is chosen by University of California rather than merely attempting to prevent further degradation or merely improving the creek's aesthetic value. In the context of this goal, restoration elements are addressed included water quality (both point and nonpoint pollutant sources short of stormwater retrofits), biological communities and habitat, hydrologic conditions/erosion, and education and awareness (Resh, 1995).

On the other hand, as daylighting' activity has increased especially across the United States; it has also been widespread in parts of Europe. In just the city of Zürich, Switzerland, a city wide program is developed called 'The Zurich Stream Daylighting Program' which is the concept of separating clear water streams from underground sewage pipes and surfacing stream water pipes by opening them up to simulate a natural environment. According to Conradin and Buchli (2008), the concept constituted a solution to a problem that many cities face, as traditionally the way to cope with both stream water and wastewater was to amalgamate them into one waste system. This is the ideal solution from an economic and from an ecological point of view. The concept also encompasses streams that have been channeled into pipes

The program aimed to achieve the following objectives:

1. To improve the recreational quality of urban neighborhoods and thus make them more habitable and attractive

2. To restore the lost habitat of plants, insects, and small animals, enhancing the relationship between city residents and their natural environment
3. To reduce the amount of “clean” water flowing through the wastewater treatment plants and thus improves the quality and efficiency of the treatment process.

Together with these implementations, especially in highly urbanized areas with dense population patterns, these practices seem as a solution for improvement of environmental, social and economic structure of degraded lands including damaged riverine systems. As one of the successful examples of those daylighting projects, Arcadia Creek in Michigan constitutes a good model in terms of demonstrating applicability of daylighting method in highly urbanized lands. According to Hoobyar (2002), Arcadia Creek is not in the core of the central city, but is in a north-central business district, which experienced economic decline, deteriorating buildings and infrastructure, crime, and other problems associated with declining urban areas. From this point of view, the main goal and the scope of the Arcadia Creek project determined as ‘re-development of an unhealthy core area’ in Kalamazo city (attract new business to the area and thereby revitalize it economically and socially) and reduce flooding problems resulting from an increase in impervious surface areas in the surrounding community by increasing the creek’s capacity. With these two major objectives planners and staff looked for ways to revitalize the downtown area. This project was part of a major downtown redevelopment campaign.

From another perspective, daylighting projects are implemented also for educational issues. Such that, the project on Jolly Giant Creek in Arcata, California began as an environmental education project at the adjacent high school. The biology teacher Armin-Hoiland purposed the idea and his objective was to create an outdoor ecology laboratory for the high school by daylighting a section of the creek, which ran underneath an area of the school grounds that had been neglected. As these daylighting projects consider about educational objectives or aim only to re-establish the creek to a more natural state as in the example of Taddle Creek in Toronto, Canada; they also serve the goal of flood control. In 2007, the primary purpose of the project in Castro Valley Creek, California was to increase the creek’s capacity to carry a 100-year flood. In this context, The Alameda County Flood Control and Water Conservation District, as a key institution for the project, aimed to restore the urban creeks in the County to more natural conditions while ensuring flood

protection. Restoring essential habitat for wildlife species enhances the ability of species to adapt to climate change.

In addition to all these cases, a successfully implemented daylighting project in Seoul, has propounded its goal with gathering all these different aspects in a broad perspective goal, which is described as ‘Preserving the unique identity of the natural environment and historic resources of Seoul. It mainly focused on restoring the cultural and historical heritages of downtown city, to initiate a balanced development between South and North of Seoul, and bring the ecosystem back in the heart of the city. Identifying the scope of work began in early 2002 with numerous public relations meetings held by future project leaders. Many political and professional representatives attended these meetings and workshops. As it became clear, the project’s scope was to improve the overall physical and natural environment in and around the Cheonggyecheon River. Considering Cheong Gye Cheon's traditional values and its urban image as well as restoration of its ecosystem, the project design was made with the upstream representing ‘history and tradition’, the midstream ‘culture and modernity’ and the downstream ‘nature and future’ (Figure 4.3). The basic concept of the landscape design is to implement the image of ‘Urban Stream with Nature’ and the optimal balance between exploitation and ecology (Lee, 2006).

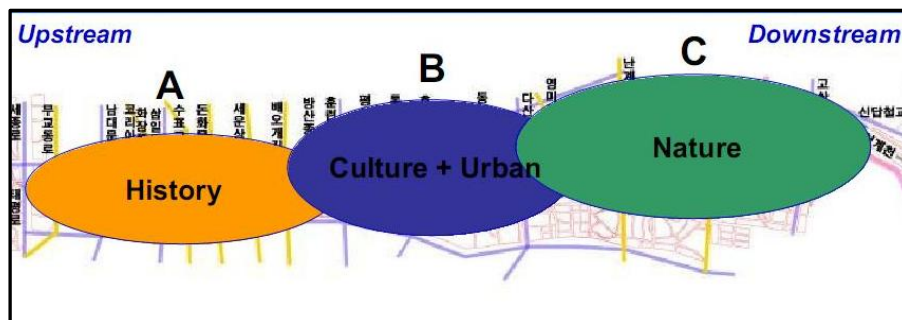


Figure 4.3 : Segmentation diagram of landscape in Cheong Gye Cheon River Daylighting Project (Lee, 2006).

As another different context in several daylighting cases, the implementation on Dunes Creek in Indiana, took its source from the pollution problems and focus on improving water quality. The goal of the Project determined as to reduce the urban impact to the surrounding natural area (Indiana Dunes State Park), improve water quality and habitat, and reconstruct the Dunes Creek system to reflect the natural aesthetics and the historical ecosystem present along the stream reach (Pell, 2008).

By this way, it is aimed to create a natural connection between a large watershed and Lake Michigan. In another example of daylighting implementation in Thornton Creek, Seattle, after five years community process and controversy against Northgate Mall development plans, the efforts put step towards to improve the balance between urbanization and environmental sustainability. Such that, the Thornton Creek watershed is the largest one in Seattle, covering over 11 square miles and including numerous tributaries and constitutes an extensive corridor of urban nature in the city (Mayhew, 2009). The creek is revitalized as part of a re-development of a mixed-use residential & commercial private development of an old mall parking lot (Figure 4.4) The facility, which is called The Thornton Creek Water Quality Channel, is designed to remove pollutants from stormwater by slowing urban runoff before these flows enter the creek.



Figure 4.4 : Thornton Creek Water Quality Channel and the parking lot with pipe under it. (Mayhew, 2009).

4.2.2 Drivers for daylighting

In recent decades, with the acceleration of population growth and related agglomerations (population, industry, trade, social & physical infrastructure etc.) in urban areas, many problems have occurred in socio-economic, cultural and environmental systems. As long as human societies believe in the idea of controlling nature and creating human-dominated living spaces, the well-balanced system of nature played its role and put its power on manmade systems in order to find the way to continue its natural functioning in company with giving several damages on human systems.

Thus, at the turn of the 20th century, prominent landscape architects and urban planners like Frederick Law Olmsted, Charles Mulford Robinson, and Werner Hegemann envisioned preservation of riparian corridors throughout the rapidly

developing San Francisco Bay Area and this approach precipitated several daylighting projects in the bay area. (Pinkham, 2000). One of these projects was on Strawberry Creek, which first began to suffer severe erosion in the late 1800s. As the watershed urbanized over time, the creek began to suffer full range of urban stream problems: continuing erosion and flooding, channelization and diversion, deteriorating water quality (because of sewage and illegal discharge, chemical contamination, and runoff), sediment contamination, and loss of pool-riffle sequences. These changes were manifested in a sharp loss of fish and insect diversity in the creek. At 1987, stream assessment noted that 40% of the watershed was urban and the lag time between peak rainfall and peak runoff was only 15 to 20 minutes on the central campus (Resh, 1995). These problems led to the need activities for protection and improvement of the Strawberry Creek.

As another reason that requires practicing the daylighting method on riverine systems was the combined sewer systems, which are culverted together with the sewer and clean stream waters in the same pipe. Due to the fact of introduction of stream water into sewer systems, too much clean water was flowing into the sewage treatment plant in the city of Zurich. As a result, a citywide program is started in 1988 to modify the combined sewer system to accommodate a partially separate system because of limited wastewater treatment plant capacity and a 1991 Swiss law mandating removal of clean water inputs to combined sewer systems. Hence, a citywide daylighting program called the “Creek Concept” was the primary impetus for daylighting projects in Zurich (Smith, 2007). Also, with the projects implemented in Zurich, this has been considered that there is also a need to bring a more natural environment into the cities and that the urban landscape needs to be more attractive (Conradin and Buchli, 2008).

Moreover, daylighting projects can be affected by re-development initiatives of damaged central areas in the city as in the example of Arcadia Creek in Michigan. The Creek drains a highly urban watershed encompassing the central business district. As development in the watershed progressed through the middle part of the 20th century, flooding problems increased because the culvert was not sized to accommodate greater runoff from increased impervious surfaces. As a result, these problems, northern portion of the central business district experienced an economic decline with rundown buildings, increasing crime, and flooding, and this core area

had come to be perceived as a risky place for investment. The idea of daylighting Arcadia Creek surfaced during a national design competition for this redevelopment zone. Accordingly, the drivers behind the daylighting project of Castro Valley are similar to the reasons of Arcadia Creek, which is implemented as a part of redevelopment process of an area. In the case of Castro Valley Creek, Alameda County bought a site, which the buried stream flowed under, planning to construct a library on it. Seeing a change to enhance the library and improve the environment, county officials planned to uncover the stream's culverted section. A stretch of Castro Valley Creek near Norbridge Avenue and Redwood Road in Castro Valley was once buried underground in a culvert and covered with an asphalt parking lot. Due to the District's efforts, this section of Castro Valley Creek is naturalized.

Similar to the drivers of Strawberry Creek project, also in Taddle Creek, the pollution levels was the main impetus for daylighting that reached the point where people complained of the 'noxious smells' and worried about the health of residents. Also in the Thornton Creek, highly urban nature of this watershed has created water quality and flow control problems, which has degraded the creek's function as aquatic habitat. Beginning in the late 1960s, homeowners downstream of the mall began to note the deteriorating conditions of the creek and a marked increase in flooding incidents. These concerns eventually led to the formation of the Thornton Creek Alliance in 1992, (an organization that continues to be active in monitoring, restoring, and educating area residents about the creek). Before daylighting it, Thornton Creek was reputed as the one of the most abused creeks in the city due to the intensive development of the watershed. Accordingly, in the case of Cheong Gye Cheon River in Seoul, due to development and growth of the city industrial functions around the Cheong Gye Cheon area moved to the outskirts of the city, which led to several deteriorations and emerging problems such as; unwholesome environment raising hygiene-related concerns inside the covered road, air pollution caused by increased traffic and endangered citizens' safety due to aging road structures. Briefly, the Cheong Gye Cheon restoration project was initiated based on citizens' demand to improve the quality of urban life (Figure 4.5a). In addition, Dunes Creek represents a different example in terms of water pollution problems. In the area, it was discovered that the enclosure of Dunes Creek, a tributary to Lake Michigan, had been contributing to the presence of E. coli in the lake. Also, the beach located

downstream of this culverted section periodically experienced unsafe levels of *E. coli* associated with Dunes Creek (Figure 4.5b).



Figure 4.5 : a) Sanitation & safety problems of road structure in Cheong Gye Cheong area (Lee, 2006) b) Dunes Creek under the parking lot and its estuary to Lake Michigan near the beach (Peel, 2008).

In the case of Jolly Giant Creek, the driver to implement daylighting method on a riverine system was totally different than others. In 1990, biology teacher Lewis Armin-Hoiland proposed daylighting a section of the creek that crossed underneath a corner of Arcata High School district property in order to create an outdoor ecology laboratory.

4.2.3 Feasibility assessment of implementation: challenges and limits

Most of the daylighting projects have experienced several constraints, challenges, contradictions and problems from both physical and socio-economical environments. As these limitations or difficulties occur in the decision-making and planning process of the project, they can also emerge during the implementation or maintenance processes. The constraints could be related with physical environment which has an important role to determine the availability of constructions and also the consensus between stakeholders including community groups and parties is essential for the success of the project. As it is deduced from the inspected case studies, many projects starting from the San Francisco Bay area have experienced similar difficulties during their implementation process in highly urbanized areas. Such that, a common feature of San Francisco Bay Area projects is their location in densely developed urban and suburban watersheds. This creates a number of challenges for the designers: identifying the proper geometries for restored channels, securing the confidence of project neighbors, and dealing with the problems of older urban infrastructure. Designers of these projects have used historical aerial photographs,

measurements of less disturbed upstream reaches of the creeks, and other techniques to determine meander patterns and channel cross-sections. Similarly, Dunes Creek was also a heavily modified, low gradient, sand-bottom coastal tributary to Lake Michigan and its watershed contains a mix of urban and natural areas. Therefore, when the daylighting project moved into its second phase in the fall of 2009 it faced with a damage that occurred during a September 2008 flood, in which a 20,000-square-foot portion of the parking lot collapsed after receiving 16 inches of rain over four days.

Accordingly, in the case of Arcadia Creek, due to its watershed is mostly urban and a densely populated area, the biggest challenge was establishing the channel geometry in a floodplain that constrained by surrounding development. Also, the aged infrastructure under downtown created some surprises for the city public works department and some property owners. Crews found (and often broke) a number of unmapped water service line. In addition to these challenges, major efforts are needed to remove concrete slabs, which cost a lot. On the other hand, city engineers examined the cost of replacing the culvert but discovered that daylighting the creek and placing it in a canal would be cheaper (Jones, 2001).

The Zurich experience also faced with similar problems depending on the sewer separation strategy. As the Swiss Water Legislation requires the separation of extraneous water from the sewer system, the question often is whether a new clean water pipeline is cheaper than an open stream. Often the daylighted stream is cheaper, and, even when it costs slightly more, this solution is chosen due to the other obvious benefits (attractiveness of the city, recreation opportunities, well-being of the residents and natural protection). Many projects in Zurich held in mainly populated urban areas with large areas of impermeable surface and culverted or underground creeks integrated with sewer system pipes. As a similar example, Taddle Creek in Toronto was also running in a combined sewer underneath and so, daylighting of its full flow was difficult and require expensive treatment facilities. Therefore, several options were examined ranging from full daylighting of the combined sewer to a daylighting supplemented by re-routed storm water to doing nothing. As another challenge type depending on the place it takes in the case of Castro Valley Creek there were site constraints and the fact that design plans for the

adjacent library site were nearly complete affected many aspects of restoration design. Also, the site's relatively steep gradient presented challenges.

On the other hand, Strawberry Creek was an early example of a challenge that must be faced in nearly all daylighting projects: fear (Pinkham, 2000). Strawberry Creek has a 1,161 acre watershed, which begins in the canyons above the University of California-Berkeley campus and is the focus of open space on campus. The creek then disappears into a pipe for most of its journey through the city of Berkeley until it enters central San Francisco Bay (Figure 4.6a) (Resh, 1995). The project comes in many forms city officials worrying about hydraulic performance or fretting over maintenance, and neighbors afraid the project will attract vermin or drown their children. In 1974, the Santa Fe Railroad abandoned a rail yard and the land reverted to the city of Berkeley. The land in the flat bayside area of west Berkeley lay neglected until 1982. At that time Douglas Wolfe, one of the city's staff landscape architects, began promoting a park project with a visionary plan to daylight Strawberry Creek as its centerpiece. City officials were unsympathetic, fearing the exposed creek would be a safety and flood hazard and a litter-filled eyesore. As landscape architect Gary Mason, a member of the city's design team and Wolfe's eventual business partner, puts it: "They wanted to know why we would bother to dig up a perfectly good culvert." But citizens rallied behind the daylighting component of what was to be called Strawberry Creek Park (supporters launched a vigorous leafleting campaign, attracting up to 75 people at a time to various public meetings) and the Berkeley Parks Commission eventually voted unanimously in favor of it (Pinkham, 2000). Following this, the project design and construction occurred in 1983 and 1984. The designers did not have modern watershed analysis and fluvial geomorphology tools at their disposal, but paid careful attention to determining the proper channel geometry for the "new" creek. They looked upstream several blocks, to where Strawberry Creek still flowed free on the University of California campus, to analyze channel width, depth, and meander pattern. After digging out the turn-of-the-century culvert, restorers also examined soil types to help find and re-establish the original meanders of the creek (Figure 4.6b). Finally, as might be expected, the Strawberry Creek project encountered problems that will be familiar to most stream restoration practitioners, including the need to coordinate among multiple

institutions, a lack of funding, few possible stormwater retrofit sites, and difficulty with anchoring check dams (Resh, 1995).

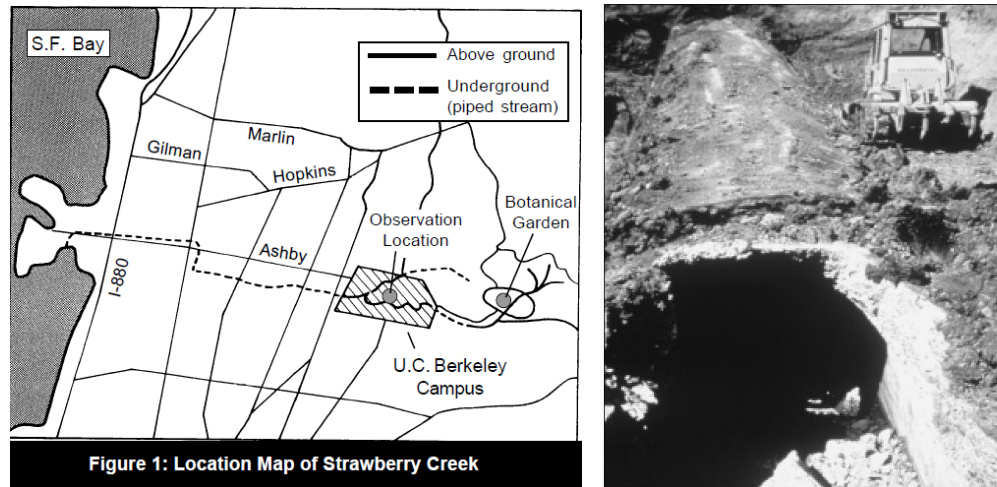


Figure 4.6 : a) Location map of strawberry creek b) Removal of the Strawberry Creek in Berkeley, California in 1984. (Pinkham, 2000.).

In comparison with the first implementation of daylighting, the Cheonggycheon river restoration as an early example has also faced several problems. The project involved the removal of an elevated highway built over the course of the river (Figure 4.7a). The removal of the elevated highway, built in 1976, was less problematic than it might have been because it was in a structurally poor condition and if not removed would have required extensive renovation (Lee, 2006).

As with any large urban project, there were major challenges that required particular adaptive solutions for both the contractors and citizens alike. Because, it was not easy to control a construction site with disregarding thousands of people at the centre of the city. In the project, generally there were initially two big public involvement problems: resolving inconvenience and encouraging participation. The inconvenience involves two issues: traffic congestion caused by the reduced lanes of roads and economic loss to businesses adjacent to the stream due to construction work. The traffic problem was eased by introducing new transportation policy focusing on public transportation. For compensating business losses, measures to provide business stability fund and to relocate the places of business to other areas where tenants and/or owners want were introduced. Besides the physical constraints, environmental challenges also occurred. During the rainy season, the water floods within 30 minutes after rain begin (Figure 4.7b). This caused many constraints to working in the streambed.



Figure 4.7 : a) Procedure of demolition work & removal stages of highway b) Flood in Cheong-Gye Plaza on August 3, 2003 (Lee, 2006).

4.2.4 Public reaction and participation assessment

Human factor has always been an important element for implementation and maintenance processes of daylighting projects. In some cases, the ongoing process has led to the formation of local groups whilst, during some implementations decision makers organized many activities to encourage public interest and awareness. As in the case of San Francisco Bay area, all daylighting activities in the bay area both grew from and spawned a plethora of local “Friends of the (name of a local creek)” groups as well as the Urban Creeks Council, an umbrella organization. Also, the designers have pushed hard for significant public involvement in developing the creek and park restoration plans. That involvement continues beyond the planning stage volunteers have been very active in landscaping, planting, and maintaining many of the projects. As the most daylighting projects need continued planting and maintenance in their early years, the bay Area projects have benefited from a variety of maintenance arrangements. At some, city maintenance crews remove debris in the fall to prepare for winter rainstorms. Participants in a local job training program maintain two of the projects. Local citizens look after others, and the Urban Creeks Council and Waterways Restoration Institute hold two or more expertly supervised volunteer workdays each year, usually for weeding in the spring

and planting in the fall. As a part of Bay area projects, the city of Berkeley put in place an innovative program to maintain the creek and the park. A proposal from a local job training program to maintain the facility is developed and an \$80,000-per-year contract is signed between the city and Berkeley Youth Alternatives to maintain four parks (Pinkham, 2000). At any one time, about a dozen high school students from low-income families are enrolled and paid to pick up garbage, weed, prune plantings, and otherwise maintain the parks. The youths work every day after school and half days on Saturday, and receive some tutoring as well as income and job training. The city gains financially by not having to hire and pay benefits for adult parks staff. Similarly, also in Jolly Giant Creek project, many students have been involved in restoration and monitoring throughout their high school year and community groups are involved to the process.

As a different practice than other case projects, during the daylighting process of Dunes Creek, a live camera is placed that uploads images to the Internet at NOAA.gov. and this “Dunes Creek Recovery Cam” gives the public a real-time view of the project’s progress.

Also, the effect and importance of public participation on daylighting efforts can be viewed clearly in the example of Thornton Creek Daylighting Project. The community groups have fought against to the development plans of the mall that the creek runs beneath it. Mall redevelopment plans (to double the size of the mall) by mall owners, targeted the south parking lots the primary site for new development. The City Council approved the development plan and neighborhood residents protested that the redevelopment would increase automobile traffic in the area. They also argued that the project would conflict with the goals of the 1993 Northgate General Development Plan as well as forego any opportunity to restore the buried portion of Thornton Creek that ran beneath the south parking lot. The situation discussed by Thornton Creek Alliance, the Thornton Creek Legal Defense Fund, and a neighborhood group called Citizens for a Livable Northgate.

On the other hand, during the daylighting processes in Zurich, the initiative of the neighborhood was very important and helped to raise the money for the project in some cases. Participation of residents in the neighborhoods increased the awareness and social interaction. Similarly, in Arcadia Creek case public involvement in planning, and preliminary engineering continued into 1990. The city also

orchestrated a public relations campaign, with public meetings and workshops to inform the residents and get them involved in generating ideas about design. The city made a concerted effort to reach out to the corporate and business community. Also, collaboration with local agencies during the process of Castro Valley Creek Daylighting played an important role as it is done in Cheonggyecheon River Project in Seoul including operated intensive public involvement programs with project teams which had about 4000 meetings with resident and citizens individually or in groups. To motivate citizens' participation, the 'Wall of Hope Program' was developed. More than 20,000 citizens participated and wrote down their wishes on a 10cm×10cm ceramic tile and put them on the slope wall (Figure 4.8).



Figure 4.8 : Citizen's participation in Cheonggyecheon River Project: 'Wall of Hope' (Lee, 2006).

4.2.5 Related stakeholders and funding institutions

The economic issues have always played a critical role for planning projects in any field. They act as determinant factors to realize the thoughts, desires and plans on the land. As it has an important role on implementation, the effectiveness and work distribution among the stake holders are also constitute an essential step for the project success. In the case of San Francisco Bay area, local firms like Wolfe Mason Associates have built expertise in stream restoration, and the Waterways Restoration Institute, a nationally active nonprofit river-restoration design, training, and advocacy group, makes its home here. As the implemented studies in Bay area show, collaboration between local governments, institutions, businesses, nonprofits, and citizen groups has been a key to the success of Bay Area daylighting projects. Accordingly, the entire park project of Strawberry Creek Project was completed within its \$580,000 budget (1984 dollars) from city funds (Pinkham, 2000). Creek

restoration amounted to less than 10 percent of the cost, and a substantial part of the restoration budget was the cost of a pedestrian bridge over the creek. During the project, grading costs were low because much of the site work was required for the park, irrespective of the new creek. The budget included most of the restoration labor (unlike later Bay Area projects, which have sometimes used considerable donated labor). In general, terms, City of Berkeley collaborates with University of California and Berkeley Youth Alternatives during this project process.

Due to the concept of daylighted streams instead of pipes in Zurich was also strongly supported by a group of people from different city departments, politicians, and the citizens. In addition, The Zurich Stream Daylighting Program was set up and presented to the press and the public in 1988. Beside The Zurich City Council, The Stream Daylighting Group, an interdepartmental task force, was set up to coordinate the various field activities between city departments and to overcome resistance within the city administration. During the process employment of private landscape architects and other experts, such as water engineers and biologists are provided.

On the other side, for the project of Arcadia Creek, the city formed a Downtown Development Authority (DDA) to coordinate and fund the project with its consultants 'STS Consultants Ltd.' The project was done largely with the involvement of consultants and the City of Kalamazoo and private donations helped with acquiring some properties (Jones, 2001).

Accordingly, the project of Jolly Giant Creek was taken up by a regional development and advocacy agency, and was eventually funded by the state. Natural Resources Services Division of the Redwood Community Action Agency (RCAA), a private nonprofit regional development organization, funded the project with the budget taken from California Department of Water Resources Urban Streams Restoration Program. Also, an aquatic ecosystems restoration class in the fisheries department of Humboldt State University, worked with various teams and examined the creek's ecology, hydrology, and use, and designed concepts for daylighting and restoring the stream where it passed the high school. Beyond Humboldt State University and Arcata High School, community groups, and government programs were involved to the process (Pinkham, 2000).

As a local umbrella organization like in the case of San Francisco Bay Area, The Taddle Creek Watershed Initiative is also a grassroots alliance of residents. With the coordination of this association, business and community organizations, institutions, and local environmental groups in the center of Toronto worked together to give new life to the creek hidden at the heart of the city. Also, a class at the University of Toronto spent an entire year developing proposals for a daylighting project. As a result, University of Toronto, the City of Toronto, and the Taddle Creek Watershed Initiative worked together with local community and environmental groups.

In the case of Dunes Creek Project, The Indiana Department of Natural Resources, Save the Dunes Conservation Fund, and JFNew partnered to develop the restoration design, to complete stream restoration, and to assess the water quality within the stream prior to and following restoration. They completed stream daylighting of 800 lineal feet of Dunes Creek. In addition, the project was funded by NOAA. In federal stimulus funds from the American Recovery and Reinvestment Act of 2009.

Moreover, the daylighting project of Cheonggyecheon River, The Seoul Metropolitan Government had the key role in this process. In addition, recommendations given by KSCE (Korean Society of Civil Engineers) in 1992, and massive repair works were executed. The project is funded by Federal Emergency Management. On the other hand, The District (Alameda County Flood Control and Water Conservation District) received much of the funding from the City of Union City for the daylighting projects of Castro Valley Creek and in 2002, nearby Union City began designing a multi-modal transit project. This project was made possible under the leadership of the District, and in collaboration with the Alameda County Library, the Alameda County General Services Agency, the Hayward Area Recreational and Park District, the City of Union City, which contributed funding for the project, and several state and federal regulatory agencies. As a practical example of government correspondences about daylighting projects, 'Water Quality Certification for the Castro Valley Daylighting Project' document demonstrates the formal process of Castro Valley Creek daylighting implementation. The document is prepared as a guideline response to the application materials proposed by applicants (Alameda County Flood Control and Water Conservation District) to San Francisco Bay Regional Water Quality Board (Appendix A).

As another example for the stakeholders and funding of these projects, The Thornton Creek in Toronto also formed a local organization; Thornton Creek Alliance is formed due to the indicated deteriorating conditions of the creek in 1992. The overall facility was constructed completed by in 2009 with the cooperation and coordination with Lorig on the Thornton Place Development. It is also funded by Seattle Public Utilities (SPU) with funding support from Washington State Department of Ecology via Washington State Water Pollution Control Revolving Fund Loan (Thornton Creek Water Quality Channel Final Report, 2009). Community involvement was also instrumental in making the facility successful from a number of perspectives. A stakeholder group, made up of a broad balance of community, environmental and business interests that helped to drive the projects design, which integrates environmental and commercial concerns.

4.2.6 Legal background

In addition to the importance and support of institutional and economic factors, the legal background is also one of the key components of project realizing. However, as the daylighting efforts started in early 1980's, legal tools are still insufficient for daylighting implementations especially in highly urbanized urban areas. As the inference of case study analyses, it can be viewed only in two cases that legal background is actively be a part of daylighting projects.

First, in Zurich, as a consequence of the introduction of stream water into the sewer system, about one third of the flow was clean extraneous water. As a result, the city's two treatment plants had to deal with large amounts of "clean" runoff, which increased operational costs and diminished the efficiency of the water treatment process. As this was a nationwide problem, the revision of the Swiss Water Protection Law in 1991 stipulated that clean runoff and unpolluted rainwater should seep directly into the ground or, where this is not possible, should be diverted into a drainage system separate from the pipes carrying the wastewater.

In contrary with Zurich example, the efforts shaped the city policy in the case of Jolly Giant Creek in Arcata. After the daylighting project, the city actively pursued acquisitions and easements along local streams, and is initiating projects to restore hydrologic and ecological functions of its riparian corridors. It has also prepared a new drainage master plan.

4.2.7 Positive impacts: ecologic, social and economic dimensions

As a result of the implemented cases of daylighting in ten different areas, numerous positive effects are provided in a wide range of scope. The efforts influenced indirectly or created important chances on social, physical, cultural and economic structure of the area and its neighborhood which daylighting efforts are practiced.

To start with, daylighting offers significant urban infrastructure benefits in the San Francisco Bay Area. Most importantly, without daylighting efforts, many culverted streams in this region have required expensive repairs because of earthquake damage. According to Pinkham (2000), daylighting also allows an increase in storm flow capacity.

The Strawberry Creek Project was also one of the first daylighting projects in the United States, and anchors a popular urban park in a mixed-density residential neighborhood of Berkeley. Four acres of abandoned rail yard was transformed in 1984 into Strawberry Creek Park, featuring playing courts, landscaped hillocks, grassy meadows, native trees, and 200 feet of babbling brook. The successful restoration sparked other local daylighting efforts and is considered a model daylighting project. Also, property values in the neighborhood have increased, once a high-crime area and drug-dealing hotspot, the area now has a family-oriented feel. As a result, this project galvanized the community, leading to several other daylighting and channel-restoration projects in Berkeley and surrounding communities. In addition, Strawberry Creek Park has won many awards, including a Design Merit Award from the American Society of Landscape Architects in 1995 (Pinkham, 2000).

As another successful implementation with a special context to be a ‘city wide’ act, the case of Zurich daylighting program completed more than 40 projects, and 20,000 meters of streams were daylighted or revitalized within this extensive daylighting program (Conradin and Buchli, 2008).. The program approved by the Zurich City Council in 1988 and the concept serve as a typical result of integral thinking. In citywide, daylighted streams represented in many ways the wishes and needs of city-dwellers for a more natural environment in the city. In Zurich, the streams are especially popular with children who often use them as playgrounds.

Consequently, the program considered the outcomes from five different perspectives:

1. With respect to the cultural system; the program strengthened the relationship between humans and nature
2. The social system supported by increased social interaction and networking in the neighborhoods, residents' participation in the planning and implementation process, and interdisciplinary cooperation across city government departments.
3. In the human (individual) system, opportunities for regeneration in the living environment, aesthetically pleasing shapes and sensory stimulation, and opportunities (for children) to play are provided.
4. In the biological system, it is reached to the increased diversity of plants and animals in urban neighborhoods and more linkages between natural habitats lead to sustainability.
5. In the chemical/physical systems, energy savings in the wastewater treatment process, and reduction in the amount of sealed urban land, are turned to positive situation.

Multi-perspective benefits of daylighting activity can be seen on the case of Arcadia creek. Because, after daylighting Arcadia Creek, the City of Kalamazoo in California now estimates that annual property taxes in the area of the redevelopment have risen from \$60 000 US to \$400 000 US and that associated economic output from a new festival site near the creek is approximately \$12 million US annually (Pinkham, 2000). To address the flooding problem, the DDA created an open stormwater pond. It is considered a successful project because the resulting “stream” and “pond” have worked very well to mitigate the urban flooding problems Kalamazoo had been facing for years. Previously subject to frequent flooding, city engineers predict that Kalamazoo is now protected from anything up to a 500-year flood and so downtown businesses no longer have to pay flood insurance. Also the city's floodplain map was completely redrawn. In this context, the city decided to maintain ownership of the land to protect developers from potential environmental liabilities. The city leases out each parcel in the redevelopment zone, and indemnifies developers from future environmental problems related to the site. Moreover, Arcadia Creek daylighting projects also constitutes a good example at the Arcadia Creek, where the daylighted river is now the centerpiece of a successful festival site, providing opportunities for recreation and also acts as a flood-control reserve during winter high flows (Figure

4.9). A stream walkway parallels the daylighted stretch and links this pedestrian path with walking paths that are part of a larger pedestrian/bicycle path system in the region. The open stormwater pond that was also designed as an amphitheater to provide cultural activities for city residents and summertime tourists. The area is now called the “Festival Site” and hosts five annual festivals during the summer: the Blues Fest, Rib Fest, Taste of Kalamazoo, Island Fest, and Greek Fest. This site was formerly a parking lot. Part of it still is a parking lot during the week and a site for festival events on weekends and during the summer. However, the project has been so successful that the DDA is now planning to remove the remaining parking lot in the near future and turn the entire area into a park and festival commons area. As another outcome of the project, Kalamazoo pursued some innovative public outreach strategies to generate initial interest and support for the daylighting project. One of the first things the city did was to create and produce a children’s book that focused on the Arcadia Creek project. Copies of the book were handed out to schoolchildren to generate support and help educate the community about the daylighting project.



Figure 4.9 : The “Festival Site” a key component of the completed daylighting project for Arcadia Creek in Kalamazoo (Hoobyar, 2002).

As another effective activity of daylighting, The Jolly Giant daylighting and associated channel restoration work has created a valuable new public space in the city of Arcata, and an attractive asset for the neighborhood. The project increased pedestrian traffic and use by school biology classes. The project also provides the outdoor classroom for students. Monitoring of the project by high school and university classes has shown improvements in water quality and aquatic biodiversity. The restored creek provided settling of sediments, improved channel and floodplain geometries, improved flood control and stormwater detention, habitat-creating structures, erosion control, and riparian and wetland vegetation.

Overall, both Jolly Giant and Arcadia Creek projects are considered successful because they met their primary objectives. As with the creation of a park amenity, in terms of ecological function neither project guarantees a holistic environmental outcome.

As an unsuccessful example, the efforts were made to turn Taddle Creek back into an aboveground waterway using daylighting. However, because of suitable water source was unobtainable, the plan could not realized. Also, the challenges of daylighting a very polluted creek in highly built-up part of the cit characterized by a lack of parks or open species proved difficult to overcome.

In addition to all these cases, a successfully implemented daylighting project in Seoul Cheonggyecheon River, had proved that, daylighting can have impressive effects on social wellbeing and economic benefits including environmental protection and improvement (Figure 4.10).



Figure 4.10 : The development process of Cheonggyecheon River (Lee, 2006).

The positive outcomes of the entire project are explained below:

- The daylighting project provides flood protection for up to a 200-year flood event.
- Increased overall biodiversity by 639% between the pre-restoration work in 2003 and the end of 2008 with the number of plant species increasing from 62 to 308, fish species from 4 to 25, bird species from 6 to 36, aquatic invertebrate species from 5 to 53, insect species from 15 to 192, mammals from 2 to 4, and amphibians from 4 to 8.
- Reduced small-particle air pollution by 35% from 74 to 48 micrograms per cubic meter.
- Increased the price of land by 30-50% for properties within 50 meters of the restoration project. This is double the rate of property increases in other areas of Seoul.

- Increased number of businesses by 3.5% in Cheonggyecheon area during 2002-2003, which was double the rate of business growth in downtown Seoul;
- Attracts an average of 64,000 visitors daily. Of those, 1,408 are foreign tourists who contribute up to 2.1 billion won (\$1.9 million USD) in visitor spending to the Seoul economy. (Seoul Development Institute, 2006)
- Reduces the urban heat island effect with temperatures along the stream 3.3° to 5.9°C cooler than on a parallel road (Figure 4.11)

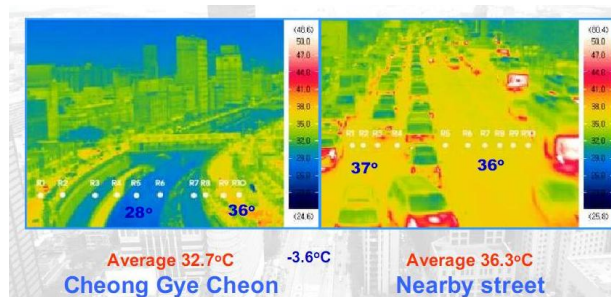


Figure 4.11 : Temperature measures on Cheonggyecheon River and nearby street (Lee, 2006).

Dunes Creek project is also one of these projects that won awards. The first phase won several awards, including the Governor’s Award for Environmental Excellence, the Chicago Wilderness/EPA Conservation and Native Landscaping Award, and the Association of Conservation Engineers 2007 Award. Completing the project in the second phase enables more benefits, such as opening the creek up to fish that migrate. Such that, restoring a natural connection between a large watershed and Lake Michigan improve the lake’s water quality, provide habitat for diverse species, improve flood protection, and enhance a public park’s recreational appeal. One of the prominent features of the project was a live camera that uploads images to the Internet every 15 minutes at NOAA.gov. The “Dunes Creek Recovery Cam” gives the public a real-time view of the project’s progress. Overall, data suggest that daylighting of this reach of Dunes Creek resulted in higher habitat quality which then translates to higher biotic quality within the daylighted reach compared to the downstream, post-piped, public bathing beach reach. A similar positive impact on habitat and biota quality is suggested by the upstream reach comparison (Pell, 2008).

Accordingly, The Castro Valley Project constitutes an important example for ecological and recreational improvement of the area. In the context of daylighting efforts, the creek banks were widened and reconstructed with earth, boulders, and bio-engineered soil slopes. The channel included deep pools that provide a variety of habitats that have become home to many different organisms. Root wads (trees trunks with roots attached) were added, and native plant species were planted along the channel's inside banks to create more natural riparian habitat (Figure 4.12). Vegetation planted along the waterway in order to help erosion control, improve wildlife habitat and maintain low water temperatures.



Figure 4.12 : Castro Valley Creek after daylighting (Modrell, 2009).

The restored stream also improves water quality. Briefly, the restored stream section became a dynamic stretch of different habitats for various fish and microorganisms. As the recreational service of the project, a creek side amphitheater was installed that can be used by teachers as an outdoor classroom to provide a space for outdoor learning. (help students to learn about creek ecosystems). In addition to the amphitheatre, also a playground is built located across the stream from the children's wing of the library. All of these efforts are intended to increase public awareness regarding the practice of stream restoration while providing recreational amenities.

Lastly, in the Thornton Creek case, a contentious, but eventually successful, community process has occurred which led to large-scale water quality project and major private redevelopment (Figure 4.13). Previously, the site was a paved-over lot, slated to become a shopping mall and parking garage. However, due to the persistent defense of neighbors who fought for years for the creek's survival, the area became a

transit-oriented mixed-use development, featuring a bioswale capable of treating stormwater through natural processes before releasing it downstream (Figure 4.14).



Figure 4.13 : Thornton Creek before and during construction (Mayhew, 2009).



Figure 4.14 : Thornton Creek draft plan and completed facility (Mayhew, 2009).

4.2.8 Major results and lessons learned

According to previous sub-titles including the key assessment themes, ten case projects are selected from scientifically approved studies in order to provide a common assessment platform for daylighting experiences from different countries. Each implementation is analyzed in terms of its pre-construction, construction and maintaining processes including the scope, drivers, feasibility stakeholders, public involvement, and legal background of the project. These themes provide an overall discussion platform for different cases, which have different backgrounds. Therefore, the assessment of ten implemented daylighting projects presents a basis to understand and compare previous experiences including the lessons that should be learned. The assessment also can guide for future practices including the discussions and analysis over these various cases.

According to the analyses of each case, major results can be discussed in terms of their benefits and failures. In this framework, it can be viewed from the case of San Francisco Bay Area, removing the cover on Napa Creek without naturalization concerns did not fix the problems of watershed and a damaging flood occurred in 1986 (approximately 10 years after removal). During the flood, 5000 people were evacuated, 250 homes were destroyed and three people died (Smith, 2007). As a result, Napa River Flood Project was revitalized, approved by local governments in 1998. Construction began in 2000 and projected to be completed by 2015.

Following projects in both Bay area and other countries were mainly exposed to growing impacts of urban areas. As a result of multiple human activities, they are physically and ecologically degraded and these effects caused similar problematic results in urban areas. The riverine systems in urban areas are mainly polluted, diverted, channelized, put in to concrete canals or culverted in pipes. These alterations caused several chain effects on their system functioning. For illustration, the sediment contamination, erosion, impervious surfaces, and stormwater runoff increased overtime including also the flood risks. On the other hand, ecological functions, aquatic habitats and species decreased due to damaging effects. In addition, daylighting efforts in these urbanized areas faced with several difficulties before, during and after the implementation processes in terms of feasibility of the project. For illustration, identification of channel properties, establishing channel geometries, old infrastructure, removing concrete slabs and insufficient mechanical tools (especially for early implementations) became constraints for the project. Moreover, physical conditions of the working site and weather conditions (heavy rain) are also act as constraints in some cases.

On the other hand, many projects demonstrate the importance of public involvement in each stage of implementation. As in the cases of San Francisco Bay Area and Taddle Creek, umbrella organizations and community groups had an important role for the success of the project. Furthermore, as in the projects of Strawberry Creek and Jolly Giant Creek, cooperation with youth groups including the student from low-income families, provided mutual benefits for project and the students. So that, maintenance of the area is taken by this youth group with providing an income for students. Similarly, participation of residents in Zurich Daylighting Program, increased social interaction among the people such as in the example of public group

efforts in Thornton Creek that brought the success to implement daylighting method on a riverine system which is under pressure of urban development. As another case, the government in Seoul created several opportunities for people to involve the process of Cheonggyecheon River Daylighting Project and they organized various activities (such as ‘Wall of Hope’ program) to encourage public participation. Differently, in order to increase public awareness for Dunes Creek Daylighting process, a live camera is prepared to upload implementation stages as a transparent act. The camera uploaded images to the internet every 15 minutes at NOAA.gov, and make the project available to follow by citizens. Similarly, as another effective way to increase awareness level and public involvement, the practice of publishing books for schoolchildren is provided during the Arcadia Creek Project in terms of integration with citizens.

In addition to public participation and volunteers working in both planting and monitoring stages, also the stakeholders and funding institutions work as key variables in each project duration. For example, coordination among multiple institutes and collaboration between local governments, business, non-profit and citizen groups played a key role for the projects in San Francisco Bay Area. Accordingly, involvement of universities as in Taddle Creek and Jolly Giant Creek projects had an important contribution to this process. In many cases, mainly the city council or metropolitan government (as in Zurich, Cheonggyecheon River, and Castro Valley Creek projects) was responsible for the coordination and implementation processes. On the other hand, in some projects, a new organization is formed for coordination and funding purposes such as, ‘Downtown Development Authority’ which is newly formed for Arcadia Creek Project and ‘The Thornton Creek Alliance’ that is created as a local organization. In the case of Jolly Giant Creek, Non-profit Regional Development Organization (RCAA) was the main responsible organization. On the other hand, funding is mostly provided by city funds (as in Strawberry Creek project) or Federal Emergency Management (as in Seoul) or private organization for the site like Save Dunes Conservation Fund.

Assessment of case implementations from legal perspective shows that only in two projects legal support is provided for daylighting efforts. In one case, city policies in Zurich encouraged daylighting projects (Zurich Daylighting Program) due to 1991

Swiss Law and as another example, daylighting efforts shaped city policies after Jolly Giant Creek Daylighting Project and a new 'Drainage Plan' is prepared.

According to the positive effects of implemented cases, the results indicate the benefits of daylighting from social, economic, physical and ecological aspects. In the case of Strawberry Creek, an abandoned rail yard transformed to a park and as a result of Arcadia Creek project a festival site and amphitheater is constructed for recreational and cultural purposes. The Jolly Giant Creek case constituted a different example in terms of its scope of educational purpose for creating an outdoor laboratory. The project provided many opportunities for student to be a part of the process and get different experiences. Both projects in Arcadia and Jolly Giant Creeks were successful at creating a park amenity and improving ecological functions of the riverine system. In addition, multiple benefits of daylighting projects can be seen on Zurich and Seoul (Cheonggyecheon River) implementations including increase of social interaction, human & nature relationship, biodiversity, attraction of the site, land values and business investments (also as in the case of Strawberry Creek, Arcadia Creek and Seoul), with decreasing air pollution, temperature, safety problems & crime rates and providing re-generation of living environment. The projects in Seoul and Zurich demonstrates that daylighting projects can have positive impacts both socio-economic and environmental aspects and the achievements can be felt economically, environmentally, physically and socially. As a result of successful implementations of daylighting method, several awards are given to the cases such as Strawberry Creek and Dunes Creek.

In the case of Strawberry Creek, among many other lessons it also illustrates the reuse of materials in streambed (digging material for hillocks to carry water to creek and concrete slabs as boulders and rip-rap protection) can keep project costs down and create a unique aesthetic. In Strawberry Creek, the restorers used native trees and groundcover both along the creek and in the uplands (species used require minimal maintenance or irrigation). On the other hand, Taddle Creek Project shows that there is a multitude of options even for the same creek. From this range of options, if one of the goals is to truly provide improvements for wildlife habitat, an option must be chosen which reflects that (Pinkham, 2000).

Eventually, Zurich Daylighting Program, dubbed the Bachkonzept ("brook concept") to differentiate it from traditional drainage and sewerage approaches. It also

demonstrates that the need of maintenance or repair to damaged and old infrastructure most of the time costs more than daylighting efforts.

Moreover, according to Buchholz and Younos (2007), Arcadia Creek Project is especially noteworthy because it represents one of the most highly urbanized locations known to be daylighted. It does show that waterways can be daylighted in very dense urban centers and increase land properties with attractiveness of the city. Similarly, Castro Valley Creek project is also highlights the possibilities for restoring streams in urban areas.

Finally, the Seoul (Cheonggyecheon River) example demonstrates that a successfully completed project can be influenced by other restoration projects and in the case of Strawberry Creek, Seoul project also shows the importance of public support for a daylighting project and it would not have been possible to open up part of the channel with engaging without the local communities. Hence, a community success in Thornton Creek led to naturalize a hidden creek instead of populist development of a Northgate Mall.

In addition to these results, some key notes are reported from the analyzing of ten implemented case studies:

- Daylighting efforts began with cover removal projects and continued with several contexts of objectives including sewer separation issues, flood protection, naturalization or re-development site concerns. All these show that daylighting can serve for a broad perspective of project goals and have multiple positive effects especially for the riverine systems in urban areas.
- In urban areas, the restorers have faced similar difficulties but local participation by residents can minimize both the feasibility and cost of the project in terms of socio-economic aspects.
- In this context, cooperation between government, private sector, local groups and universities can provide a comprehensive perspective and a beneficial framework towards the solutions of problems and led to improve the status of damaged riverine systems in a healthy (both socio-economic and environmental perspective) way.

- However, each case project has experienced familiar problems about coordination between multiple actors, lack or insufficiency of funding and few possible sites for implementation including technical difficulties.
- Specifically in densely populated areas confidence of neighbors, increase public awareness, making negotiations and providing the mutual benefits among stakeholders have an important role for the success of the implementation.
- In physical aspect, safety is an important issue during the construction process (especially for removing concrete slabs) and after the implementation in terms of serving as a public open space for people (especially for children).
- Due to urbanization process and increase demands, main reasons to channeling riverine systems into large underground pipes are detected as road constructions, risk of flooding and riverine system pollutions with wastewater entrance. Therefore, in order to investigate disappeared streams and their routes, historical maps or aerial photographs can be used as main references.
- As a result of daylighting projects, flood management can be provided by ecological solutions. So that, improvement of water quality, aquatic system functioning and flood mitigation strategies can be solved together.

The assessment of case studies under key themes summarized with highlighted parts that refer the important examples in general (Table 4.4).

Table 4.4: Assessment of implemented daylighting projects under key themes.

Implement- ation Year	1970's	1984	1988	1995	1997	1998	2005	2006-2009	2007	2009
Case Studies Key Themes	Napa Creek, San Francisco Bay Area	Strawberry Creek, Berkeley	Zurich, Switzerland	Arcadia Creek, Michigan	Jolly Giant Creek, Arcata	Taddle Creek, Toronto, Canada	Cheonggyeche- on River, Seoul	Dunes Creek, Indiana	Castro Valley Creek, California, US	Thornton Creek, Seattle, Washington, US
Primary Goals & Scope	'Re-exposion of a previously hidden stream ' (only cover removal without renaturalization concerns)	Creek ecological restoration (archetype of daylighting projects)	'Sewer Seperation' program on citywide	'Re-develop- ment of an unhealthy core area' (business centre) in Kalamazo city and reduce flooding	'Creating an outdoor ecology laboratory'	'To give new life to the hidden creek at the heart of the city'	'Preserving the unique identity of the natural environment and historic resources of Seoul'	'Opening the entire Dunes Creek system to Lake Michigan and reduce the urban impact to the surrounding natural area'	'To increase the creek's capacity to carry a 100- year flood and restoring essential habitat for wildlife species'	Improving water quality and flood Protection also create public amenity
Drivers	Uncovering the waterway as a part of ungoing urban renewal project, Prominent landscape architects and urban planners envisioned protection of riparian corridors in Bay area	Creek is a heavily impacted bu urbanisation (erosion loss of fish species, flooding, deteration of water quality, sediment contamina- tion)	Flow of stream waters in to sewer system and limited wastewater treatment plant capacity, need for natural environment in the city	Part of a major downtown re- development project, a national design competition for re- development zone of the city brought the idea of daylighting	Biology teacher in a high school proposed daylighting for biology courses (to create an ourdoor laboratory for students)	Increased pollution levels, (complaints from residents) create concerns about public health	Sanitation & Safety Problems (traffic load, air pollution, aging road structures, unwholesome environment)	Enclosure of Dunes Creek, a tributary to Lake Michigan had been contributing to the presence of E. coli in the lake effects the beaches	When a nearby jurisdiction was required to conduct environmental mitigation, the District saw opportunity to restore,also enhance the library and improve the environment	Homeowners downstream of the Northgate mall began to note the deteriorating conditions of creek and marked increase in flooding incidents.

Table 4.4 (continued): Assessment of implemented daylighting projects under key themes.

Feasibility	All projects in bay area was in densely developed areas has similar challenges (old infra-structure etc.)	As an first implementation, the biggest challenge 'fear' is removed, lack of modern tools	Cobined sewer systems in densely urbanized area+ large impervious surfaces	The Arcadia Creek watershed is mostly urban and a densely populated area	The biggest challenge was establishing the channel geometry in a floodplain and majoreffort is needed to remove concrete slabs (costly)	A very polluted creek in a highly built-up part of the city. Also creek run combined with sewer made daylighting difficult	Physical (resolving inconvenience and encouraging participationof people) and environmental (rainy seasons) constrains.	Creek is heavily-modified also collapse of the the parking lot over creek due to the heavy rain, need to repair	The site's steep gradient presented challenges. Site constraints and design plans affected many aspects of restoration design	One of the most abused creeks in the city due to the intensive development of the watershed
Public Participation	Local firms and groups supported the activity, designers have pushed hard for significant public involvement	High school students from low income families worked for maintaining tasks(paid)	The initiative of the neighborhood was very important and helped to raise the money for the project.	Public involve -ment in planning, and preliminary engineering, campaigns	Many students have been involved in restoration and maintenance process	University of Toronto developed proposals for daylightig project + community support	Intensive public involvement programs were operated (Wall of Hope Program)	A live camera uploaded images on internet to alleviate public concers and questions	Collaboration with local agencies during the process	Citizen groups worked actively in the project
Stakeholders & Funding	For the following daylighting projects in the bay area, cooperation between government, business, non-profits and citizen groups play an important role	The entire park project was completed from city funds (City of Berkeley). Cooperation with Berkeley Youth Alternatives and University of California	Zurich City Council has a key role with the supports of all the relevant city departments, politicians, and the population	Downtown Development Authority funded and coordinated the project including engineering studies with its consultats, 'STS Consultants Ltd.'	-Humboldt State University, -Community groups - Government Arcata High School - Natural Resources Services Division of the Redwood Community Action Agency (RCAA)	- The Taddle Creek Watershed Initiative, - University of Toronto, - City of Toronto - Business, - Local environmental groups worked together	Operated by Seoul Metropolitan Government, recommendations given by KSCE, Funded by Federal Emergency Management	-The Indiana Department of Natural Resources, -Save Dunes Conservation JFNew partnered and Funded by NOAA, (ARRA of 2009) and FEMA	-The Alameda County Flood Control and Water Conservation District, - Alameda County Library, -Alameda County General Services Agency, the - City of Union City, agencies	Thornton Creek Alliance Citizens for a Livable Northgate Thornton Creek Legal Defense Fund

Table 4.4 (continued): Assessment of implemented daylighting projects under key themes.

Legal Back-ground			1991 Swiss Law- 'Removal of clean water inputs to combined sewer system'		The efforts shaped the city policy 'New Drainage Master Plan' is prepared					
Positive Impacts	Offers urban infrastructure benefits (expensive repairs), Several daylighting projects followed in bay area, increase storm flow capacity	Property values in neighbourhood have increased, and an old place with high crimes turned to a family oriented area, and won many awards	Excellent example of citywide daylighting program 'Creek Concept' encouraged by city policies	An unhealthy (crimes, flood risk) area transformed to an attractive business centre (increased investments)	Increased pedestrian traffic by students and accessibility to the outdoor laboratory. Also a new natural public space is created.	Unfortunately the project could not realized because of the challenges which are difficult to overcome	Improved Air quality & Temperature reduction, Increased Biological Diversity and land property, Recreational Opportunities, Restoring Historical Centre	Natural connection between large watershed and Lake Michigan and Improve water quality & aquatic habitat, flood protection, recreation	Water quality improvement, enhanced wildlife habitat, and public awareness and enjoyment (amphitheatre) playground, recreation park are built)	The majority of water flows through the underground pipe but small amount is routed through channel to provide a constant flow of water
Results & Lessons Learned	Removing the cover did not fix the problems, a damaging flood occurred in 1986	Successfully implemented first project, inspired many other projects, and shows importance of public participation and reuse of materials	City policies can encourage creek daylighting projects	Daylighting used in very dense urban area, decrease crime and increase land properties, book published for children	Daylighting projects can help to shape city policies. Also an outdoor laboratory for the school and valued natural area for the community is created.	The project show that there is a multitude of options even for the same creek.	Daylighting projects can have positive impacts both economically, environmentally, physically and socially. Importance of local communities	A live camera that uploads images to the Internet every 15 minutes at NOAA.gov , project won many Awards	Second phase is completed in fall 2010. Increase public awareness and The project highlights the possibilities for restoring streams in urban areas.	Community process led to large scale water quality project and major private redevelopment.

4.3 The Conceptual Model of Integrated Stream Daylighting (Co-MISDAL) for Renaturalization of Riverine Systems in Urban Areas

A conceptual model is a representation of relationships among natural forces and factors, and human activities (intended or not) that are believed to impact, influence, or lead to an ecological or target condition. The target condition (e.g., lake water quality, habitat, level of risk) is significant or valued, ecologically and publicly (Margoluis and Salafsky, 1998).

In this framework, as an outcome of thesis, a conceptual model is developed according to the theoretical background and literature reviews about ‘Renaturalization of Riverine Systems’ and ‘Stream Daylighting Method’. The model is designed as a result of the entire research, which summarizes the linkages between each chapter in a common platform. The model serves as a basis for a comprehensive planning approach about degraded riverine systems in urban areas. It mainly focuses on renaturalization of buried riverine systems, which are culverted in to pipes or covered with impervious surfaces due to the human activities.

From this point of view, the conceptual model took its basis from human & riverine systems relationship including the urbanization impacts on riverine systems and the results of human activities on hydro-morphological and ecological structure of riverine systems. According to the drivers including anthropogenic effects and growing impacts of urbanization process on riverine systems, a response is developed by societies, which led humanity to think about the balance between consumption & protection issues. The studies mainly focus on sustainable use of natural systems and minimize the negative effects especially on aquatic systems. These efforts brought new approaches for management and conservation of riverine systems. For illustration, benefits of natural systems for humans are defined in the context of ‘ecosystem services’ and it is viewed that the conservation and improvement issues of natural systems requires to think from an ‘ecosystem based perspective’ which focuses on supporting natural functioning of riverine systems in the context of ‘renaturalization’ approach.

To sum up, the reasons of negative effects on riverine systems (drivers) led to take precautions and develop sustainable approaches (response by the society) for

continuum of riverine eco-hydrological systems. However, the approaches require a tool to implement these newly developed attitudes to the field. Herein, conceptual models can be used as a tool for applying cognitive approaches in a project framework.

During the process of conceptual model development in thesis, in addition to the theoretical background and literature reviews (drivers and response), also assessment of selected daylighting projects constitutes as one of the key components of the model which provides a multi-variable perspective of implemented daylighting projects from different backgrounds (Figure 4.15). At that point, the model meets the need for a common platform for sharing the data & experience of former implementations. It also provides to combine them with theoretical base in order to develop of a comprehensive modeling approach for renaturalization of riverine systems through the daylighting method. Therefore, the model is formed as a combination and synthesis of previous researches, which took its roots from human & riverine systems relationship, continues with ecosystem-based approach development and finalize with Co-MISDAL.

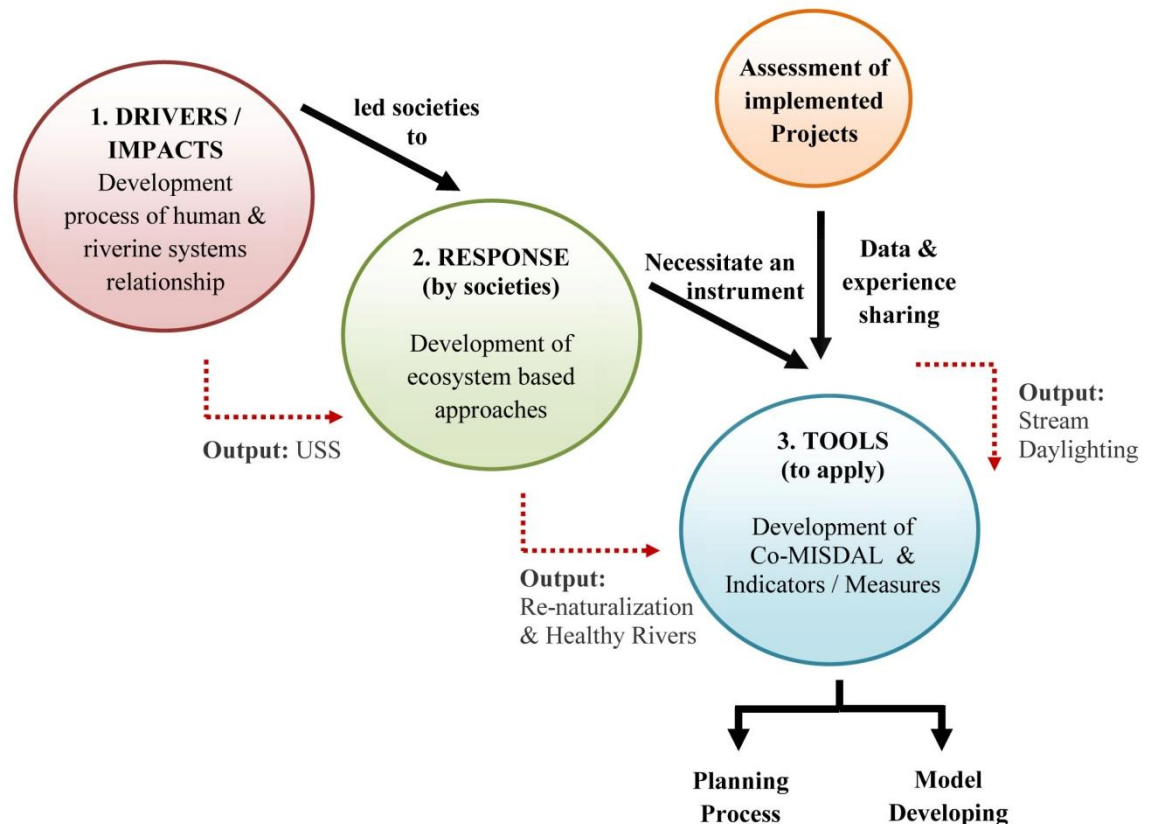


Figure 4.15 : Development process of Co-MISDAL model.

To start with, water has always been an essential resource not only for living species but also for the continuity of ecological systems on Earth. The riverine systems as components of this complicated and well-balanced structure of nature assumes the function of vessels in natural systems that they provide material transportation and the circulation of water within 'Hydrological Cycle'. In the story of (H₂O) particulates related with human beings, the process of Human & Water relationship began with the early settlements near major riverine systems. People have utilized from these flowing systems for many different purposes according to their needs. The necessities of societies differ due to the time and their development process. Such as the essential need of food and drinking water several canals and mechanical tools are constructed to get water inside the land and distribute. With the development of trading among countries, canals served as transportation routes, which provide an economic way for carrying goods to long distances by using ships. Canal systems are also used for safety issues and they created a protection zone with surrounding the city (Biswas, 2008). During this early relation between human and riverine systems, the effects of human activities were in a harmonization with natural systems and human interference did not have significant impacts on natural resources. However, the clusters of human population steadily increased and the range of human activities expanded. Especially after the 'Industrial Revolution' the consumption patterns has changed, demands per capita increased and environmental issues were not considered primarily in national and international agenda. As a result of ongoing human activities, especially water resources are exposed to several impacts as other natural systems in the places, which has human, & nature co-existence. In this framework, riverine systems were the most vulnerable sections of aquatic systems, which can be altered easily hydro-morphologically and ecologically as a result of human interference mainly in highly urbanized areas. In natural system, riverine systems as one of the main components of water cycle have an important role with water and material conveyance on Earth. However, with the expanding effect of human activities they are exposed to major damages by changing land use patterns, increased impervious surfaces and channelization activities. These alterations on stream bed configuration and riparian corridors caused chain problems in the whole catchment area of riverine system. The balance of river / stream ecosystem functioning is deteriorated including flow regimes, water quality and physical habitat structure of riverine systems (Figure 4.16).

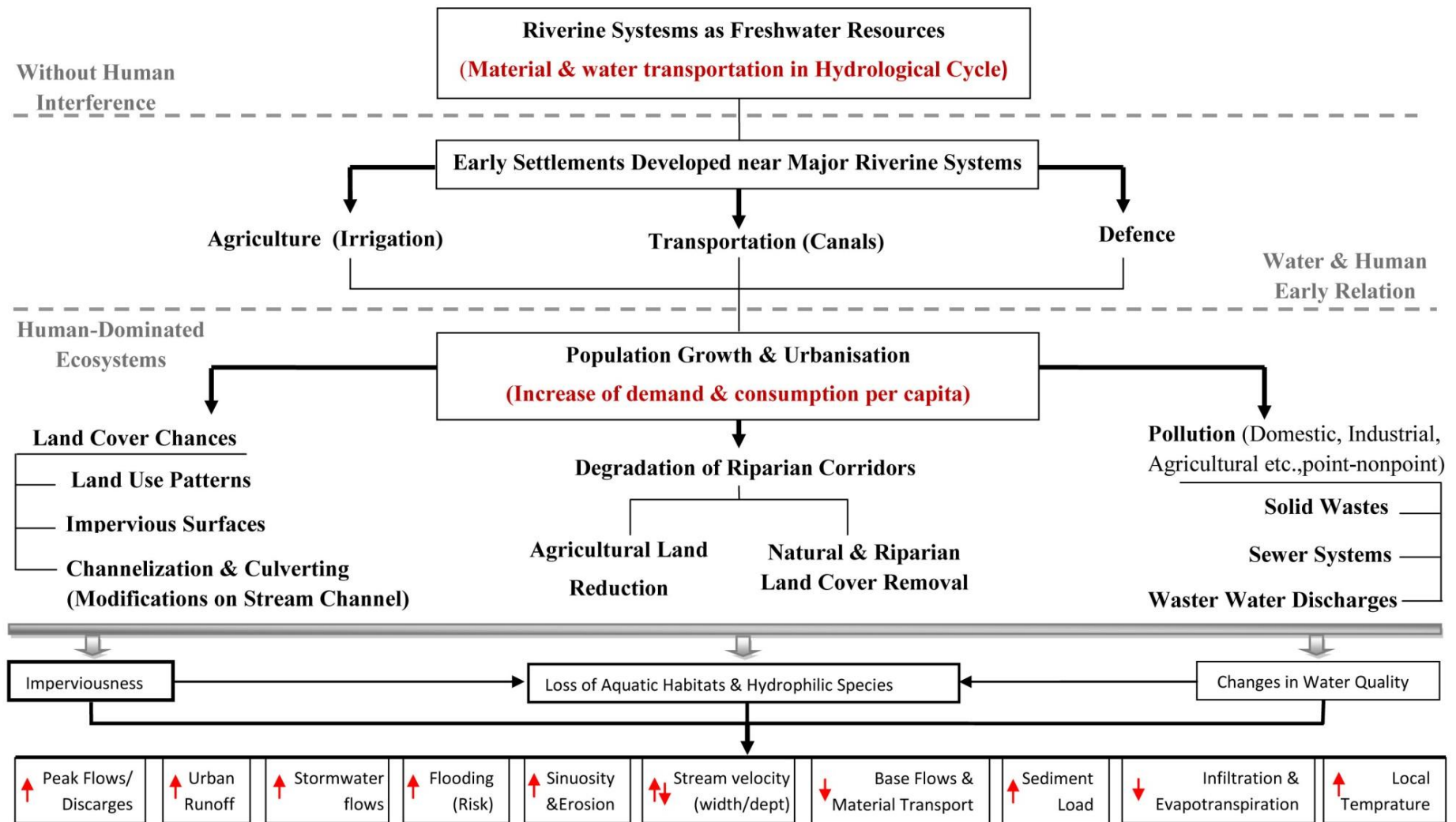


Figure 4.16 : Drivers of the problems: The Process of Human & Riverine Systems Relationship.

The Major impacts of population growth due to urbanization process are categorized under the three main titles including land cover changes, deforestation and pollution. Also, the damaging effects are indicated with sub-titles under the main titles and results of anthropogenic impacts on riverine systems are schematized including their relationship with each other. The process of relationship between humanity and riverine systems demonstrates that ecological functioning of these systems without human interference is steadily working in nature. With the emergence of early settlements near major rivers, the management and use of riverine systems began in the context of agriculture, transportation and defense purposes. However, the human intervene on natural systems did not reach to important levels to damage in these years. According to Biswas (2008), especially after 1950's, the growth of population and urbanization has distinctly occurred and the world has experienced a global change mainly on socio-economic systems. Over time, these alterations resulted with damaged natural systems and caused chain problems on environmental systems. With a focus on riverine systems in urban areas, the damaging human activities are grouped under three main titles and eight sub-titles, which have resulted mainly: increased impervious surfaces, loss of biodiversity and changes (decrease) on water quality. Although they have complicated effects on riverine systems, the changes especially on physical structure of riverine systems are indicated within small boxes below the figure including mutual relations with each other. Here, the results of human activities on functioning and structure of riverine systems can be seen clearly in terms of understanding the size and importance of human impacts on riverine systems and their natural functioning.

From this point of view, the alterations on natural systems and their functioning led people to take some precautions or change the ongoing consumption pattern of societies in order to have a sustainable future. Therefore, several meetings, conferences, conventions and regulations are held in different countries and the seriousness of current situation is emphasized internationally. Urgency problems are determined and several solutions, management plans and new approached are developed for a better management of natural resources. In this framework, especially riverine systems are discussed as one of the vulnerable systems on Earth, which are exposed to several impacts by humans. The main ideas is identified as integration of spatial planning approached to legal framework and supporting the protection of riverine systems by policies. Recently, two important concepts are propounded by United Nations and European Union, which comprises a holistic approach towards a watershed perspective. Integrated Water Resource Management (IWRM) is

developed by UN as a cross-sectoral approach that requires a participatory management process to maximize social and economic welfare within the ecosystem approach. Similarly, Water Framework Directive (WFD) is developed with the idea of balancing the demands on riverine systems and to reach the ‘good status’ in all EU member states inland and coastal waters (Clarke et al., 2011). Both approaches are based on reaching the balance between the social, economic and environmental aspects related with riverine systems and provide a comprehensive management approach by considering improvement of ecological functioning of riverine systems. Ecosystem based approach constitutes the basis for each management tool in addition to socio-economic dimension. Ecosystem based approach took its place as a key concept in management of riverine systems and precipitated to several new approaches. In 2005, the benefits of humankind from natural systems are indicated with the concept of ‘ecosystem services’ and defined as the benefits from a multitude of resources and processes that are supplied by natural ecosystems by MEA Report (Egoh et al., 2007). The entire concepts and approaches compromised and based on the same point, which highlights the ‘healthy’ status of riverine systems. Health rivers approach requires thinking riverine systems as an entire ecological system within socio-economic aspects and meeting with human needs in a balanced status. It also demonstrates good health by being resilient in the face of environmental changes. The approach led to think about the criteria for restoration or rehabilitation of riverine systems especially in urban areas that have numerous impacts on riverine systems. The efforts to improve the damaged status of riverine systems are mainly differs according to the site, structure of the riverine system and the type of problem. However, many projects focus on hydro-morphological or ecological alterations of aquatic systems and solely work on stream channel design, physical remediation, habitat reclamation or aesthetic concerns without considering turning the damaged riverine system to its original status as much as possible. By this way, natural functioning of the systems can be continued with the native vegetation of catchment area. This process which is called as ‘renaturalization’ of riverine systems is recently discussed and began to be considered especially for flood management projects that search for solutions from nature and choose the way of implementations which is close to natural systems instead of being against of it. According to Harrison, (1996), renaturalization approach also defends the connectivity between social, economic and ecological systems for a better integration within urban areas including urban ecosystem functioning. Renaturalization concept as an essential component for the recently developed water related approaches also highlights the way of restoration / rehabilitation issues for damaged riverine systems especially in highly urbanized areas (Figure 4.17).

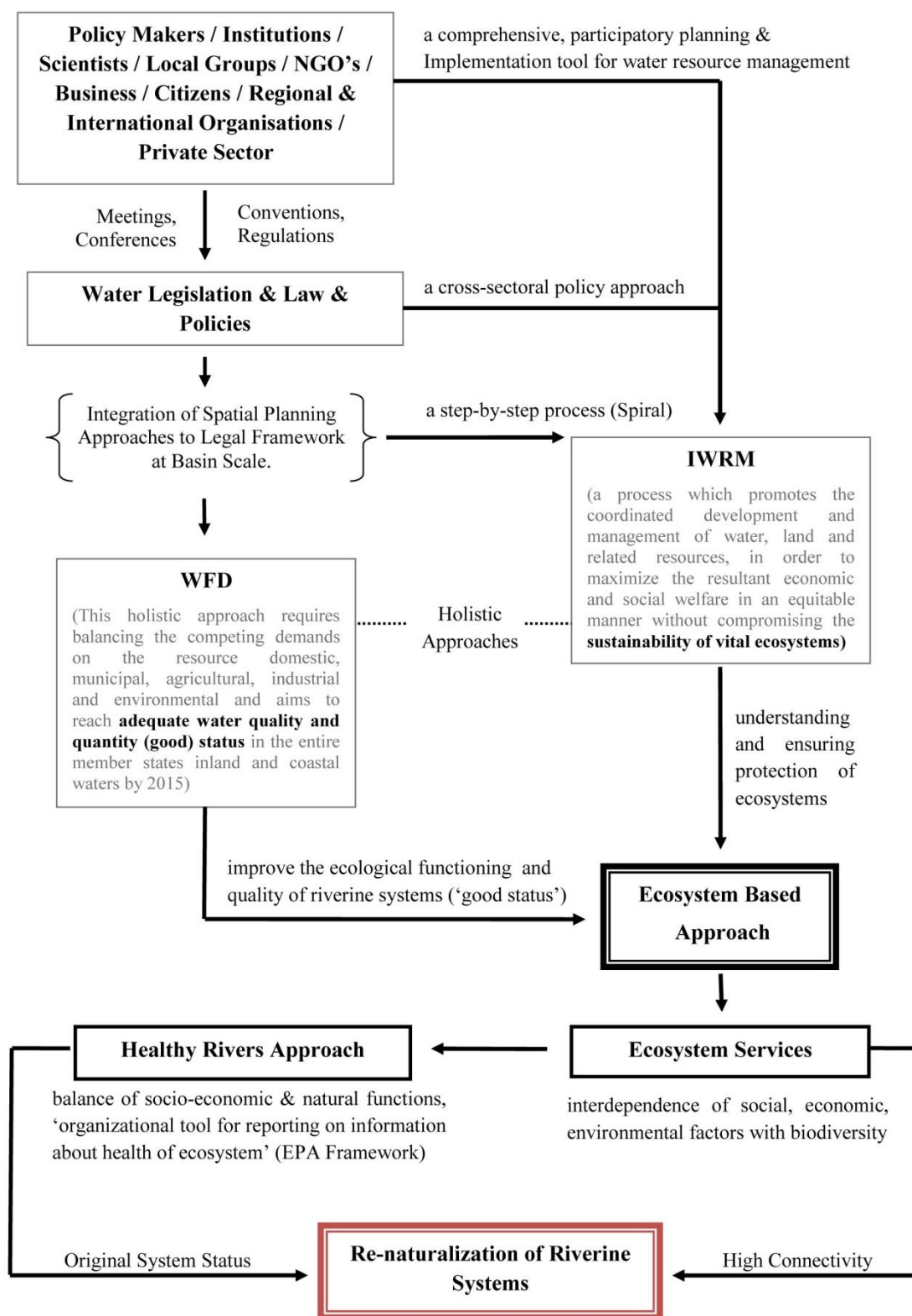


Figure 4.17 : Response by societies: Development of Ecosystem based Approaches.

According to the framework, renaturalization approach constitutes a common outcome of different approaches about riverine systems conservation and management and it contains the idea of providing original system status within a high connectivity with socio-economic

systems. However, the approach requires an implementation tool in order to realize theoretical background in to field. Renaturalization of riverine systems in urban areas has an important role to improve damaged status of these systems. Especially, channelization of riverine systems as one of the major impacts of human activities, need to reclaim deteriorated conditions and bring the system back to daylight including renaturalization of its ecological functioning. At that point, ‘Stream Daylighting Method’ can be used for renaturalization of culverted/buried riverine systems in urban areas.

According to Pinkham (2000), Daylighting describes projects that deliberately expose some or all of the flow of a previously covered river, creek, or storm water drainage. The approach of daylighting offers a radical chance and re-establishes a waterway in its old channel where feasible, or in a new channel threaded between the buildings, streets, parking lots, and playing fields currently present on the land. Most importantly, daylighting projects can restore streams to a naturalized state, or bring water to the surface in more architectural treatments where the stream corridor is highly constrained by surrounding development. The method can provide multiple benefits including improvements to the functional values of waterways, increased hydraulic capacity for flood control, lowering of water velocities to reduce downstream erosion, removal of water from combined sewers, improvements to water quality and aquatic habitat to provide “new” riparian corridors for wildlife. It also revitalizes neighborhoods, and increase property values. In addition daylighting projects can projects help educate children and adults alike about the workings and values of stream corridors and wetlands.

In order to realize this method as a tool for renaturalization of buried riverine systems, a methodology should be improved to guide the projects and highlights the route to follow. In this framework, a conceptual model that contains planning and implementation processes can constitute a basis for possible daylighting projects in urban areas.

The conceptual models are the map of entities (concepts) and their relationships, which are used to identify well-known cause-effect chains. Conceptual models have been described as qualitative or descriptive narratives or graphic representations that demonstrate the causal relationships between natural forces and human activities that produce changes in human and ecological systems (Odum, 1953). Many conceptual models are characterized as influence diagrams, representing our understanding of causal relationships. Other models are representations of perceived relationships between system components or between existing, separate models. Graphical representations are the most common expression of a conceptual model, although word models are frequently used, sometimes as the precursor to a graphical

representation. Current applications of conceptual models have their genesis in risk assessment frameworks (EPA 1992, 1998), environmental impact assessment approaches and systems analysis and diagrams (Odum, 1983).

The Conceptual model of the thesis is called as ‘Integrated Stream Daylighting Method’ (Co-MISDAL) which indicates the integration between social, cultural, legal, economic and environmental systems within urban system functioning. The model aims to provide mutual benefits for both riverine systems and urban areas in the context of this multi-systematic approach. The model also constitutes a basic platform to discuss and analyze former daylighting implementations in conjunction with theoretical background and recently developing approaches. According to the identified drivers and the developed response by societies the following third step (model development as a tool for implementation) takes its roots from the common outcome of previous processes which indicates the common approach of ‘Renaturalization’. The approach constitutes a basic for model structure and the modeling process begins with the question of ‘How renaturalization of riverine systems in urban areas should be planned, managed and implemented?’

At that point, the method of stream daylighting corresponds as an answer of this question and provides an implementation tool for proposed theoretical approaches (renaturalization) to realize the idea. However, according to the question, also the route and components of the planning and implementation process should be defined. Therefore, an instructive and comprehensive approach is required in terms of guiding possible stream daylighting implementations. Herein, according to case study assessments and literature reviews an inclusive approach is developed as a conceptual model structure, which provides the basis for the answer of ‘How it should be planned and implemented?’ and defines the major components, possible challenges and main steps of this process. The model is developed as a blending result of theoretical background and assessment of different case studies including different experiences. Therefore, it contains a comprehensive perspective of preparation, implementation and monitoring processes of stream daylighting implementations for renaturalization of riverine systems in urban areas.

The model consists of two main parts including planning process and model components. The first section includes phases of implementation and second part defines the main components.

In the context of planning process the stages of the project is defined under four titles: Pre-implementation, Feasibility Analyses, Implementation and Monitoring (Figure 4.18).

A. Pre-Implementation	B. Feasibility Analysis	C. Implementation Process	D. Monitoring /Maintenance
A.1. Defining the problems of the area (the entire catchment area) A.2. Determining the general (preliminary) scope of the project A.3. Monitoring Creek's water quality & biological communities at upstream/ downstream parts of the watershed (adopting the watershed approach within environmental aspect) A.4. Historical data review and using old maps as reference A.5. Measurements of channel morphology and stream bed A.6. Assessment of the overall situation of site (floodplain survey analysis)	B.1. Be aware of feasibility problems of former daylighting implementations B.2. Economical (cost-benefits) analysis and Technical Analyses (identifying the proper channel geometry which is difficult in highly urbanized areas) B.3. Identifying the need for land use (floodplain area) in terms of legal & technical aspects B.4. Defining the stakeholders & funding for the project through social & economic aspects B.5. Securing the confidence of neighbourhoods (social aspects) B.6. Determining the length of riverine system to daylight	C.1. Determining the scope, goal and workplan of the process C.2. Encouraging public participation and increase awareness level (publishing books, brochures, group meetings, live camera to upload the process on internet can be alternatives to use) C.3. Consider about (100-500) years storm peak flow (feasibility) C.4. Recapturing the original shape of the riverine system (as much as possible) and re-use of materials in stream bed C.5. Planting native vegetation and species which require minimum maintenance C.6. Forming a local organisation and working with a variety group of expertises (engineers, hydrologists, biologists, landscape architects, city planners etc.)	D.1. Coordination with local groups, universities, schools, students and youth groups D.2. Public participation in this process could decrease the project cost D.3. Vegetation structure could need time to adapt D.4. In order to increase public awareness and involvement field trips can be organized or educational materials can be prepared such as 'maps of disappeared rivers' for community D.5. Linking the project to a larger area development scheme or a master plan (if possible) or the implementation can lead to shape water policies (within legal aspect)

Figure 4.18 : The planning process phases of Co-MISDAL.

The first two phases consist of the actions that should be considered before the implementation. First of all, a field survey should be done including hydrological and physical analysis and observations of the site together with determination of the current problems. Secondly, feasibility analyses play an important role to determine the limits and the scope of the project including physical constraints, responsible stakeholder groups, economic analyses and coordination with legal background. During the feasibility analyses, the former challenges of previous daylighting projects should be considered and the feasible area to daylight, the length, implementation type and cost of the project should be defined. As a result of first two preparation phases, the implementation process starts with the determination of the framework and main goals of the overall project including a work plan. During the implementation, coordination between institutions, local groups, business, private sector and scientific groups play a vital role for the success of implementation. Especially involvement of public groups, residents and volunteers to the both planning and implementation processes is necessary for completion of the project. Moreover, several engineering and designing works took place in the site including improvement of aquatic habitats and vegetation. Also, reuse of materials for remediation of the site would provide cost benefits. The last process of monitoring and

maintenance constitutes one of the most important stages for the success of the implementation. In this process, participation of citizens and volunteer work provide mutual benefits to the project and local groups by decreasing the project cost and supporting the workers financially. This collaboration also provides the maintenance of the area after implementation with strengthen the social integration and increase awareness level of citizens.

The planning process highlights the route to follow since the preparation stage of the project until the maintenance of the implementation. In addition to this directive, the Co-MISDAL propounds a framework including a wide range of broad categories that should be considered during the planning process. The categories with their themes and sub-themes are determined according to the literature reviews and case study assessments as major components of a daylighting implementation with a focus on renaturalization. According to the framework, the broad categories consist of environmental, socio-cultural, economic and technical / practical aspects, which consist of 11 themes and 17 sub-themes. Overall themes and categories compose different dimensions of a successful daylighting implementation and renaturalization. However, as the model provides a basis and implementation tool for stream daylighting projects, it is required to measure the success of implementation or evaluate the performance of the activity in terms of determining the change as a result of the project. Herein, indicators for each sub-theme is identified in order to assess the success of the process and mainly selected to identify ‘healthy’ conditions of riverine systems in terms of ecological, socio-cultural legal and economic aspects.

Indicators can provide crucial guidance for decision-making and they can translate physical and social science knowledge into manageable units of information. In addition, they can provide an early warning, sounding the alarm in time to prevent economic, social and environmental damage. They are also important tools to communicate ideas, thoughts and values because as one authority (UN, 2001). In recent decades, indicator based models are developed (such as models of PCR by OECD and DPSIR by EEA) especially for sustainable development goals and this approach is adapted to environmental science with a focus on riverine systems by ‘Healthy Rivers Indicators’. The Co-MISDAL also based on healthy rivers indicators in both socio-economic and environmental aspects of a healthy system, which provides mutual benefits in terms of urban & riverine systems integration (Figure 4.19).

Conceptual Model of Integrated Stream Daylighting (Co-MISDAL)

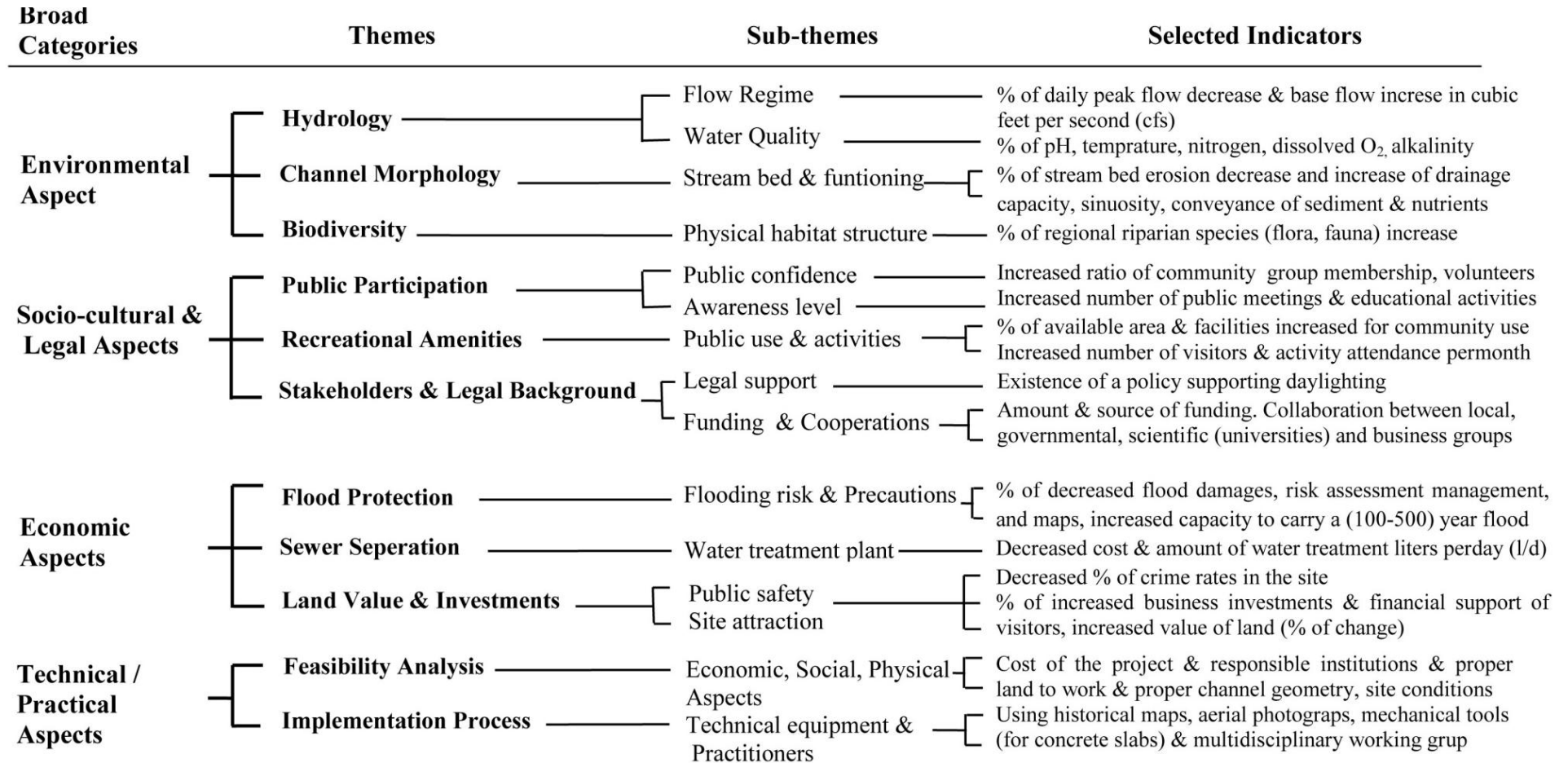


Figure 4.19 : The general framework of Co-MISDAL.

4.4 Summary of the Chapter

As a result of literature reviews in the first three chapters, the theoretical background of thesis is completed including the explanation of crucial functions of riverine systems in nature and significant alterations on their ecological and hydro-morphological structures due to population growth and damaging human activities by the time. The interrelated effects of social & natural systems are discussed in the context of human & riverine systems relationship, which is rapidly separated in urban areas and caused several problems on riverine system functions and structure. The overall effects of human activities on these systems are called as ‘urban stream syndrome’. Renaturalization of damaged riverine systems versus urbanization impacts is also discussed as a comprehensive improvement approach. At that point, the theoretical base of the study requires an implementation tool in order to realize developing concepts and approaches on the field. Therefore, ‘Stream Daylighting Method’ is assessed with its historical background and implemented case projects for a better understanding of the method and its scope in the fourth chapter. In addition to the method assessment, also an integrated conceptual model is developed with a broad range of improvement aspects of stream daylighting implementations considering renaturalization of buried riverine systems especially in urban areas.

The method mainly focuses on culverted riverine systems, which are buried in to pipes or covered with impervious surfaces for economic benefits or land reclamation issues. According to Paul and Meyer (2001), the process known as stream burial (where streams are directed into culverts, pipes, concrete-lined ditches, or simply paved over) is probably the most extreme impact of urbanization on streams. It results in the destruction of natural stream channels and contributes to downstream habitat degradation, aquatic habitat fragmentation, enhanced transport of water and toxic contaminants, and reduction of ecosystem services such as nutrient and sediment retention (Walsh et al., 2005). Because they constitute the largest fraction of stream length and are the most economically feasible to bury, the smallest streams are among those most affected by urbanization (Elmore and Kaushal, 2008). Herein, the newly emerging science of urban stream daylighting is a distinctly valuable and viable tool in such a future. By taking the stream out of the concrete channel, daylighting allows for infiltration, and it improves downstream water quality by

removing pollutants from the water. Wildlife habitat, as well as eye-pleasing green space, is expanded through creek daylighting (Brzozowski, 2010).

In order to understand the daylighting concept in depth, several case studies are selected from scientifically approved sources and chosen ten projects are compiled according to their general features as a first step. Following this assessment, the implementations are analyzed and discussed under eight key themes, which highlight the crucial points of each project. As a result of case study assessment, the variety of stream daylighting implementations is seen clearly in terms of their main challenges, problems, implementation types and primary objectives within different scopes and results. The assessment provides the common platform for data and experience sharing on daylighting activities and enables to form a comprehensive approach about improvement of buried riverine systems in urban areas. From this point of view, including the whole data of theoretical framework and case study assessment a comprehensive conceptual model is developed as a complementary component of thesis research. The model is designed as a basic tool for understanding, planning and management of damaged riverine systems especially in highly urbanized areas with a focus on buried systems, which require urgent solutions for their deteriorated structures and functioning.

In the context of Conceptual Model of Integrated Stream Daylighting (Co-MISDAL) basic categories of a holistic daylighting, approach is determined under four main titles: Environmental, Socio-cultural & legal, Economic, Technical / Practical Aspects, which are composed of several themes deduced from overall research and case study assessments. The themes represent the main components of the model that should be primarily considered during the project planning and implementation processes. Similarly, identified sub-themes guide the project to reach the 'healthy' status of renaturalization act. At that point, the model needs to measure the health of current situation and ongoing process to compare with the result of implementation. Therefore, indicators are developed for the measurement of conceptual aims in a numerical way

As a result of the fourth chapter, the first three theoretical chapters of thesis is combined with the assessment of former daylighting projects (case studies) and resulted with an integrated conceptual model, which contains the essential elements for a successful daylighting implementation with a focus on renaturalization issues.

Herein, healthy rivers approach guided the model structure to assess each important factor for a healthy riverine system in urban areas (social, economic, legal, environmental factors) and the indicators of the model is developed in the context of overall interferences of theoretical background and project assessment phases of the thesis to measure the success of the activity on field. The entire process is schematized in (Figure 4.19).

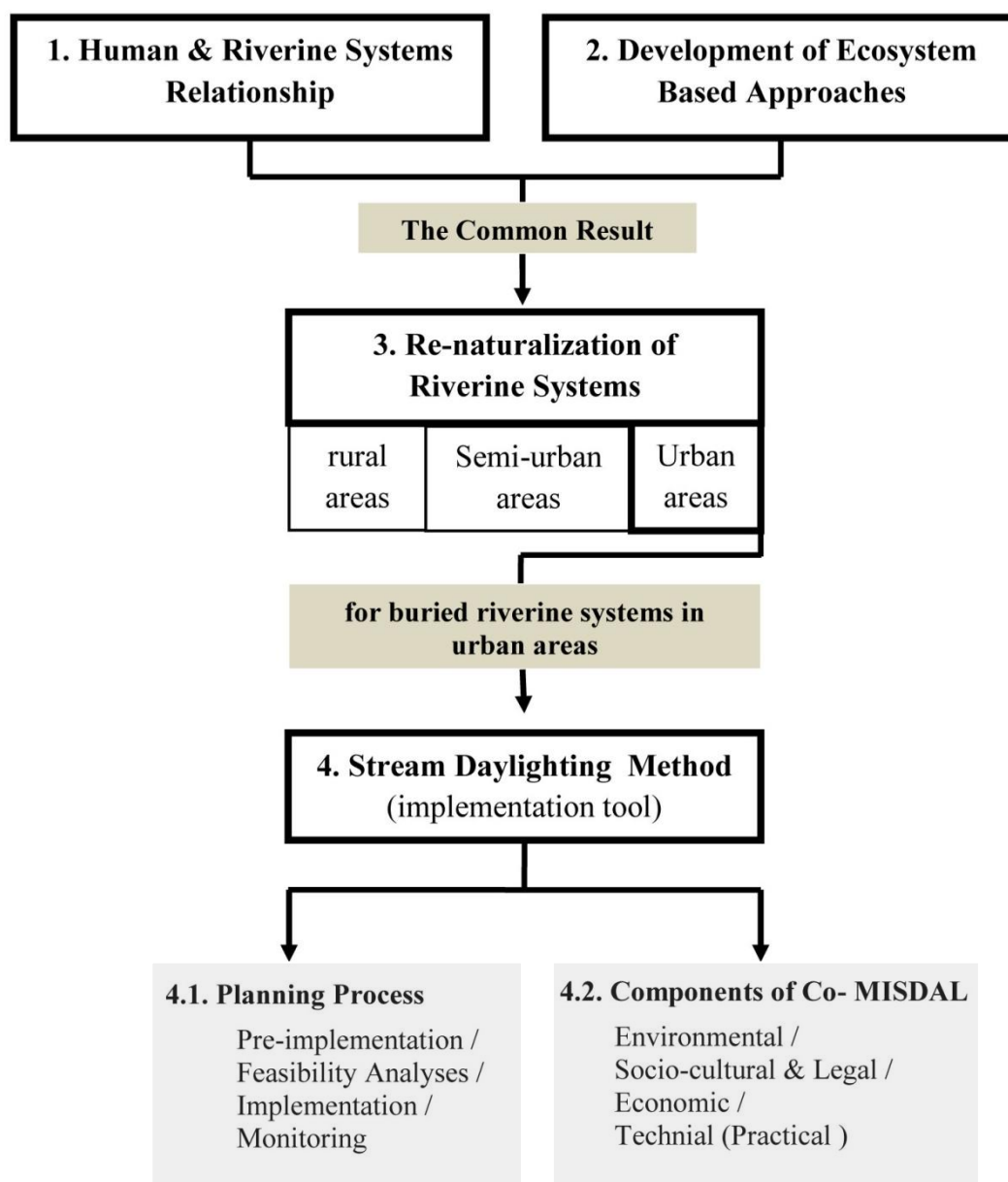


Figure 4.20 : Flowchart of the model development process.

5. INTEGRATION OF ‘CO-MISDAL’ ON AYAMAMA STREAM IN ISTANBUL

In the context of thesis, the ‘Stream Daylighting’ method is assessed in terms of renaturalization of buried or culverted riverine systems in urban areas. During the research process, in addition to literature reviews about relevant technical terms (USS, healthy rivers, renaturalization, stream daylighting etc.) including the background of human & riverine systems relationship, recent situation of riverine systems within the increasing impacts and pressures of human activities is also discussed. As a result of overall discussions, analysis and explanations in the first four chapter, a comprehensive conceptual model is developed and it is designed as a common platform for data and experience sharing among different daylighting implementations from different countries. The model also includes a broad perspective about riverine systems in urban areas including positive (the role and functions of riverine systems as a part of urban ecosystem) and negative (urbanization impacts on these systems) interactions between these two systems.

From that point of view, as a practical section of the thesis research, a case study area is selected in terms of empirical analysis of developed model and conceptual framework. In this sense, the case of Ayamama Stream in Istanbul is selected due to its critical and problematic situation in a highly urbanized area. Typically, many riverine systems in Turkey are under the pressure of human activities in a wide range of industrial, commercial, engineering, land reclamation etc. issues. In recent years, increased flood problems and damages led societies to be aware of the existence of riverine systems in urban areas as an entirely living system. Accordingly, several precautions have taken through some rehabilitation projects on riverine systems, which mainly focus on morphological alterations on streambed to increase the canal capacity to carry floodwaters.

One of these implementations are carried in to practice on Ayamama Stream in European part of Istanbul which was recently struck by a huge flash flood in 2009 (after 2002 and 1999 floods) causing severe damage to men and materials.

Following to the 2009 flood, Istanbul Metropolitan Municipality (IMM) and Istanbul Water and Sewerage Administration (ISKI) had taken action and initiated rehabilitation project of Ayamama Stream with a main goal of enhancement of the section width and streambed capacity of the stream. The project also aims to direct industrial discharges to drain in to Ataköy Waste Water Biological Treatment Plant by collectors. The reclamation work is introduced in 2011 by the mayor of Istanbul Metropolitan Municipality and the first phase is projected to finish in June, 2012 (ISKI, 2012).

Herein, the efforts to improve the status of Ayamama Stream demonstrate an example for the limited perspective of riverine systems rehabilitation / restoration projects in Turkey, which solely focus on only, water quality issues, alteration of channel/ streambed capacity or aesthetic concerns. As a result of those unidirectional approaches, permanent solutions and stable conditions cannot be realized in long term in terms of riverine and urban systems integration. Hence, the efforts with lack of a comprehensive approach including social, economic and environmental aspects of urban riverine systems result with limited and temporary solutions without improving the system integration and improving ecological status of riverine systems.

Consequently, Ayamama Stream is selected as a case study area of thesis research for several reasons:

1. Ayamama Stream encompasses 6676 hectares of basin area with 21 kilometers (42 km with tributaries) length in a highly urbanized part of Istanbul. “That means a broad area of natural riparian vegetation including aquatic habitats and species is under the pressure of urbanization.”
2. The catchment area consists of different patterns of land use including industrial, commercial, military, urban agricultural and settlement areas together with urban facilities (education, health, administrative units etc.). “The pluriformity of land use and their interactions cause various human activities and their impacts on riverine system to increase.”
3. The watershed area of Ayamama Stream is fragmented horizontally by two important highways: TEM (Trans-European Motorway) and D-100 (E-5) with a longitudinal link between them: Basın Ekspres Road. “This dense transportation

pattern of the area provides opportunities for business investments that increase the pressure on stream system.”

4. The Ayamama Stream flows through 6 districts and 28 neighborhoods with a dense population pattern in western part of Istanbul. “Different administrative units in watershed of Ayamama Stream necessitate a collaborative approach for planning and management of the stream including the control of the anthropogenic pressure.”

5. Considerable changes on land use and spatial pattern can be observed in the catchment area of Ayamama Stream between the period of 1950’s and 2012. “The development process of area demonstrates the lack of legal background and inaccurate decisions about streambed protection and improvement.”

6. Significant floods have experienced on Ayamama Stream in 1999 and 2009 with major damages of people deaths and economic losses. “The influence quantity and area of flood damages indicate the size of human interference on stream structure including the densely constructed buildings around the Ayamama Stream and its watershed area.”

In this chapter, physical and social characteristics of Ayamama Stream is described with general land use patterns and population structure of the area. As the temporal development process, land use and spatial changes of catchment area are compared in the context of four different time periods. In addition to general characteristics and development process of the site, major problems of Ayamama Stream and its watershed are discussed through the prepared synthesis maps including the data of land use, transportation, flood risk and human intervention on Ayamama Stream. As a result, the integrated model of Co-MISDAL is re-designed for adaptation to the case study area according to proper features of the Ayamama Stream and its watershed.

Hence, 1) definition of general properties and characteristics of the area 2) description and analyses of current situation and major problems of Ayamama Stream 3) development of comprehensive and permanent solution alternatives for watershed area of Ayamama Stream is aimed to reach as a result of this chapter.

5.1 Physical Structure of Ayamama Stream and Its Watershed

The Ayamama Stream is in the north-western part of Turkey in the Marmara Region, which rises from the eastern part of Başakşehir district. The stream has a basin area of 66,76 km² and 42 kilometers (21 km mainstream) length including 8 tributaries and 8.5 kilometers between TEM (Trans-European Motorway) and D100 highways (Figure 5.1) (Saral, 2010). The stream flow has a north-south direction and discharges into the Marmara Sea in Bakırköy district (Einfalt and Keskin 2010).

There are various prospects about the origin of the name of ‘Ayamama’ which has a possibility to derive from ‘Αγία Μαριά’ that means ‘mother mary ‘of Jesus (Url-20, 2012).

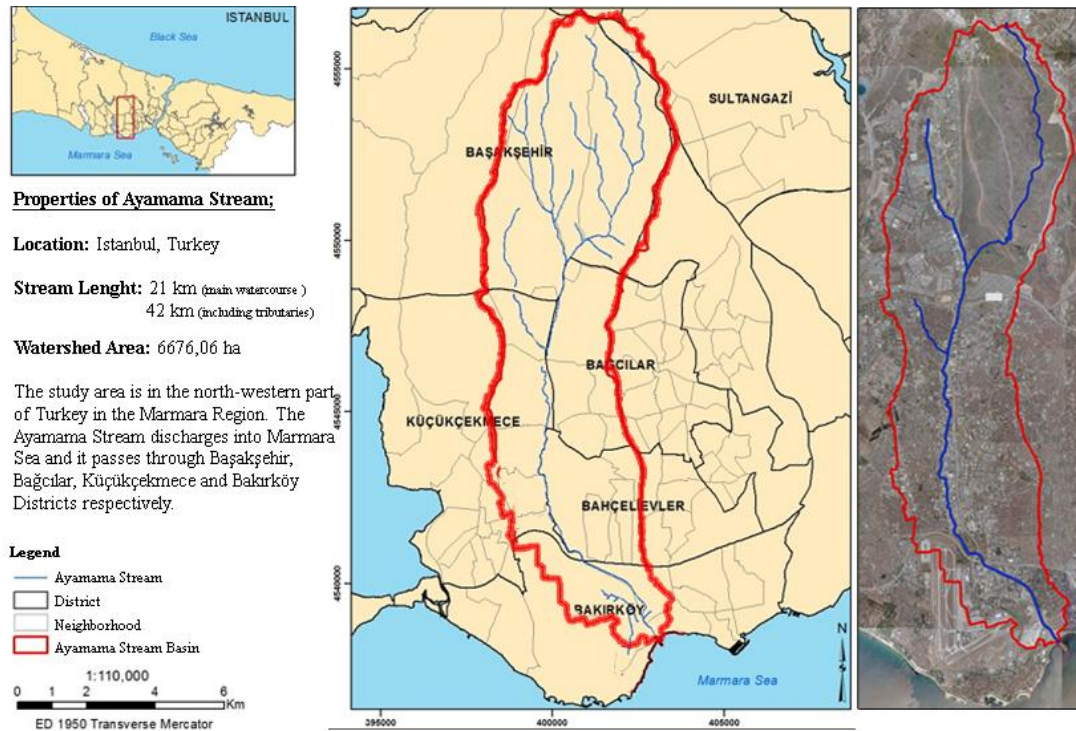


Figure 5.1 : Location of Ayamama Stream and its watershed (Generated from ‘Ayamama River Basin’ by Alejandro et. al., 2011).

The basin has an average slope of 6.94% and the concentration time for the basin is about 7-11 hours (Saral, 2010). According to Einfalt and Keskin (2010), the concentration time decreases with resulting higher peaks in floods. Also, the average elevation of the watershed area is 86, 64 meters and the elevation decreases through the streambed at downstream sections. In addition to elevation and slope analysis,

sub-basins of the watershed and soil classification of the area are also demonstrated in the (Figure 5.2).

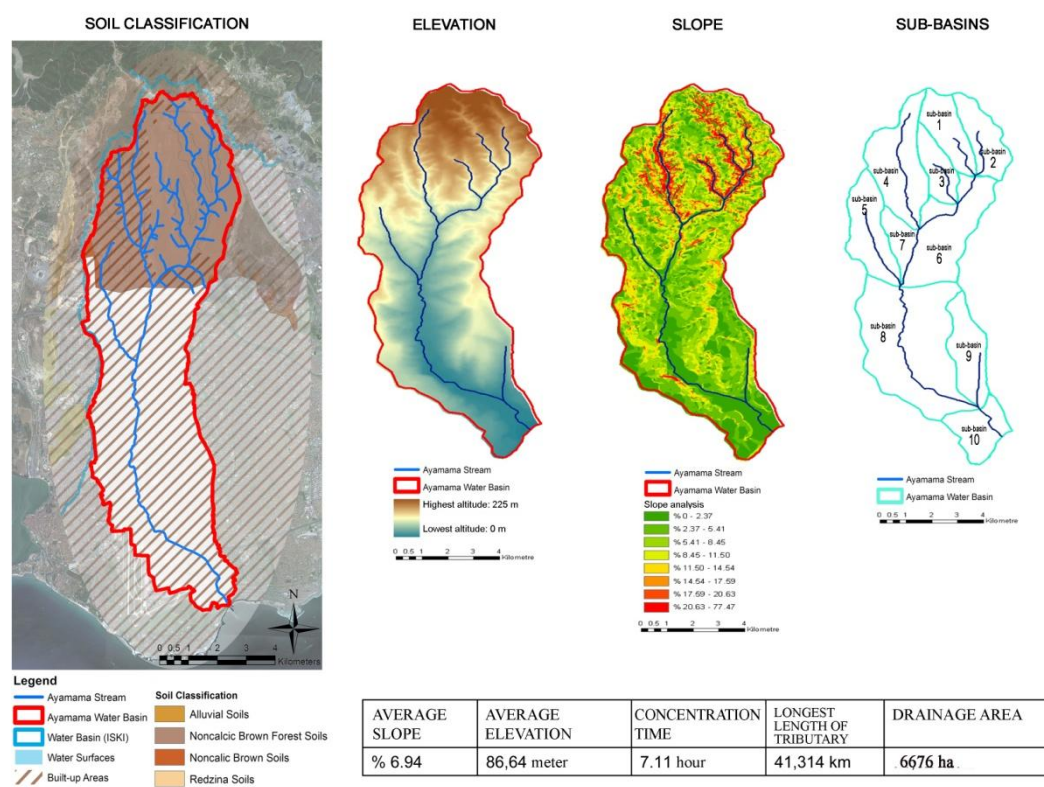


Figure 5.2 : Physical characteristics of Ayamama Stream and its watershed (Generated from ‘Watershed Characteristics of Ayamama Stream’ by Yucel, 2010).

As the entire watershed covers a wide range of area, it encompasses different land use patterns. Accordingly, the Ayamama Stream flows through in a highly populated and urbanized area in European side of Istanbul, which includes different patterns of human facilities. In this context, general land use in the catchment area of Ayamama Stream consists of different land use patterns including industrial, commercial, residential, military areas, urban facilities (education, sports areas, health units etc.), urban green areas and barelands. This multifarious structure of land use in the basin occurred as a result of constant development in the area, which primarily began with road constructions and precipitated with business and tourism investments. Also the, migrations rates increase residential units including squatter settlements. As a general overview, the land use characteristics of the area mainly consists of three main patterns including industrial areas, residential areas and military areas which encompasses the majority of the land surface in the watershed.

Moreover, an active transportation network between TEM, E-5 and Basın Express Roads overlaps with the watershed area of Ayamama Stream. These important highways are constructed in east-west direction that connects the Europe and Asia continents through the Bosphorus Bridges, and have a dense traffic load. Throughout the overall land use pattern in the watershed, it can be seen that transportation linkages are improved in the area and industrial areas compact with residential and the other functions (Figure 5.3).

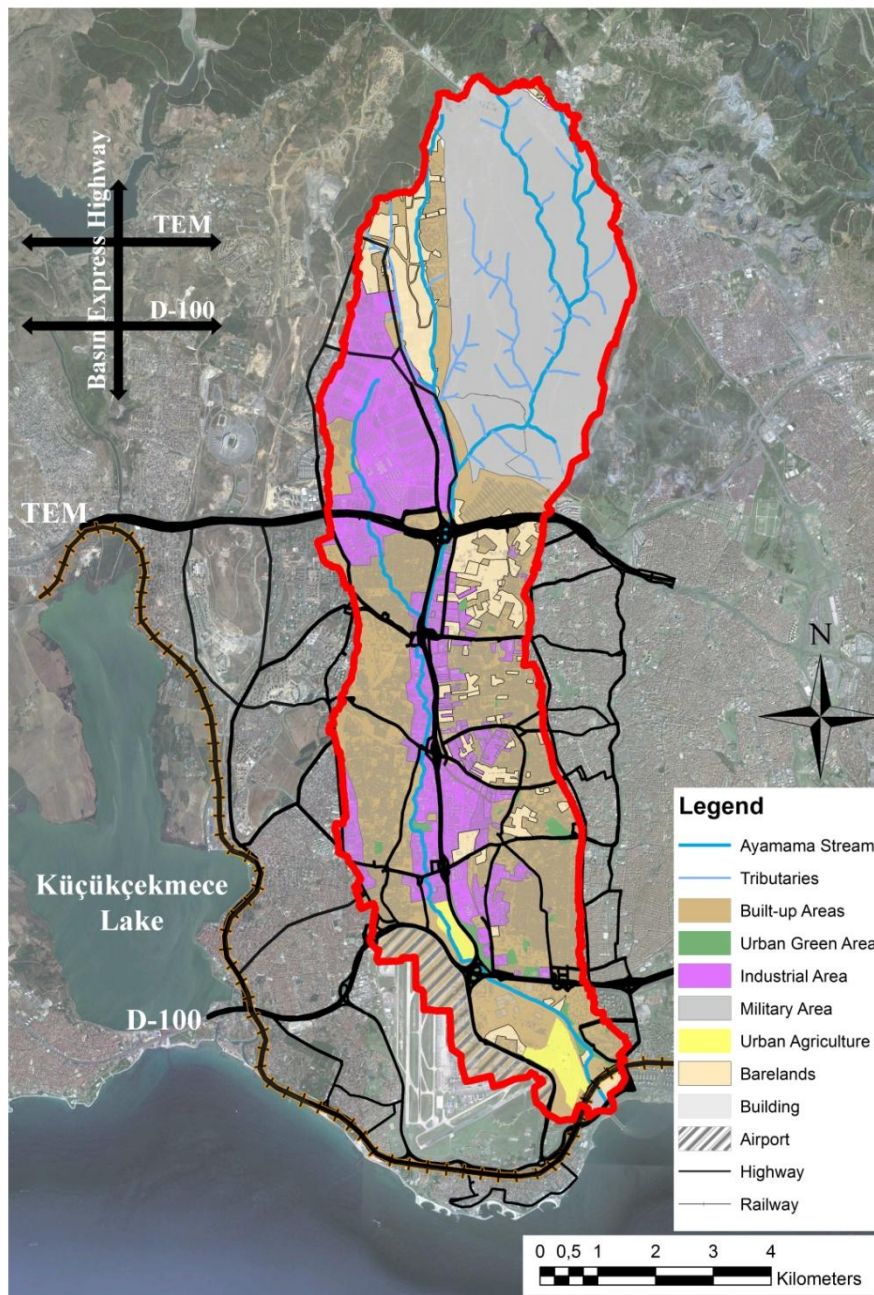


Figure 5.3 : Land use characteristics of Ayamama Stream and its watershed.

5.2 Social Structure of Ayamama Stream and Its Watershed

The watershed of Ayamama Stream is located in Istanbul, the most crowded city in Turkey with a total population of 12 915 158 inhabitants (TurkStat, 2010). Throughout the catchment area of Ayamama Stream, the basin encompasses 28 neighborhoods and 6 districts which are Bağcılar, Bahçelievler, Bakırköy, Başakşehir, Küçükçekmece, and Sultangazi (Figure 5.4).

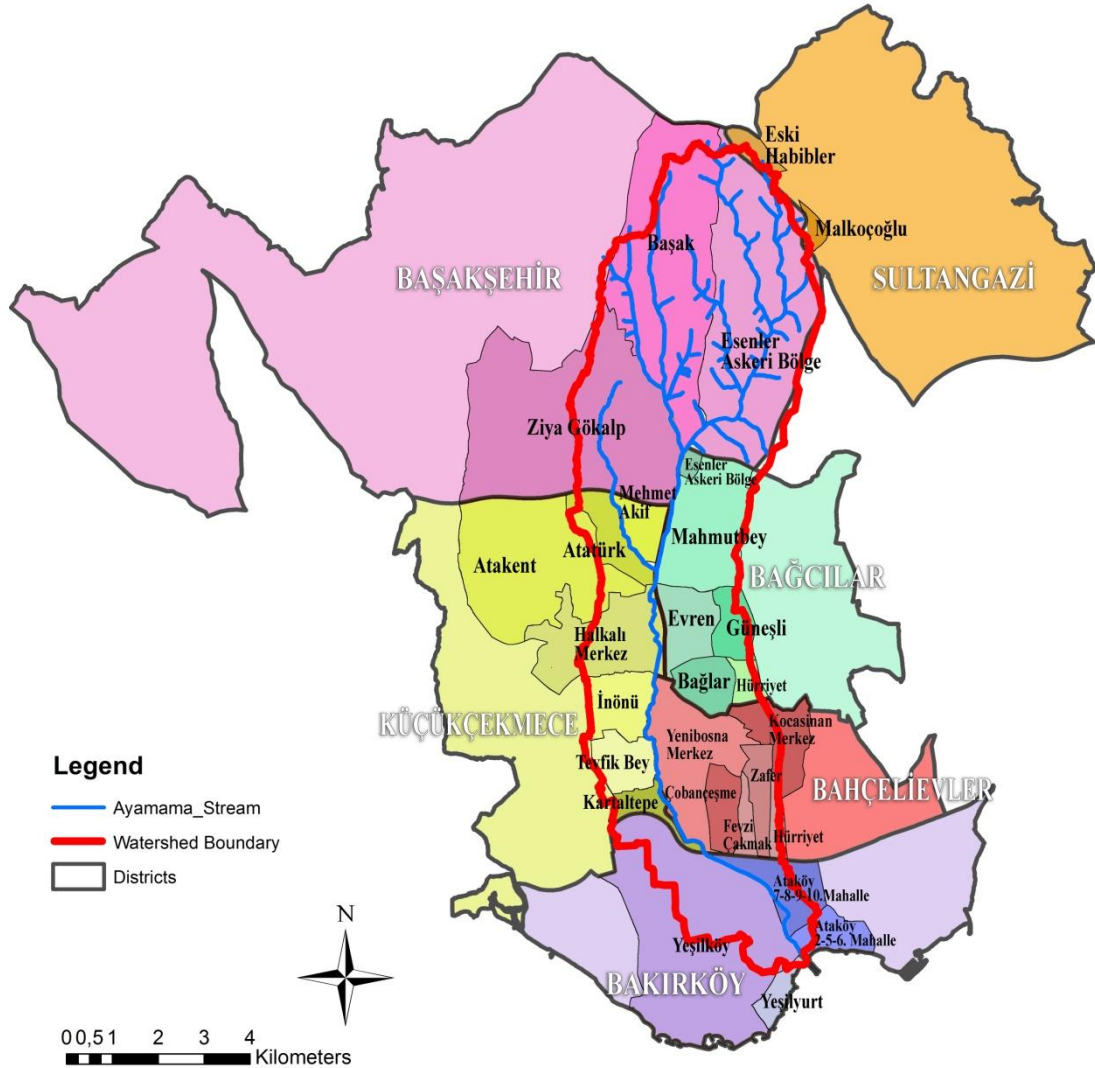


Figure 5.4 : Administrative structure of Ayamama Stream and its watershed.

Ayamama stream goes through a line of these districts starting from Başakşehir, continue in Bağcılar, Küçükçekmece and Bahçelievler, reaching Bakırköy which is one of the most crowded districts of İstanbul.

Bakırköy had legally become a district in 1926, which had the largest surface area as a district in Istanbul until 1989. Firstly, in 1987, Küçükçekmece is separated from Bakırköy and became a district. Accordingly, Bahçelievler and Bağcılar splitted up in 1992 and the population and area of the Bakırköy district decreased with these separations (Url-20, 2012).

Küçükçekmece district is located at the west side of Istanbul, east of Küçükçekmece Lake, among E-5 and TEM highway. At the west part of the district, it is located Küçükçekmece Lake, at the southeast part of the district, it is located Atatürk Airport and at the north part of the district, it is located Başakşehir district. At the east part of the district, it is located Basın Express way and Ayamama Stream flows through the eastern part of the district. Küçükçekmece district had become a district at 1989 and up to 2009 Başakşehir was a quarter in Küçükçekmece district. In 2009, Başakşehir splitted up from Küçükçekmece and had become an independent district (Aydın, 2012). The northern parts of Başakşehir is covered with forests with a rich biodiversity and Sazlıdere Dam reservoir is also located in the district. In addition, Ayamama Stream rises in Başakşehir.

Bahçelievler and Bağcılar districts which are located between two major roads TEM and E-5, also separated from Bakırköy and the population of each district increased rapidly around 1960's due to migration. Specially Bağcılar has been urbanized within the last decades and the district became one of the densely populated districts in Istanbul including illegal buildings and squatter settlements.

Population within Ayamama River basin was approximately 799,556 inhabitants in 2006 (IMP, 2006). According to TurkStat (2010), total population of 28 neighborhoods in the catchment area is calculated as 1.591.265.

The population and illiteracy rates of residents in 28 neighborhoods in the Ayamama Stream catchment area is determined in order to assess the size and amount of pressure generated by population density on the streambed (Figure 5.5). In addition, the criteria and measures of illiteracy are important in terms of public awareness and involvement to conservation and improvement efforts for riverine systems. Illiteracy indicates the percentage of inhabitants older than 6 years old who know how to read and write. According to the analysis, the higher the percentage of people in the area

is illiterate which will be a positive driver for public education and supports the idea of public education and participation.

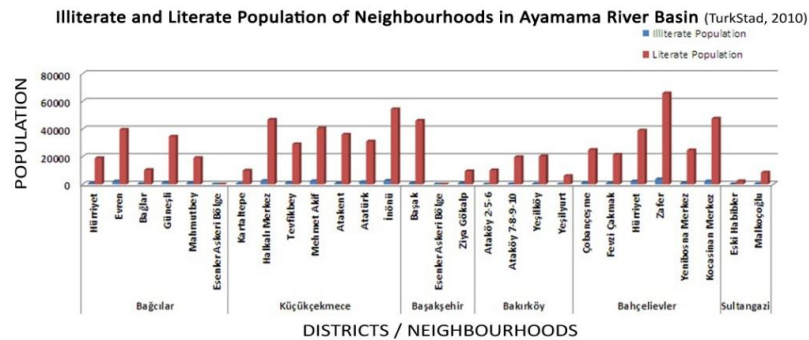
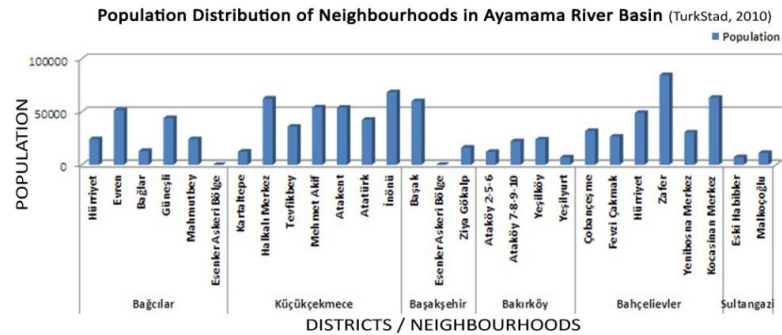
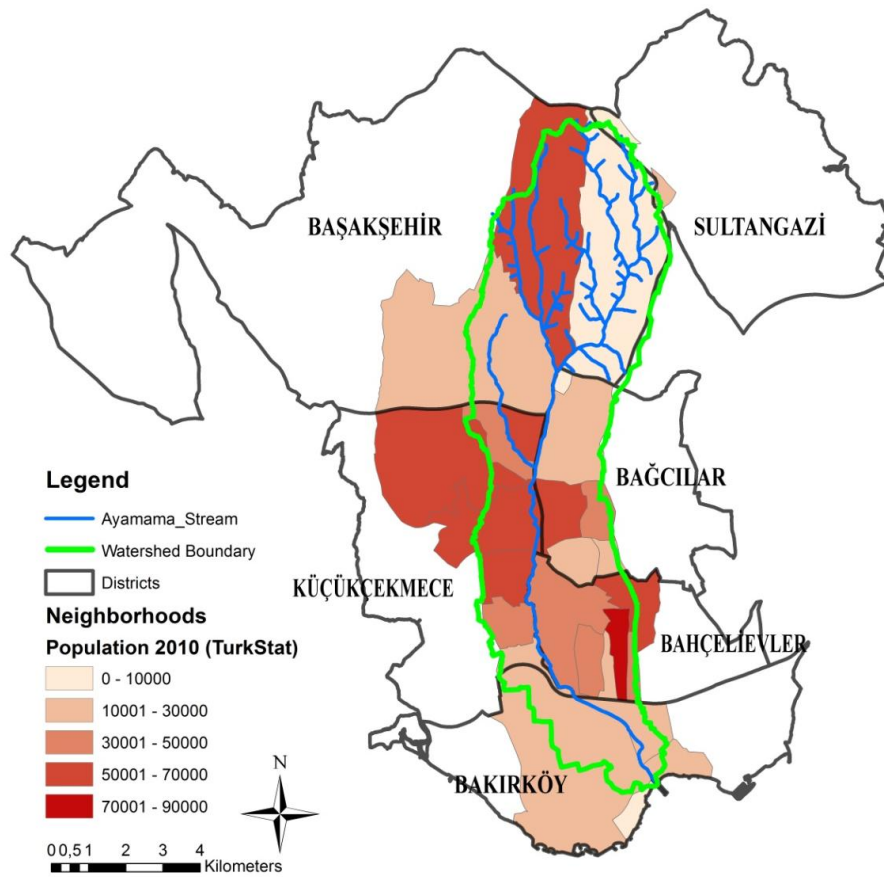


Figure 5.5 : Population density and illiterate rate of neighborhoods in watershed area

5.3 Development Process of Study Area

Almost all major cities around the world have rivers that run underneath their impervious surfaces. However, in recent years, the importance of riverine systems and their healthy functioning within urban ecosystem are realized and the stream corridors are developed with recreation facilities along their sides. Unfortunately, this is not the case in Turkey. Although, there are some successful cases such as Eskişehir and Adana many other cities disregarding the existence of their riverine systems. Especially the rivers that flow in Istanbul are exposed to several pressures due to dense urbanization pattern.

Istanbul is Turkey's most crowded city, located at the Bosphorus and linking Europe and Asia with a population of 13.624.240 (TurkStat, 2012). Besides, it has a high tourism potential with its historical places and cultural heritage. Historically, as an international junction point for land and sea routes, Istanbul is the center of the Turkey's economic life. The region is highly populated with fast urbanization and industrialization in recent years. Especially due to the migration from rural parts of Turkey, the land use pattern of the city has changed and impervious surfaces increased rapidly. Over time, riverine systems are buried, forest areas decreased and these parts started to be used as settlement areas, which cause several problems for the city such as flood risk. The flood event of Ayamama Stream in September 2009 constitutes a good example for the effect of land use change specifically on flood events (Einfalt and Keskin 2010).

Ayamama Stream as one of the degraded riverine systems in Istanbul has been under development for over 15 years with many new constructions and facilities. Evidently, many settlements, industrial and commercial facilities including newly built shopping centers have been built ignoring the protection zone along the both sides of the river. On the other hand, the upper part of the basin is less inhabited since these neighborhoods are not completely urbanized and still have natural land cover. The area where the basin is located has experienced a process of rapid land cover change in the last decades: bare soil areas, grasslands and shrubs (some of them still present in the upper part of the basin) have been progressively replaced with built-up areas designed for densely residential and industrial uses (Kaya and Curran 2006). This has been reported to constitute a threat since many of the industries located along the

Ayamama River throw part of their wastes to the river, and people do the same with their solid garbage. There is no specific information about the increase in built-up areas for this area; however, for Istanbul, it has increased in 126.7% between 1987 and 2001 (Kaya and Curran, 2006).

5.3.1 The period before 1950's

Until the 1950's Ayamama Stream was a popular recreation area with its clean waters and recreational opportunities including vast agricultural lands around the riverbed. The catchment area consists of barelands and agricultural facilities including orchards. Also the river itself was the meeting point of Ottoman army before military expeditions (Erez, 2009). During the Byzantine and Ottoman Periods the catchment area of Ayamama Stream was used as a public open space without built-up areas. This land use patterns also continued in Republic period of Turkey till 1950's (Figure 5.6).

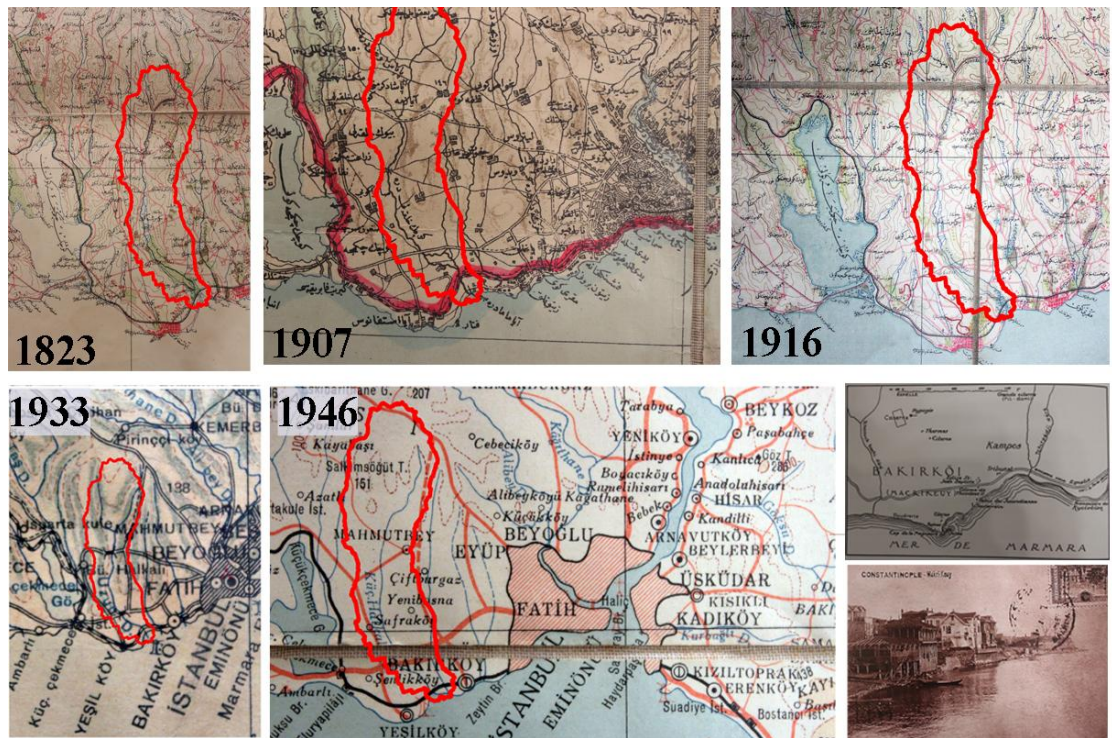


Figure 5.6 : a) Development Process of Ayamama Stream and its watershed b) The old map and postcard of Makriköy (Bakırköy) in 1920.

During the Byzantine times Bakırköy where the Ayamama Stream discharges, was a separate community outside Constantinople, a well-watered pleasant seaside retreat from the city, and was called Hebdomon. Later the place was also named as

‘Makrohorı’ (long village), which was adapted to Makriköy in the Ottoman period, when many large houses were built here. In 1925 the ancient denomination was changed to Bakırköy (Copper village) because of the law which imposed to eliminate all place names of non-Turkish origin. Since the 1950’s Bakırköy has grown considerably. (Url-20).

5.3.2 Between 1960’s and 1980’s

In the republic period of Turkey (1920’s) due to increased trade relations with Europe, the railroads are viewed as insufficient transportation lines and main roads had started to be constructed. In addition to the road of ‘Londra Asfaltı’ (London Asphalt) as one of the important roads, which is built in these years, a new state highway is constructed in 1960’s to sustain the transportation in east-west direction. This road called ‘E-5’ or recently named as ‘D-100’ constitutes a link between the cities Ankara, Istanbul and Edirne through the First Bosphorus Bridge which is completed in 1973 and connects the continents of Europe and Asia.

Following to these developing transportation linkages, construction of ‘E-80’ Highway, also called as TEM (Trans-European Motorway), which connects 10 countries with a route extending from Lisbon, Portugal to Gürbulak, Turkey on the border with Iran, is began in 1970’s. The 71 km section of the road passing through the Istanbul is completed in early 1980’s. The TEM also links Europe and Asia through the Second Bosphorus Bridge which is completed in 1988 (Figure 5.7) (Url-18, 2012). This rapid growth of transportation facilities in this period have initiated for future developments in the watershed area. Also, the district of Bakırköy became a popular residential area in the late 19th century after the construction of a railroad connection to Istanbul (Figure 5.8).



Figure 5.7 : 1/25000 scale map of Turkey in 1972 (General Command of Mapping).

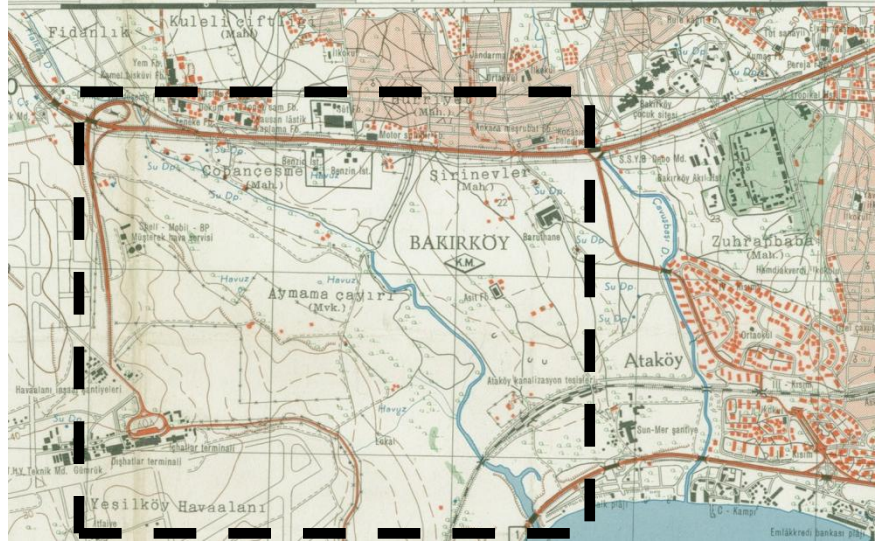


Figure 5.8 : Ayamama Stream in Bakırköy at 1/25000 scale map of Turkey in 1972.

5.3.3 Between 1980's and 2009

As one of the major roads of Istanbul, TEM is completed in early 1980's (1983-1986) and thrown open to the public in 1986 (Figure 5.9) (Url-18, 2012). According to the constructions of First and Second Bosphorus Bridges with the link roads of E-5 and TEM, density of transportation network and the capacity has enlarged and developed steadily. The construction of roads also brought populations and investments to these areas including new opportunities for development projects such as business, commercial, industrial and residential areas. As one of the results of this development process, the Basın Express Road (Mahmutbey-Yeşilköy Link Road) is constructed in 1980's to sustain the link between two highways TEM and E-5. Thus, the completion of triple transportation axes in this area led to rapid land use changes in the watershed of Ayamama Stream and caused significant alterations on streambed morphology. On the other hand, during the construction of Basın Express Road the entire watershed except from Yenibosna, Güneşli, Mahmutbey, İkitelli and Halkalı rural areas was covered by agricultural lands, whilst after the construction built-up areas have increased rapidly instead of agricultural areas (UCTEA, 2009). In 1990's, industrial estates, commercial centers and media services moved to the area and precipitated the future growth of dense agglomerations of industrial, commercial, residential and urban facility units (Figure 5.10). The area has become industrial and crowded with huge housing projects which still going on and is indeed accelerated as the TEM motorway to Europe passes through.



Figure 5.9 : Construction of TEM in 1982 (IMM, 2012).

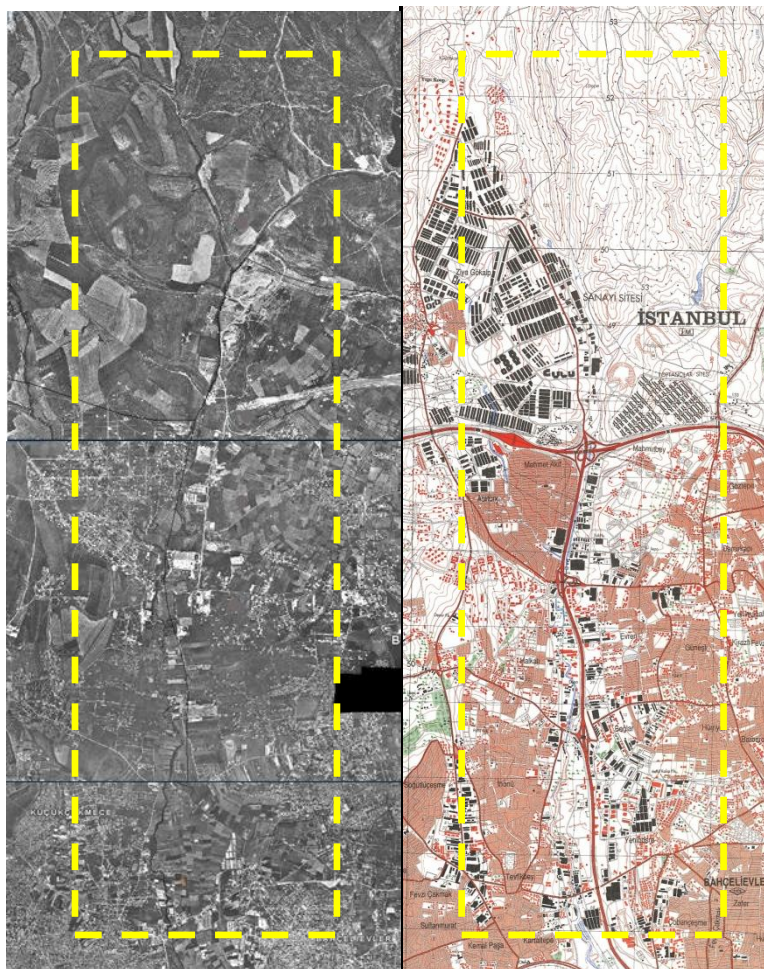


Figure 5.10 : Land use changes between 1982 and 1997 (IMM & General Command of Mapping).

5.3.4 Recently planning projects and land use (between 2009-2012)

Istanbul Environmental Master Plan (1/100000): Istanbul Municipal Commission adapted the new environmental design plan in 2009 drawn to a scale of 1:100.000, which will be the source document for all investment decisions and plans in the metropolis. Transportation decisions that has effective role in macroform development of Istanbul, is seen to be decisive also in the development of Kucukcekmece district. E-5 and TEM highway are the most important factors affecting the development of the district. At the eastern border of the district today, the industry began to evolve into service, also Basın Express way is located there. At Istanbul Environmental Master Plan, this axis is defined as an area of the CBD (Central Business District) interaction (Figure 5.11) (IMP, 2010).

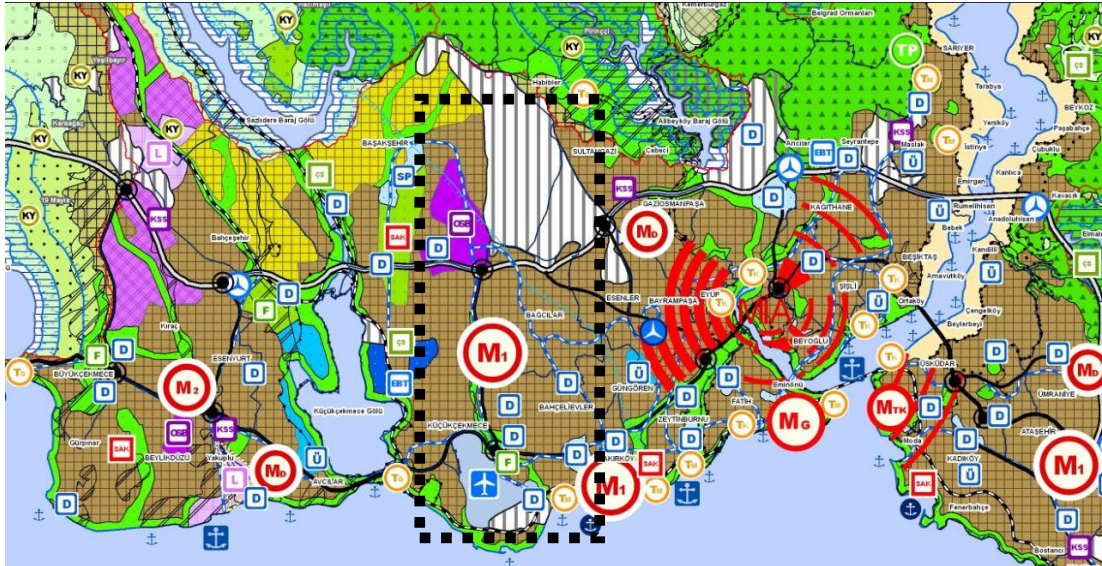


Figure 5.11 : Istanbul Environmental Master Plan (1/100000) (IMM, 2009).

Istanbul Metropolitan Planning Centre (IMP) - The Transformation Project of Airport Transportation Axis from Industrial to Service Area (Havaalanı Aksı Sanayiden Hizmet Alanlarına Dönüşüm Projesi): The study area of the project is defined as the Basın Express Link Road and its surrounding area which has a critical location with linking two main highways (TEM and E-5) of Istanbul and close to Atatürk International Airport. This important property of the area brings the potential of a business and activity centre with providing an attraction point for the city. The projects aims to prove the integrity of land use patterns in the area together with increasing recreational areas and facilities. In the 1/25000 scaled Master Plan, the area is defined as one of the ‘25 Special Planning and Special Project Areas’. The

area is called as ‘The Special Project Area of Media Road High Level Centre (Medya Yolu Üst Düzey Özel Proje Alanı) with an area of 1160 ha (Figure 5.12).

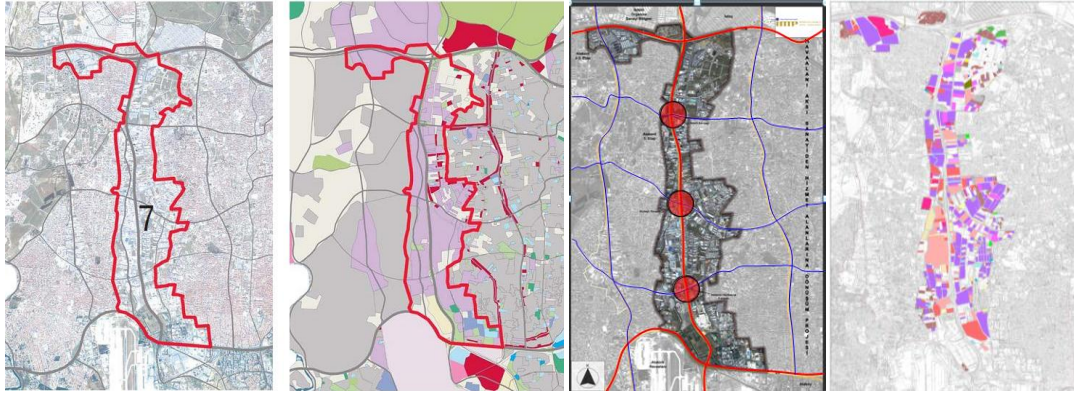


Figure 5.12 : IMP- The Transformation Project of Airport Transportation Axis from Industrial to Service Area.

Istanbul Metropolitan Municipality (IMM) - The 1/5000 scaled Master Plan of Yenibosna Media Axis (Yenibosna Aksı 1/5000 ölçekli Nazım İmar Planı): The study area is defined as the Yenibosna Axis which is included in Başakşehir, Küçükçekmece, Bağcılar, Bahçelievler and Bakırköy districts with a planning area of 310 ha. The plan is proposed in a coordination with Istanbul Environmental Master Plan at 1/10000 scale and the Transformation Project of Airport Transportation Axis from Industrial to Service Area which is defined at 1/25000 master plan. The Yenibosna Axis Master plan at 1/5000 scale is prepared by IMM in 2012 and provides a complementary tool for implementation of planning decisions at 1/100000. The plan supports the transformation approach (from industrial to service area) with a mission of creating a regional service area with a focus on ‘urban design’ including creating recreational, open green areas in this newly determined CBD. In this context, the Ayamama Stream is designed as an open and green corridor, which provides recreational opportunities. The report of the plan is prepared with the physical and social structure analysis of the area including the development process of land use (Figure 5.13). The plan mosaic of the study area consists of eight master plans at 1/5000 scale.

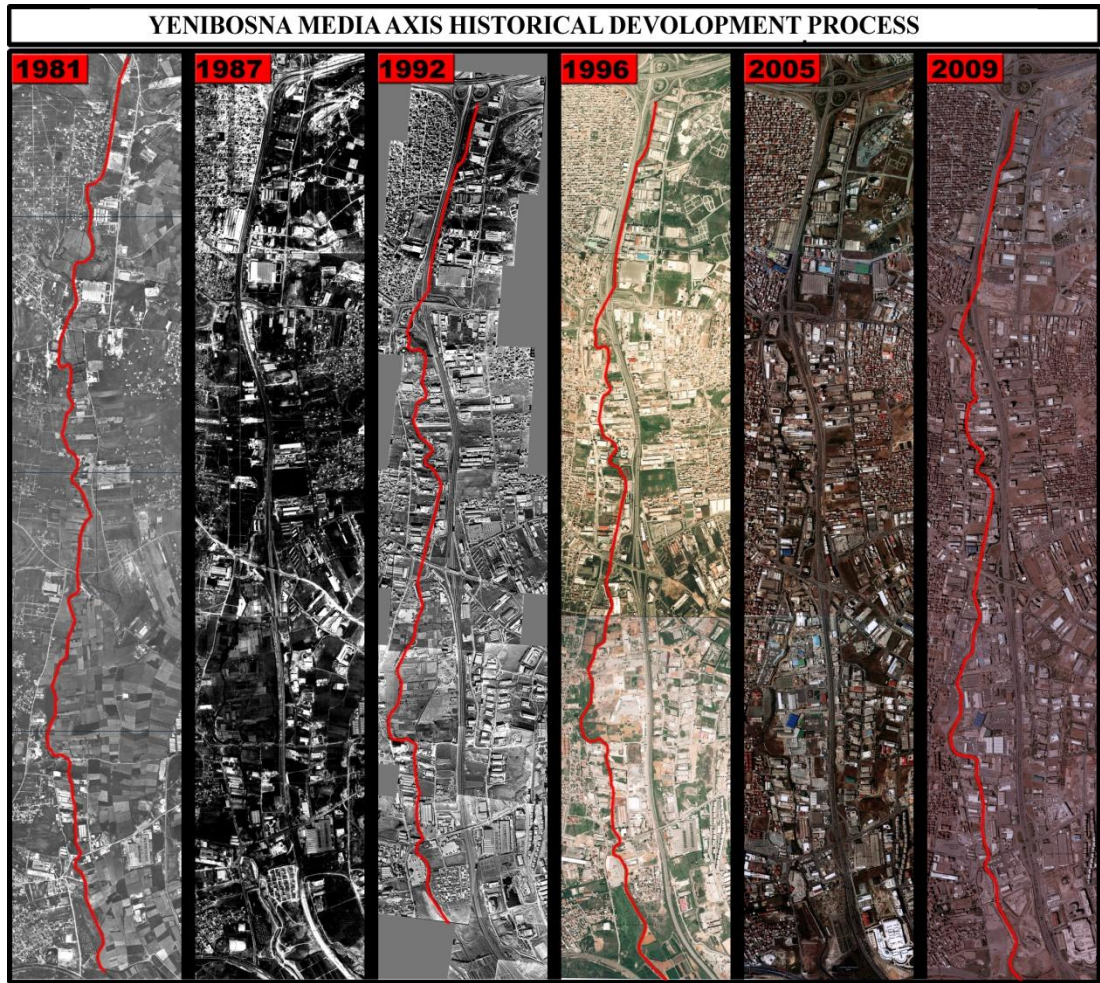


Figure 5.13 : Yenibosna Media Axis Historical Development Process (IMM, 2012).

Two of these plans are, Bahçelievler Yenibosna Kocasinan Master Plan confirmed in 20.01.2008 and Yenibosna Master Plan which is confirmed date of 02.12.1981 and contains urban green areas that is shown in number 1, graveyards at number 2 and plantation area in number 3 (Figure 5.14).



Figure 5.14 : Yenibosna Media Axis Historical Development Process (IMM, 2012).

On the other hand, Istanbul Water and Sewerage Administration (ISKI) also take the action of Ayamama Stream Rehabilitation Project which is started in 2008 and accelerated with the 2009 flood. The project mainly focused on reducing the flood risk through enlargement of the cross-sections of streambed in cross-roads (Figure 5.15). In addition, industrial discharges are planned to convey to Ataköy Waste Water Biological Treatment Plant by constructed collectors. The project is introduced to media by the mayor of Istanbul Metropolitan Municipality in 2011 and the project is in the ongoing process in 2012. On the other hand, in addition to rehabilitation efforts, the project about ‘Early warning systems’ is developed by AKOM (Studies on Disaster Preparedness) on five different streams in Istanbul including Ayamama Stream. The project will provide the evacuation of people before the flooding by configuration of cameras and observation stations.



Figure 5.15 : Enhancement of streambed cross-section of Ayamama Stream and a part of flood risk map prepared by ISKI (Demir, 2010).

Besides the recent projects that are planning for the Ayamama Stream, the current land use pattern of the watershed demonstrates the variety and complexity of urban facilities which are the results of rapid development process in the area starting with 1950's. Particularly, main road constructions precipitated the development around transportation networks and let to the investment opportunities and migration of people which cause a densely populated and highly urbanized pattern. In the context of land use analysis, it can be seen that majority of the watershed area is built-up and mainly industrial and residential areas encompass the catchment area with a small amount of urban agricultural and green spaces (Figure5.16).

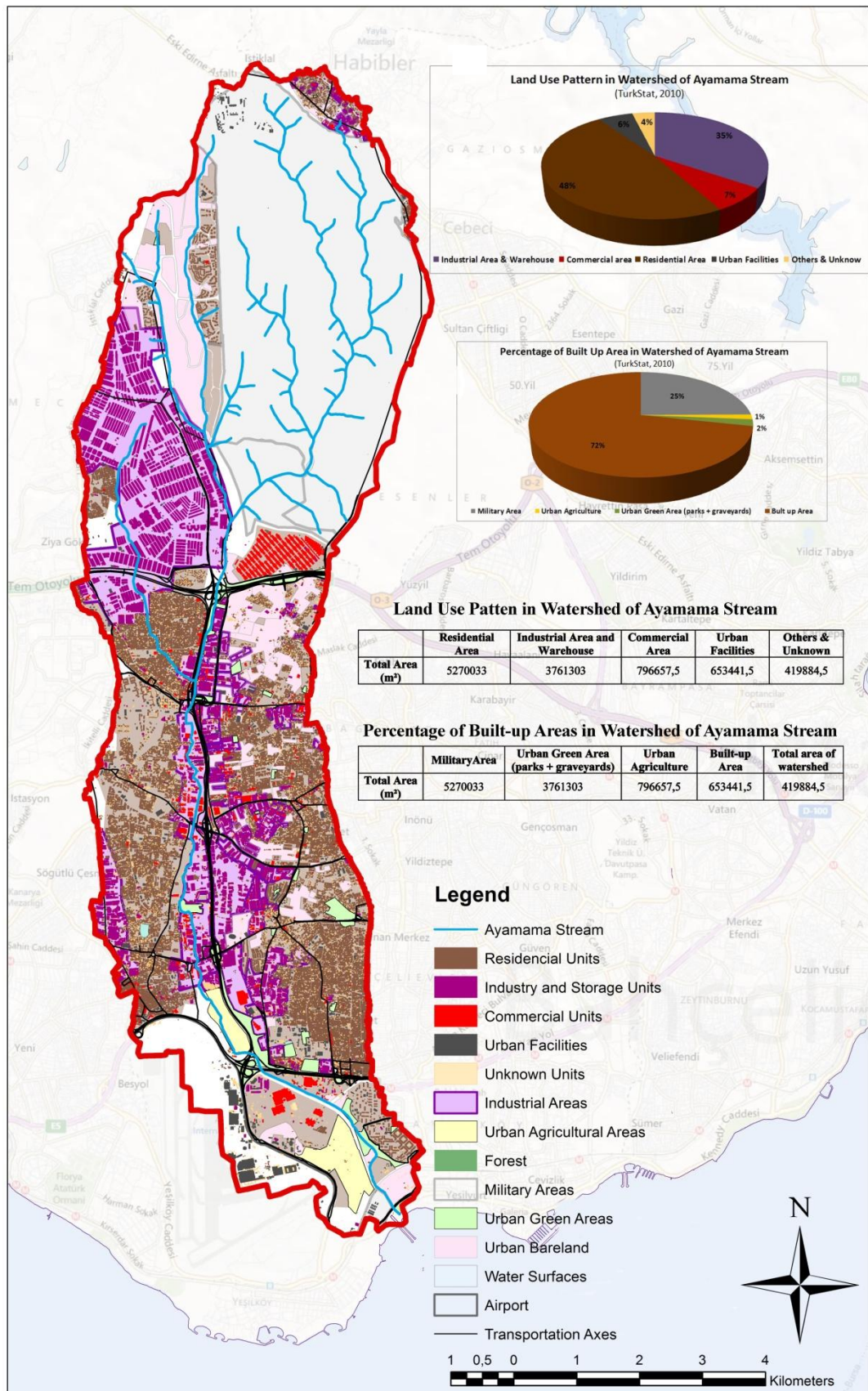


Figure 5.16 : Current land use pattern of Ayamama Stream and its watershed (Generated by the data of IMM, 2011).

5.4 Major Problems of Ayamama Stream and Adaptation of Co-MISDAL to the Study Area

According to dense urban pattern of the watershed area, the Ayamama Stream is exposed to several anthropogenic intervenes which resulted with serious damages. The main problems of Ayamama Stream are categorized under three main titles including: flooding, pollution and stream burial.

Floods: Flash floods are characterized by a rapid and violent movement of water in a small spatial area produced by heavy rainfall. During a precipitation event, there is a short time span between the storm peak and the discharge stream peak. Urbanization reduces the infiltration capacity of soils and reduces the time period between the two peaks. Thus, flash floods are more likely to occur in urban areas, where soils have been progressively replaced with man-made features (Alejandro et. al., 2011). Floods can happen at any time. They are caused by increasing ground water levels and hillside run-off from sudden rain as well as flooding from rivers and the sea. The definition of flood risk can be defined as the possibility of a particular flood event and the result that the flood would cause if it happened (Saral, 2010).

During the 1950 – 2010 periods, Turkey has experienced 35 flood events (EM-DAT 2010). Part of Istanbul is located on flood-prone areas, where flood events have already occurred. Here, a combination of different factors such as unplanned urbanization, an increase in population density, weak construction control by the authorities (Yalçın and Akyürek 2004), deficient urban master plans and heavy rainfall have caused floods with severe economic and social losses (Dubovyk 2010; Einfalt and Keskin 2010; Yalçın and Akyürek 2004).

According to Turoğlu (2011), the city of Istanbul has been increasingly suffering from flashfloods and floods leading to loss of life and property for the last few decades. Between the years of 1989-2009, flashflood and flood disasters causing loss of life and property in Istanbul have occurred 59 times. The existing artificial drainage systems, which are different from the natural flow direction, cannot drain the water coming with extraordinary rainfall. This is one of major causes of flashfloods and floods in Istanbul. The channel cross-section, reduced by filling, does not possess the capacity of natural rivers and has far less water- carrying capacity. The main arterial motorways D100 and E80 were planned and built to cut vertically

into the natural flow direction. Link roads between the E80 and D100 motorways were constructed on both the valley floor and following the lowest lineaments of the valley floor. In this case, the main arterial highways hinder surface flow, and the link roads act as natural flow channels. The rain water coming with exceptional rainfall, reaching huge volumes, does not flow into the present artificial drainage systems but prefers to flow according to existing slope conditions and on roads (Figure 5.17).



Figure 5.17 : Main roads served as drainage channels (Basin Expres link road, September 9, 2009) (Ozcan and Musaoglu, 2010).

Ayamama Stream basin in Istanbul is a densely populated urban area that is frequently impacted by flash floods causing damage to people and infrastructure. Flood events in Ayamama Stream basin happened in 1995, 2002 and 2009. The lack of mitigation measures and the lack of implementation of new disaster policies after the 2002 event have enlarged the negative consequences of September 2009's flash flood: 31 people killed (Watson and Comert 2009) and a loss of more than \$100 million. Also during the flood of Ayamama Stream in July 1995, the damage cost about \$40 million. Most of these damages occurred along the highway that connects E-5 to TEM which runs parallel to the river and the stores and factories located along the river suffer a great amount of damage of during a flood event.

According to the city development plan, the region the Ayamama Stream runs through had been set aside for recreational areas until an amendment was made in 1997 to turn it into a residential area. The Ayamama Stream is an ecological corridor that crisscrosses Istanbul's urban landscape and is polluted, interrupted and narrowed by development. Urbanization in the region has both destroyed the environment and

has put an extra burden on the already insufficient infrastructure (Ozcan and Musaoglu, 2010).



Figure 5.18 : Basın Expres Road, before and during the flood (Ozcan and Musaoglu, 2010).

Pollution: Development of industries and over population in the watershed area creates pollution in water quality and relatively in aquatic life. In the research of ‘Determination of genotoxic pollution on Ayamama and Haramidere Streams’ mutagenic effects of samples are determined in Ayamama Stream which is polluting by domestic and industrial waste water sources (Dülger et.al., 2008).



Figure 5.19 : Industrial - Domestic Discharges to Ayamama Stream (Delibaş, 2012).

Due to negative effects of anthropogenic pollutant carried by the Ayamama Stream to Marmara Sea, the pollution threatens the aquatic health of both interconnected systems. In addition, according to the research by Sivri and Seker (2010), in Atakoy wastewater treatment plant, at the stations 1 and 2, the density of the enteric bacteria has been determined as the higher values almost every month except cold season.

The pollution problem of Ayamama Stream also led to close the public beach on Bakırköy-Ataköy coast, which was in use until 1970's.

Culverted / Buried Sections: As a result of dense population and high urbanization pattern in the watershed area, the stream channel altered due to serve human activities. Such that, in some sections, the streambed cross-section is decreased by filling or the stream has put in to concrete linear channels which cut the interaction between the soil & water and prevent infiltration. In addition to this important intervenes, some sections of the stream has buried and impervious surfaces (asphalts, concrete cover, buildings, roads etc.) are constructed over the stream. In other words, the societies disregarded the existence of a living system as an essential component of urban ecosystem for their benefits. These interferences also increased the pressure on the entire stream system with the built-up areas on both sides of streambed. In the watershed area of Ayamama Stream, the stream is highly impacted by transportation networks in terms of construction process and the driving force of transportation for new development opportunities. Relatively, the Ayamama stream channel is altered in many sections with different types. Mainly the crossroads constitute one of the problematic nodes for the stream, which is exposed to put underground during the each cross-road (Çobançeşme, Sefaköy, Halkalı-Güneşli, İkitelli, Mahmutbey cross-roads) (Figure 5.20). In addition, the stream channel is straitened in some residential areas (Mehmet Akif and Atatürk neighborhoods) within concrete streambed conditions, which increase the flow speed and flood risk in these sections (Figure 5.21). Especially in Başakşehir district, the main watercourse is put under the road of 10th Street and instead of the tributaries of Ayamama Stream, artificial waterways are designed for recreational amenities in the 'Sular Valley' (Figure 5.22).

The dense urbanization pattern together with transportation axes led some sections of Ayamama Stream to be channelized, and in some sections covered by concrete surfaces. Accordingly, in north of the basin, the stream has more tributaries flowing openly than the middle and south parts due to less built-up areas in the north.

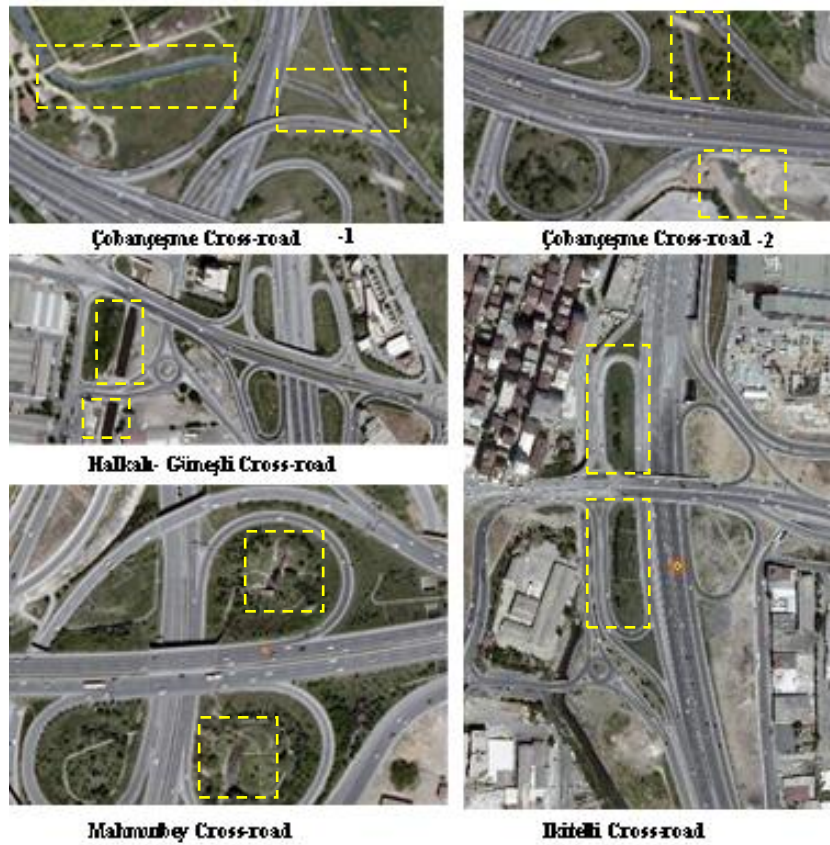


Figure 5.20 : Fragmentation of Ayamama Stream on cross-roads.



Figure 5.21 : Ayamama Stream in Residential areas of Mehmet Akif and Atatürk neighborhoods (Alejandro et. al., 2011).



Figure 5.22 : Başakşehir 'Sular Valley' (Url-20, 2012).

In addition to flood, pollution and modification problems of the area, transportation linkages constitute the primary cause of those problems, which effects the area directly or indirectly and led to continuing future projects (Figure 5.23).

As a result of whole analysis about the major problems of the watershed area, a map is prepared which is attached in the appendices B including land use, flood risk areas, pollution points, buried/channelized sections of Ayamama Stream with recent pictures from the area.

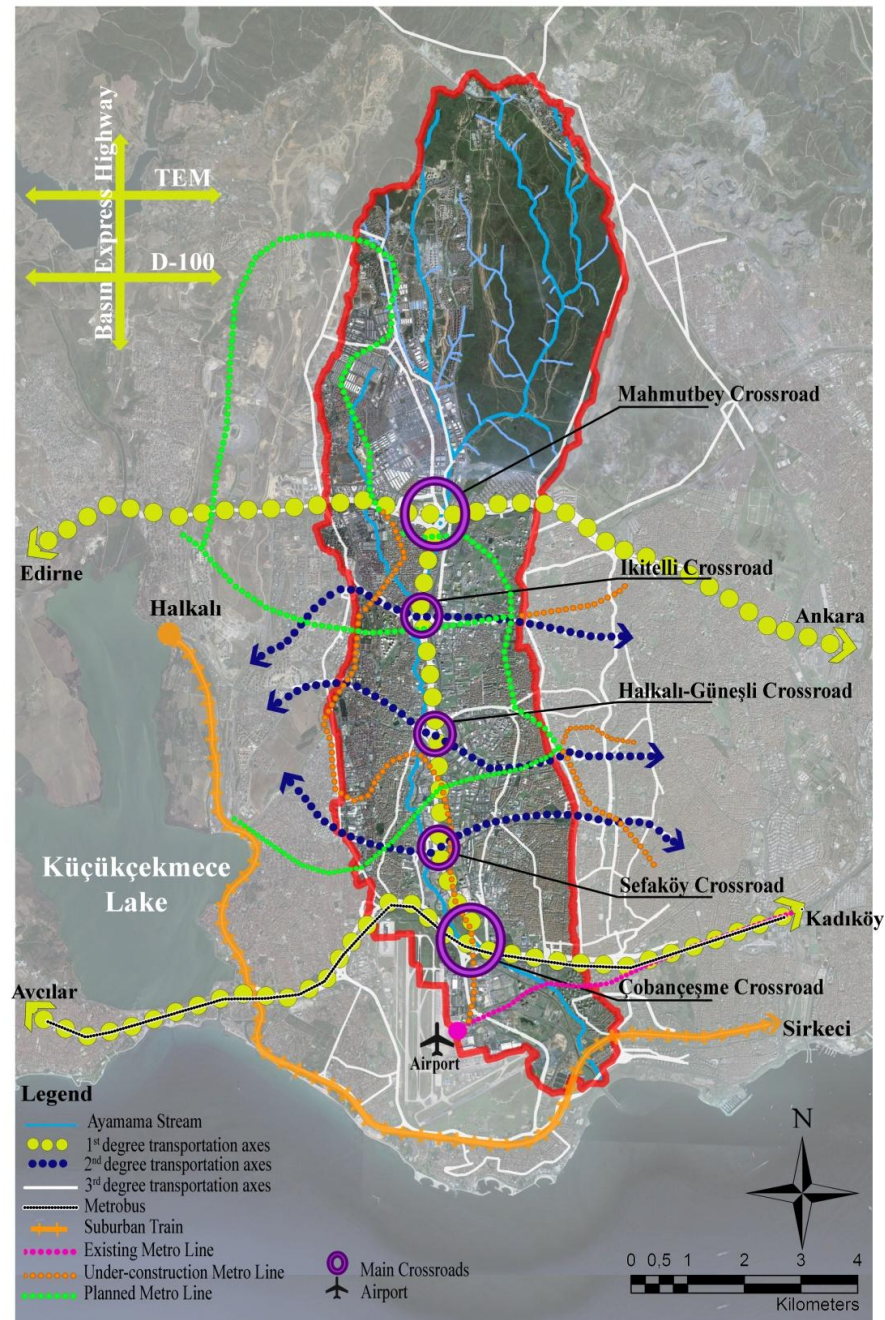


Figure 5.23 : Transportation synthesis in watershed of Ayamama Stream.

In the context of site analysis, the data about the physical, social and problematic structure of Ayamama Stream Watershed which is acquired from relevant materials (maps, field observations, literature reviews and recent analysis) can be summarized as below:

1. Ayamama Stream has an expanse watershed area of 66.76 m² and 42 total length with tributaries.
2. The watershed of Ayamama Stream is located in a highly urbanized area of Istanbul, which is the most crowded city of Turkey.
3. The existing transportation networks in the area consists of two major roads of TEM and E-5 (D-100) which divides the entire watershed in 3 sub-areas horizontally. TEM and E-5 highways constitutes the horizontal axes whilst, the Basın Express Road links these two major roads as a longitudinal axis. In addition to those important transport linkages, a suburban railroad (Sirkeci-Halkalı) and metro line (Aksaray-Havaalanı) reach to the watershed including planned and under-construction metro lines. On the other hand, Ataturk International Airport in southwestern part of the watershed area has an important role on the transportation strategies of the area.
4. In social respect, the watershed encompasses a vast area including 6 districts and 28 neighborhoods, which creates an institutional variety on conservation & management of Ayamama Stream.
5. The distribution of neighborhood population in the catchment area is densely located in the middle (horizontally) section of watershed in between TEM and E-5 Highways. On the other hand, industrial facilities mostly concentrated on strambanks, which threaten the stream system.
6. Significant land use changes are observed in the area especially in the middle section of watershed (in between TEM and E-5 highways) after 1960's due to road constructions, which constitute a driving force for population growth and investment increase in the watershed. In this process, the grasslands and agricultural lands declined in parallel with increased built-up areas.

7. The development process of the area has steadily increased since 1960's and for the last 15 years, the pressure on the stream system has grown due to the plan decisions, investments and insufficient control mechanisms in the area. According to the Istanbul Environmental Master Plan (1/100000), E-5 and TEM highways are defined as the most important factors affecting the development of Küçükçekmece District including the Basın Ekspres Road as a linkage between them. As a result, Basın Ekspres axis is defined as an area of the CBD (Central Business District) interaction.
8. Besides the CBD development mission and service type transformation projects (from industrial to service area) on the area, Ayamama Stream has announced its name with the major floods in 1995 and 2009 resulted with deaths and substantial economic damages. The flood effected mostly the area of Basın Ekspres Road (the middle section of watershed between TEM and E-5 including the high concentration of industrial and residential facilities). During the flood, Basın Ekspres road served as drainage canal for the stream flow because of its location which is constructed in the north-south flow direction of Ayamama Stream.
9. In addition to flood problems in the area, water quality is also a problematic issue due to the discharges especially from industrial facilities on stream banks. According to the chemical water analysis of Ayamama Stream, the density of the enteric bacteria has been determined at higher values.
10. Modification on stream channel morphology is another significant result of human activities in the area, which cause flood problems. As a result of dense population pattern, industrial facilities and active transportation linkages in the watershed, Ayamama Stream is culverted in concrete channels or buried under impervious covers in different sections. Although, some projects about Ayamama Stream are taken action by ISKI, IMM and AKOM in recent years, unfortunately they solely focus on reducing the flood risk and related

damages on urban systems without considering bringing the systems' natural structure and functioning back.

In relation with the previous sections of thesis study, the drivers of the problems in Ayamama Stream and its watershed are analyzed in the context of renaturalization of

buried / culverted riverine systems by stream daylighting method. The Ayamama Stream has major problems of flood, pollution and stream channel alterations, which cause significant damages on both eco-hydrological system of Ayamama Stream and also on urban systems. Relatively, the response against to these problems is developed by primary institutions in order to decrease flood problems in the watershed area. However, proposed and started projects to regulate and minimize the negative effects of Ayamama Stream solely focus on stream channel enhancements and separation of industrial water discharges without considering a holistic approach on the entire stream system. On the other hand, according to former experiences in different countries it can be seen that the efforts without a comprehensive perspective provides only short-term solutions. As long as the interaction and integration cannot be provided between urban & riverine systems, the efforts and developed solutions will only serve for current problems. Therefore, previously developed ‘model development process’ is adapted in to Ayamama Stream and its watershed area in order to analyze the factors, effects and results of interactions (Figure 5.25) including the drivers&results of major problems and their interactions over time (Figure 5.26).

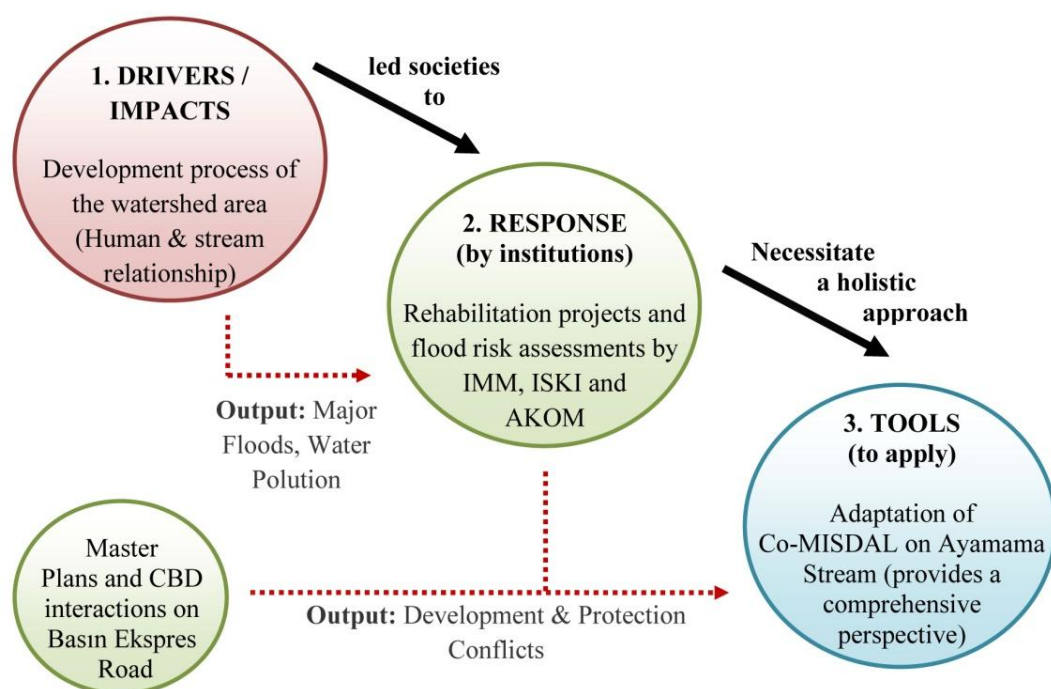


Figure 5.24 : Interactions and model development in watershed of Ayamama Stream

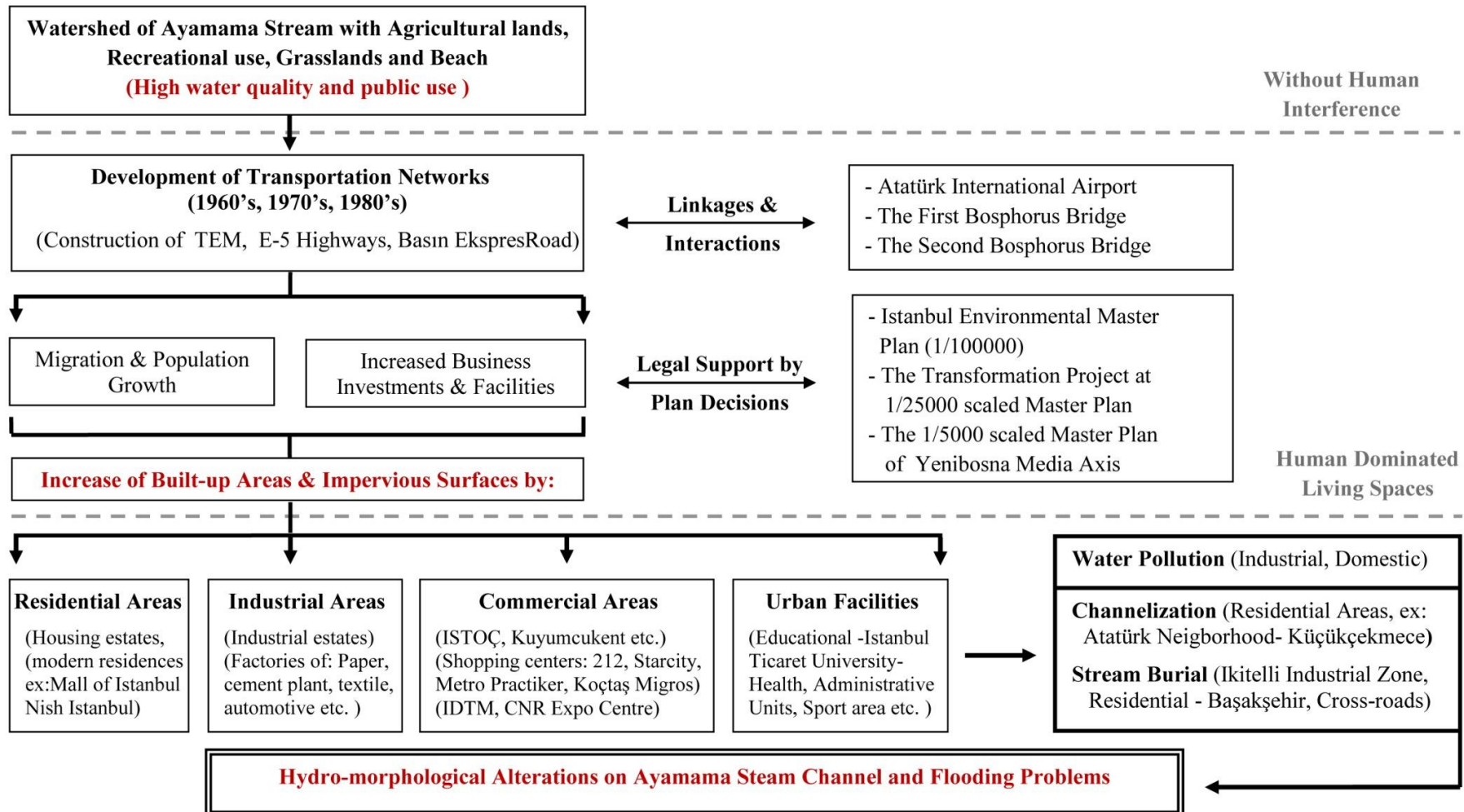


Figure 5.25 : Drivers of the major problems in the watershed of Ayamama Stream.

In the context of model development process, first of all the background and drivers of current problems are defined in connection with the proposed master plans which provides a legal support for the business development in the area. According to site analysis and literature reviews about the watershed area of Ayamama Stream, it is determined that the middle (horizontal) section (inbetween two major highways) is most vulnerable part of the whole watershed system due to the dense land use pattern by commercial, industrial and residential units. This middle section of the watershed contains several industrial and commercial facilities through the streambank and densely populated neighborhoods of Küçükçekmece and Başakşehir districts. On the other hand, the first (horizontal) section of the watershed which is located above the TEM is exposed to the impacts of industrial estates (Ikitelli OSB) where the stream is buried under the ground in many parts. In addition to this industrial pressure in the first section, instead of one of the buried tributaries of Ayamama Stream, an artificial waterway is used for recreational issues as a part of a housing estate project (Sular Valley in Başakşehir). The third (horizontally) section of the watershed area which is in between the mouth of the stream in Bakırköy and E-5 Highway is the section with the lowest impact on the stream system and contains an urban agricultural land and Ataköy Water Treatment Biological Plant with a low density of population.

Although, the highest pressure of human activities on streambed can be seen in the middle part of the watershed system, the 1/100000 scale Environmental Master Plan defined the area of Basın Ekspres Road as a CBD site. In order to clarify the contradiction between the plans and projects taken by IMM and ISKI following to the 2009 flood of Ayamama Stream, the Co-MISDAL guides the process with providing a comprehensive approach in terms of social, economic and environmental aspects. In this framework, following to the definition of drivers and related response, Ayamama Stream and its watershed is assessed under the key themes of the Co-MISDAL (Table 5.1). The assessment is developed according to the experiences of former implemented case studies from different countries. Thus, a common framework for stream daylighting projects considering the renaturalization of buried/culverted riverine systems in urban areas, is adapted to a problematic stream in a highly urbanized part of Istanbul. As a result, the integration of Ayamama Stream case in to Co-MISDAL development process is provided and a comprehensive daylighting approach is proposed.

Table 5.1 : Assessment of Ayamama Stream Daylighting project under Key Themes of Co-MISDAL.

	Primary Goals & Scope	Drivers	Feasibility	Public Participation	Stakeholders & Funding	Legal Background	Positive Impacts	Results
Ayamama Stream Watershed	Integration of Ayamama Stream with urban systems in Istanbul - Environmental improvement -Economic benefits - Social integration	Flooding problems Water Pollution (Industrial & Domestic discharges) Stream Burial / Channelization (Residential, Industrial areas and cross-roads)	Located in a densely populated area, Industrial facilities on stream banks, Important transportation axes (TEM,E-5, Basin Express)	Collaboration with schools, youth groups Encouraging Public involvement and volunteer working during planning and maintenance process	Coordination among institutions, local groups, non-profit organizations, universities and business Multi-sectoral expert group (landscape architects, city planners, bio/hydrologs)	Integration with large scale plans (The 1/5000 scaled Master Plan of Yenibosna Media Axis) Integrate WFD measures	Increase the lost prestige of the business district, land values, investments, site attraction Improve aquatic habitats and functions, air quality Recreational opportunities	Creating an outdoor ecology laboratory Forming local organization Educational meetings & activities(to increase awareness level and participation)
Reference Case Project (s)	Cheonggyecheon River- Seoul	Strawberry Creek (heavily damaged) Zurich and Taddle Creek (pollution) Dunes Creek (bacterial pollution caused beach to close) Thornton and Castro Valley Creek (flooding)	Located in Highly Urbanized Areas: San Francisco Bay Area Zurich Arcadia Creek Castro Valley Creek Cheonggyecheon River (Transportation)	Strawberry and Jolly Giant Creeks (students) Zurich (volunteers) Cheonggyecheon River and Arcadia Creek (public participation) Thornton Creek (Citizen groups)	San Francisco Bay Area (successful cooperation between local business government) Castro Valley Creek (collaboration with legal agencies)	Zurich (city-wide program, 1991 law) Jolly Giant Creek (efforts shape a new drainage master plan)	Cheonggyecheon River and Arcadia Creek (business district) Cheonggyecheon River (environmental improvement)	Jolly Giant Creek (outdoor lab.) Arcadia Creek (publishing books, brochures) Dunes Creek (online live camera setting) Strawberry Creek (map of disappeared streams)

5.5 Summary of the Chapter

The Ayamama Stream and its watershed in Istanbul is in a densely populated urban area which is frequently impacted by flash floods causing damages for people and infrastructure. The Ayamama basin is selected as a case study area because of its critical situation between urban development & conservation issues. The area consists of different land use patterns which threaten the health of watershed system. In addition, as a result of major floods in the basin deaths and economic damages are occurred.

On the other hand, according to Saral (2010), flooding in Turkey is a common natural disaster and causes serious damages. In July 1995, the Ayamama Creek flooded; the insurance sector received around 1,200 claim notices during that period, insurance companies paid a total of \$40 million in claims (ISKI, 2012). In 2009, the same creek flooded again and killed 31 people over two days and insurance firms estimated the damage would cost €150 million. The experienced floods led societies and decision makers to re-think about the relevant subjects including urban planning issues, water resource management or early warning systems. However, these efforts generally focused on the solutions for improving the current situation rather than a long-term perspective with removing the main causes. Because, for the riverine systems which are degraded to a high degree, increased efforts of hydro-morphological renaturalization are necessary to improve the degraded structure and functioning of the system. According to Müller and Koll, (2004), a measurement of the success of the first realized projects shows that improvement in stream morphology has a remarkably positive influence on aquatic ecology.

From this point of view, the literature reviews and case study assessments of implemented daylighting projects are used to develop a conceptual model which provides a common platform for data & experience sharing for daylighting implementations in the context of renaturalization. Ayamama Stream is adapted in to the model development process by assessing the drivers of the current problems of the stream, response of societies including rehabilitation projects and assessment of the watershed configuration for a daylighting implementation under the eight key themes of Co-MISDAL model. Consequently, a comprehensive approach is required for the conservation & management of Ayamama Stream and its watershed area.

6. CONCLUSION AND RECOMMENDATIONS

The Epilogue of the thesis: Water is life itself.

In this study, the significance of healthy rivers in urban ecology and ongoing threats and challenges from urbanization dynamics on them are discussed to be understood for a better integration of spatial, social and economic development of urban rivers. The study also assessed the case of Ayamama Stream in Istanbul in terms of the improvement of current damaged status of streams from social, economic and environmental aspects.

The results of the research demonstrate that there is a sensitive balance between the functions of terrestrial (land) and aquatic ecosystems in nature and land use changes in urban environment have significantly been altering this balance, degrading the aquatic environment and resulting in causal chain alterations to stream structure and functioning.

In brief, riverine systems in urban areas:

1. Are the important components of freshwater systems and they play a critical role in the water cycle.
2. Constitute as mass & energy exchange channels and their natural functioning is supporting soil fertility while material carrying (bio-interactions).
3. Provide freshwater, food, fibre and habitats for aquatic life (for birds, fish, small mammals, amphibians and other wild life) within the catchment area (or urban watersheds).
4. Help to regulate stormwater management and urban drainage by conveying run off and minimizing threats of flooding by flood management approaches (natural drainage canals against flooding)
5. Also regulate water & air quality by removing pollutants and cooling the air temperatures.
6. Provide space for recreation, public amenity and aesthetic values (socio-cultural benefits)

7. Provide opportunity for scientific research laboratory.
8. In addition riverine systems offer opportunities for city dwellers to build connection with nature by providing ecotourism activities.

However, in addition to the value of these systems in urban areas:

1. Due to the human activities to control the environment and create more space to growth, impervious surfaces increase in urban areas which has important ecological and hydro-morphological effects on riverine systems.
2. By the increase of impervious surfaces, infiltration and evaporation rates decreased, local temperatures (heat island effect) is effected negatively and with the increase of roads and traffic loads air quality is declined
3. Many parts (in some cases the whole) of riverine systems in urban areas are channelized or culverted with critical modifications on stream bed which cause multiple and complex problems. These problems interacts with each other including increase on stream velocity, flood risk, water treatment costs, sedimentation, peak flow discharges, erosion and stormwater run off. Whilst, they cause the degradation on base flow, aquatic habitats and biodiversity, water quality, and natural functioning (material carrying & energy exchange) and recreational value of the system.
4. Due to, point and non-point polluters (domestic, agricultural, industrial etc.), urban run off and pollutants from infrastructure constructions (hard infrastructure such as roads, bridges etc.) and polluted air are causing unhealthy aquatic life and declines on species diversity.
5. As a result of culverting riverine systems in to underground or replacement of these systems and their watersheds with impervious surfaces such as roads and buildings over them, urban drainage patterns are altered and public access to these areas are impaired due to effected ecological & recreational values of urban riverine systems because of development pressures (urbanization, population growth, industrialization etc.)

As human populations have been growing, their effects on aquatic ecosystems have been increasing as well (Postel 1999; Vitousek et al. 1997). In this framework, freshwater ecosystems have always been particularly the most vulnerable ones, because human populations are concentrated near waterways and exposed to several

anthropogenic effects. According to UNEP (1999), these problems are very complex and their interactions are hard to define. The EU-WFD offers a better basis for the implementation of integrated strategies for the protection of water bodies that take into account the complexity of anthropogenic influences and define quantitative environmental quality aim. However, it is very important to examine problems through the social-economic-cultural systems. In general, the environmental outputs of negative urban impacts can be summarized as increased flooding, increased stream velocity, impervious land covers, erosion, stream burials, increased sedimentation loads and loss of riparian habitats on riverine systems. In addition, human dimension of urban ecosystems should be considered as an integral component of this system and the solutions should be taken into consideration by including social needs and structures (Pickett et al., 1997, Paul and Meyer, 2005). Because the success of any attempt to improve the ecological condition of streams in urban areas will largely depend on human attitudes and integrated social and ecological studies may help to maximize social and ecological outcomes. Such that, the world's ecosystems provide a wide range of essential and economically valuable services (Costanza et. al., 1997). Aquatic ecosystems provide a wide range of such services, including freshwater for agricultural, industrial and municipal uses, transportation corridors, food, opportunities for recreation and esthetic enjoyment, and waste disposal.

However, as humankind has enlarged agricultural areas, built roads, and clustered into cities of large and small ones; they have polluted, diverted and straightened streams, confined them in concrete channels, put them into pipes, filled their associated wetlands with structures and otherwise used and abused these systems, often beyond recognition (Pinkham, 2000). Therefore, the practice of daylighting can be part of larger restoration projects. It can be a less expensive option for municipalities that have to repair or replace decaying culverts or channels to avoid fines for violations from combined sanitary and storm waters, sewer overflow occurrences (Brzozowski, 2010).

According to Findlay & Taylor (2006), rehabilitation of riverine systems has become an important objective of many local, state and national governments around the world, who allocate substantial investment into various river projects even if the riverine system encapsulates the lands of different nations because, watershed

boundaries are defined according to natural structure of land rather than administrative ones. Therefore, many metropolitan watersheds are politically fragmented, streams have cross-political boundaries and sometimes they serve as boundaries between municipalities, counties, or even states. Furthermore, local watersheds encompass areas of great social and economic diversities.

In this framework, the watershed of Ayamama Stream, which includes six districts, constitutes a model for fragmented watershed system by both administrative units and land use patterns. The area is exposed to pressures of highly populated neighborhoods and dense agglomeration of industrial facilities on the stream banks. Urban facilities such as transportation networks, industrial and commercial activities and residential areas cover the majority of the land surface in the watershed area.

The outputs of the analysis on Ayamama Stream and its watershed can be summarized as:

- ✓ Watershed area of Ayamama Stream is under the dense pressure of urbanization (72% built-up area) .
- ✓ Transportation networks are the primary drivers of the development in the area (increase land values and investments with increased accessibility levels).
- ✓ Spatial development plans (1/100.000, 1/25.000, 1/5.000) encourage business investments and developments into the area (CBD functions).
- ✓ On the other hand, hydro-morphologic alterations on the Ayamama Stream (channelization, burial, industrial & domestic discharges) cause major problems and the response of the stream by significant floods.
- ✓ Related governmental institutions (IMM, ISKI, AKOM) take actions against these human&urban induced problems (stream-bed enhancement, flood risk maps, establishment of early warning systems) recently. However, the contradiction between plan decisions and recent actions demonstrate the lack of comprehensive approach on the Ayamama Stream which led to get short-term solutions without an integrated approach of socio-cultural & environmental urban systems for the entire watershed.

- ✓ The assessment of Ayamama Stream under the key themes of Co-MISDAL Model, indicates the similarities of the area (pressures and problems) with previously compiled case projects from around the world. Therefore, the need for a comprehensive approach on the Ayamama Stream meets with the context of CO-MISDAL model.
- ✓ The similarities with various case implementations mentioned before can be grouped as locating in a densely urbanized area, pollution and increased flood risks. Differently, watershed of the Ayamama Stream contains a dense use of industrial facilities through the stream bank. Therefore, industrial areas constitutes the critical part of the project.
- ✓ In general terms, an integrated (environmental improvement, social integration, economic benefits) scope for the project is required including the coordination among different institutions.
- ✓ As it is seen in implemented case projects, public awareness and involvement should be taken into account during the planning and maintenance processes of the project. Herein, residence confidence should be encouraged by the government and non-profit organisations. In this context, establishment of a new local organisation for Ayamama Stream and its watershed area can provide a link between local and government in terms of organizing public issues, meetings etc. This organisation can be called as ADEKOD (Association of Ayamama Stream Conservation).
- ✓ Preparing maps of disappeared streams, publishing books and brochures with organizing field trips can help to make people to be aware of the process. Also an outdoor ecology laboratory can be created near the Fatih Private Highschool according to its close location to the Ayamama Stream.

The analysis of land use patterns demonstrated the high rates of impervious surfaces in the watershed. According to the TurkStat 2010 data, 72% of the area is built-up and only the 2% constitutes urban greens. The result indicates the significance of the urbanization problem in the watershed and necessitates a comprehensive improvement approach in order to provide the long-term balance between development and stream-bank conservation in the entire watershed in terms of socio-cultural, economic and environmental perspectives.

Therefore, from the view of global and regional perspectives, understanding of a riverine system in urban areas is not only about better understanding of interactions between catchments and stream processes, but also to integrate this system with social, economic, and political drivers of the urban environment.

In the context of thesis, riverine systems are assessed together with their functions and structure at different levels (global regional, local). At global level, it is seen that riverine systems as an important component of freshwater systems, has an important role for the continuity of water cycle process on the Earth. On the other hand, these essential natural systems should be considered and managed within ‘watershed’ units at regional scale. The watersheds as natural borders of riverine systems include the aquatic and territorial interactions in the area provided by these systems. Therefore, throughout the history, the riparian areas have always been a preferable and convenient place for human settlements. Over time, human beings have experienced adapting themselves to water and learnt how to manage it as a result of several flood accidents. In this process, the riverine systems mostly used for irrigation, navigation-trade and defense issues. However, in contrast with their role and importance of in urban ecosystem, these systems are exposed to several impacts as a result of rapid urbanization and growing populations. The expansion of anthropogenic activities led riverine systems to be polluted, culverted, buried or changed (hydromorphological structure) by human intervenes. At that point, the thesis focuses on buried riverine systems in urban areas, which are lost their aquatic characters and ecological functions with the impervious surfaces they are covered with. From this point of view, thesis examines about the problems and potential solutions for these systems under ‘Urban Stream Syndrome’, ‘Healthy Rivers’ and ‘Renaturalization’ approaches. As the main objective of the study, the efficiency of ‘Stream Daylighting’ method is evaluated with the assessment of several implemented projects and a conceptual model for renaturalization of buried riverine systems in urban areas through the daylighting method is developed and evaluated in the case study area of Ayamama Stream in Istanbul. As a result, it is seen that riverine systems should be one of the essential components of urban systems in terms of socio-cultural, economic and environmental aspects.

‘Water is part of the complex web of life on Earth to which we all belong (WWF-Living Planet Report, 2010).

REFERENCES

- Alejandro M., Acevedo, R., and Flacke, J.,** (2011). *Gs-Sence Conference Resilient Societies-Governing Risk and Vulnerability for Water, Energy and Climate Change*, University of Twente, The Netherlands.
- Alhanlioglu, G.,** (2006). *Water component in Urban Space: Streams flowing to Boğaziçi (Kent ögesi olarak su elemanı: Boğaziçi'ne Dökülen dereler)*, Master Thesis, Institute of Science and Technology, Istanbul Technical University.
- Alpopi, C.,** (2005). *Socio-economics Consequences of Urbanisation*, Department of Management and Public Administration, Academy of Economic Studies, Bucharest.
- Aydın, M.,** (2012). Evaluation of World Urban System Characteristics, available at: <http://onlineurbanplanning.blogspot.com/>
- Beitel, J.,** (1976). *A Vegetative Survey of the Freshwater Wetlands of Nine Major Streams in Southwestern Suffolk County And Southern Nassau County*, New York. Unpubl. report for the Environmental Defense Fund, Inc.
- Bernhardt, E. S., and Palmer, M. A.,** (2007). Restoring Streams in an Urbanizing World, *Freshwater Biology*, 52, 738–751.
- Biswas, A. K.,** (2008). Water as a Human Right in the MENA Region: Challenges and Opportunities, Available at: [http:// web.idrc.ca/es/ev-127188-201-1-DO_TOPIC.html](http://web.idrc.ca/es/ev-127188-201-1-DO_TOPIC.html)
- Boer C., and Bressers, H.,** (2011). *Complex and Dynamic Implementation Processes, Analyzing the renaturalization of the Dutch Regge River*, University of Twente, Enschede, The Netherlands.
- Booth, D. B., Karr, J. R., Schauman, S., Konrad, C. P., Morley, S.A., Larson, M. G., and Burges, S. J.** (2004). Reviving urban streams: land use, hydrology, biology, and human behavior, *Water Resour Assoc* 40:1351–1364.
- Brown, L., Gray, R. H., Hughes R. M., and Meador M. R.,** (2005). *Introduction Effects of Urbanization on Stream Ecosystems*, American Fisheries Society Symposium, Virginia, USA.
- Brzozowski C.,** (2010). Daylighting Streams, from pipes and culverts into open, Accessible at: http://www.stormh2o.com/SW/Articles/Daylighting_Streams

- Brugge R., Rotmans J., and Loorbach D.,** (2005). The Transition in Dutch Water Management, *Environmental Change* (2005) 5: 164–176.
- Buchholz, T., and Younos, T.,** (2007). *Urban Stream Daylighting, Case Study Evaluations*, Virginia Water Resources Research Center, Virginia.
- Buckley R. M., Annes P. C., and Spence M.,** (2009). *Urbanization and Growth, Commission on Growth and Development*, Washington, USA.
- Campbell, N. A.,** (1996). *Biology*, the Benjamin/Cummings Publishing Company, 4th Edition, Inc., Menlo Park, California.
- Cascao, A.,** (2011). Cooperation Over Transboundary Water Resources in the Nile Basin: Potential, Obstacles and Challenges, *DANIDA Development Days* PowerPoint Presentation, Copenhagen, Denmark.
- Center for Riverine Science and Stream Renaturalization (CRSSR),** Available at: <http://www.umt.edu/rivercenter>
- Center for Watershed Protection (CWP),** (2004). *Unified Stream Assessment: User's Manual*, Ellicott City, MD: CWP, chapter 3, Maryland, USA.
- Changming, L., and Xiaoyan, L.,** (2008). Healthy River: Essence and Indicators, *Journal of Geographical Science*, 63(7) 683-692.
- Clark, W. C., Tomich, T. P., Noodwijk M. van, Guston D., Catacutan D., Dickson N. M., McNie E.,** (2011). Boundary Work for Sustainable Development: Natural Resource Management at the Consultative Group on International Agricultural Research (CGIAR).
- Conradin, F., and Buchli, R.,** (2008). *The Zurich Stream Daylighting Program*, Handbook of Regenerative Landscape Design, Taylor & Francis Group, LLC.
- Costanza, R., R., Groot R., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R. V., and Paruelo J.,** (1997). The value of the world's ecosystem services and natural capital. *Nature* 387:253–260.
- Cottingham, P., Walsh C., Rooney, G., and Fletcher T.,** (2003). Urbanization Impacts on Stream Ecology -from Syndrome to Cure?, *Outcomes of workshops held at the Symposium on Urbanization and Stream Ecology*, Melbourne University, Melbourne, Australia.
- D'Ambrosio, J. L., and Ward A.,** (2008). Stream Classification, *Agriculture and Natural Resources Fact Sheet*, Available at: <http://ohioline.osu.edu/aex-fact/pdf/AEX44501StreamClassification.pdf>
- Daily, G.,** (1997). *Nature's services: societal dependance on natural ecosystems*. Island, Washington DC.

- Demir, A.,** (2010). *Şehir Taşkınları ve İstanbul*, PowerPoint Presentation, ISKI (Istanbul Water and Sewerage Administration).
- Demographia World Urban Areas (World Agglomerations),** (2012). 8th Annual Edition: Version-2, Accessible at: <http://www.demographia.com/db-worldua.pdf>
- Dourojeanni, A. R.,** (2001). Water Management at the River Basin Level: Challenges in Latin America, *Natural Resources and Infrastructure Division*, Santiago, Chile.
- Dubovyk, O.,**(2010). *Spatio- temporal analysis of informal settlements development: a case study of Istanbul*, Turkey, ITC, Enschede.
- Dülger, M.,Yılmaz, S., Koçak, E., and Petek, M.,** (2008). Determination of Genotoxic Pollution of Ayamama and Haramidere Streams with SOSChromotest", ÇESKO, 3. *Üniversite Öğrencileri Çevre Sorunları Kongresi, İSTANBUL*.
- Ebersole, J. L., Liss, W. J., and Frissell, C. A.,** (1997). Restoration of stream habitats in the western United States: Restoration as re-expression of habitat capacity [J], *Environmental Management*, 21,1-14.
- Egoh, B., Rouget, and M., Reyers, B.,** (2007). Integrating ecosystem services into conservation assessments: a review. *Ecol Econ* 63(4):714–721.
- Einfalt, T., and Keskin, F.,** (2010). Analysis of the Istanbul Flood 2009, *BALWOIS 2010 Scientific Conference on Water Observation and Information System for Decision Support*. Ohrid, Republic of Macedonia.
- Elmore, A. J., and Kaushal, S. S.,** (2008). Disappearing headwaters: patterns of stream burial due to urbanization, *Frontiers in Ecology and the Environment* 6: 308–312. Available at: <http://dx.doi.org/10.1890/070101>
- Erez, Selçuk,** (2009). *Ayamama'dan Zuhurat Baba'ya Bakırköy*, Heyamola Yayınları, İstanbul.
- Erskine, A. J.** (1992). Urban area, commercial and residential. *American Birds* 26, 1000.
- Everard, M., and Moggridge, H. L,** (2011). Rediscovering the value of urban rivers *Urban Ecosystems* DOI 10.1007/s11252-011-0174-7.
- Fairweather, P. G.,** (1999). State of environment indicators of 'river health': exploring the metaphor, *Freshwater Biology* (1999) 41, 211-220.
- Findlay, S. J., and Taylor M. P.,** (2006). Why Rehabilitate Urban River Systems?, *Area*, Volume 38, Issue 3, pages 312–32.

General Command of Mapping, Accessible at: <http://www.hgk.msb.gov.tr/>

Gleick, P. H., (1996). *Water resources*, in *Encyclopedia of Climate and Weather*, ed. By S. H., Schneider, Oxford University Press, vol. 2, pp.817-823, New York.

Grimm, N. B., Grove, J. M., Pickett, S. T. A., and Redman, C. L., (2001). Integrated Approaches to Long-Term Studies of Urban Ecological Systems, *Bioscience*, 50(7), 571–584.

Groffman, P. M., Boulware, N. J., and Zipperer, W. C., et al. (2002). Soil Nitrogen Cycle Processes in Urban Riparian Zones, *Environ Sci. Tech.* 36: 4547.

Harrison, S., (1996). *Connectivity Prince George Forest Region Forest Resources and Practices Team*, B.C. Ministry of Forests, Forest Research Note; PG-03.

Hassan, F. A., (2003). *Water Management and Early Civilizations: From Cooperation to Conflict*, UNESCO-IHP Institute of Archaeology London's Global University (UCL).

Hoobyar, P., (2002). *Daylighting and Restoring Streams in Rural Community City Centers: Case Studies*, National Park Service, Rivers, Trails and Conservation Assistance Program, Seattle, Washington, US.

ICPDR, (2012). Accessible on : <<http://www.icpdr.org/> data retrieved 23.02.2012.

IWRM Guidelines at River Basin Level, (2009). Part 2-1 *The Guidelines for IWRM Coordination*, UNESCO

Jenkinson, G. R., Barnas, K. A., Braatne J. H., Bernhardt E. S., Palmer M. A., and Allan J. D., (2006). The National River Restoration Science Synthesis, *Restoration Ecology*, Vol. 14, No. 2, pp. 177–186.

Jones, S. W., (2001). *Planning for Wildlife: Evaluating Creek Daylighting as a means of Urban Conservation*, Master Thesis, Dal housie University, Nova Scotia.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen, (1997). An Ecological Perspective of Riparian and Stream Restoration in the Western United States. *Fisheries* 22(5):12-24.

Kang, C., and Cervero, R., (2009). From Elevated Freeway to Urban Greenway: Land Value Impacts of Seoul, Korea 's CGC Project, *Urban Studies*, Vol. 46, No. 13, pp. 2771-2794.

Karr, J. R., (1999): Defining and Measuring River Health, *Freshwater Biology* 41, 221-234, University of Washington, Seattle, USA.

- Kaya, S., and Curran, P. J.,** (2006). Monitoring urban growth on the European side of the Istanbul metropolitan area: A case study. *International Journal of Applied Earth Observation and Geoinformation*, 8(1), 18-25.
- Kılıcarslan, Ç.,** (1999). *Assessment of Watercourses' interactions within urban renewal process with a case of Izmir*, Master Thesis, Faculty of Agriculture, Ege University.
- Lee I. K.,** (2006). *Cheong Gye Cheon Restoration Project*, Seoul Metropolitan Government, ICLEI Presentation.
- Lei, Z., and Guanghe, W.,** (2008). *Urban River Plays Key Role in City Landscape Planning Culture Legacy and Ecological Development*, College of Urban and Rural Construction, Hebei Agricultural University, Baoding, 071001, P.R.China.
- Leopold, L.,** (1997). Let rivers teach us, Understanding River and Stream Systems, U.S.D.A. Natural Resources Conservation Service Symposium, Berkeley, California.
- Libiszewski S.,** (1996). What is an Environmental Conflict?, *Environment and Conflict Project (ENCOP)*, Berne/Zurich.
- Light, A.,** (2003). Elegy for a Garden, Terrain.org: *Journal of the Built and Natural Environment*, Accessible at: <http://www.terrain.org>
- Lord, C. P., Strauss, E. G., Toffler, A. M.,** (2001). *Natural Cities: Urban Ecology and the Restoration of Urban Ecosystems*, Lincoln Institute of LandPolicy Working Paper, Boston, USA.
- Lowrance, R.,** (1998). *Riparian forest ecosystems as filters for non-point-source pollution*, In: Pace ML and Groffman P (Eds). Successes, Limitations and Frontiers In Ecosystem Science. New York: Springer-Verla.
- MacDonald, A. M., and Davies, J.,** (2007). Improving the upstream passage of two galaxiids fish species through a pipe culvert, *Fisheries Management and Ecology*, 14, 221–230.
- MacQuarrie, P. R., Viriyasakultorn, V., Wolf, A. T.,** (2008). Promoting Cooperation in the Mekong Region through Water Conflict Management, Regional Collaboration, and Capacity Building, *GMSARN International Journal* 2, p.175 – 184.
- Maksimović, Č., Guibert, J. T.,** (2001). *Frontiers in urban water management: deadlock or hope*, IWA Publishing, UK.
- Marcotullio, P. J., McGranahan, G.,** (2005). Urban Systems, Chapter 27 in: Millennium Ecosystem Assessment, Current State and Trends: Findings of the Condition and Trends Working Group, *Ecosystems and Human-being* Volume 1, Washington DC: Island Press, pp. 795-825.

- Margoluis, R., and Salafsky, N.,** (1998). *Measures of success: Designing, managing, and monitoring conservation and development projects*, Washington, DC, Island Press.
- Martin, P.,** (1999). Rivers and Streams, Library of Congress Cataloging in Publication Data, Canada. Available at: <http://www.amazon.com/Rivers-Streams-ExploringEcosystems Patricia/dp/>
- Mayhew, R.,** (2009). Historical geography 2007–2008: Foucault’s avatars – still in (the) Driver’s seat. *Human Geography* 33, 387–97.
- McIntyre, N. E., K. Knowles-Yanez, and Hope, D.,** (2000). Urban ecology as an interdisciplinary field: differences in the use of “urban” between the social and natural sciences, *Urban Ecosystems* 4:5–24.
- Meijles, E.,** (2010). *Shaping the Dutch landscape: Physical Geography of the Netherlands, Lecture notes*, University of Groningen, The Netherlands.
- Mendiondo, M. E.,** (1999). *Towards the Renaturalization of Riparian Areas in South America Through an Interdisciplinary Approach: Management Opportunities* Deutscher Tropentag, Berlin, Oct. 1999, ATSAF Proceedings.
- Millennium Ecosystem Assessment Report,** (2005). *Ecosystems and Human Well-Being: Policy Responses: Findings of the Responses*, Working Group of the Millennium Ecosystem Assessment Series, Vol.3, Island Press, London.
- Molle, F.,** (2007). *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*, Chapter 16: River basin development and management, IWMI Standalone Summary Report. Available at: http://waterwiki.net/images/d/d9/Summary_SynthesisBook.pdf
- Moroglu, M., and Yazgan, M. S.,** (2008). Implementation of EU Water Framework Directive in Turkey, *Desalination* 226 (2008) 271–278.
- Müller, G. U., and Koll, K.,** (2004). River renaturalization: historic and anthropogenic constraints, ecosystems and their interaction, *Proceedings of the 5th International Symposium on Ecohydraulics*, Madrid, Spain.
- Nile Basin Initiative (NBI),** Accessible at: <http://www.nilebasin.org>>
- Norris, R. H., and Thoms, M. C.,** (1999). What is River Health?, *Freshwater Biology* 41, 197-209.
- NRC (National Research Council),** (1992). *Restoration of aquatic ecosystems*. National Academy Press, Washington, D.C.
- Odum E. P., and Barret G. W.,** (1953). *Fundamentals of ecology*, Philadelphia: W. B. Saunders.

ORSAM Water Research Programme, Centre for Middle Eastern Strategic Studies. Available at: <http://www.orsam.org.tr>

Ozcan, O., and Musaoğlu N., (2010). Vulnerability Analysis of Floods in Urban Areas Using Remote Sensing and GIS, *30th EARSeL Symposium: Remote Sensing for Science, Education and Culture*, Paris, France.

Palmer, M. A., Moglen, G. E., Bockstael N. E., Brooks S., Pizzuto, J. E., Wiegand C., VanNess K., (1997). The Ecological Consequences of Changing Land Use for Running Waters, with a Case Study of Urbanizing Watersheds in Maryland, *Yale F & ES Bulletin*-107.

Paul, M. J., and Meyer, L. J., (2001). Streams in the Urban Landscape, *Annual Review of Ecology and Systematics*, Vol. 32: 333-365, Athens.

Peel, S. J., (2008). Biotic Community Response to Stream Daylighting, Dunes Creek, Indiana, *16th National Nonpoint Source Monitoring Workshop*, Columbus, Ohio.

Pickett, S.T.A., Grove J.M., Nilon C.H., Pouyat R.V., Zipperer, W.C., and Costanza R., (2001). Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas, *Annu. Rev. Ecol. Syst.* 2001. 32:127–57.

Pinkham, R., (2000). *Daylighting: New Life for Buried Streams*, Rocky Mountain Institute, Snowmass, Colorado, USA.

Platt, H., R., (2006). Urban Watershed Management: Sustainability, one Stream at a Time, *Environment: Science and Policy for Sustainable Development*, 48:4, 26-42.

Postel, S., (1999). *Pillar of Sand: Can the Irrigation Miracle Last?*, W.W. Norton Company (A Worldwatch Book), New York. Available at : <http://www.waterhistory.org/histories/nile/nile.pdf>

Ramsar COP8 DOC. 36, (2002). Wetlands: water, life, and culture, *8th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands*, Spain.

Rees, W., McGranahan, G., Marcotullio, P., Bai, X., Balk, D., Braga, T., Douglas, I., Songsore, J., Zlotnik, H., and T., Satterthwaite, (2005). *Ecosystems and Human Well-Being: Current Status and Trends*, Chapter 27-Urban Systems, Island Press.

Resh, V. H., (1995). Multiple techniques benefit Berkeley campus creek. *Water Protection Techniques* 1:184-187.

Roy, A. H., Purcell, A. H., Walsh, J. C., and Wenger S. J., (2009). Urbanization and stream ecology: five years later, *Benthol. Soc.*, 2009, 28(4):908–910.

- Ruby, E.,** (2006). *Factsheet on the Effect of Urbanization on the Water Cycle*, Office of Environmental Health Hazard Assessment (OEHHA)-California Water and Land Use Partnership (CA WALUP), Sacramento, CA.
Available at: <http://www.coastal.ca.gov/nps/watercyclefacts.pdf>
- Saral, A.,** (2010). Flood Risk Analysis Using Information Diffusion Theory – A Case Study: Ayamama Creek, *30th EARSeL Symposium: Remote Sensing for Science, Education and Culture*, Paris, France.
- Schumm, S. A.,** (1977). *The Fluvial System*, John Wiley and Sons, New York.
- Scrimgeour, G. J., and Wicklum, D.,** (1996). Aquatic ecosystem health and integrity: problems and potential solutions. *Journal of the North American Benthological Society*, 15, 2154-2261.
- Seoul Development Institute,** (2006). *Improving river corridor of Cheonggyecheon in Seoul*, Project number SDI 06-R-21.
- Simsek, G.,** (2011). *An approach to urban river rehabilitation for coexistence of river and its respective city: Porsuk River case and city of Eskişehir*, Doctorate Thesis, Graduate School of Social Sciences, Middle East Technical University.
- Sivri, N., and Seker, D. Z.,** (2010). Investigation of Enteric Bacteria of Surface Waters in the Southwestern Coast of Istanbul by means of GIS, *Turkish Journal of Fisheries and Aquatic Sciences* 10(4): 505-511.
- Smith, B. R.,** (2007). *Assessing the Feasibility of Creek Daylighting in San Francisco*, Part I: a Synthesis of Lessons Learned from Existing Urban Daylighting Projects, Restoration of Rivers and Streams, Water Resources Collections and Archives, University of California Water Resources Center, UC Berkeley.
- Strahler, A. N.,** (1952). Hypsometric (area-altitude) analysis of erosional topography, *Geological Society American Bulletin*, 63, 1117–1142.
- Sustainable Rivers Audit (SRA),** Available at: <http://www.mdba.gov.au>
- Teclaff, L. A.,** (1996). Evolution of the River Basin Concept in National and International Water Law, *Natural Resources Journal* 36 (2): 359–91.
- The Global Water Partnership's (GWP),** Available at: <http://www.gwp.org>
- The Theme Document of 4th Water Forum,** (2006). Water for Growth and Development, Thematic Documents of the *IV World Water Forum Commission*, Mexico City.
- TUBITAK,** Kentsel Dayanıklılık ve Ekosistem Servisleri İçin Sürdürülebilir Kent PlanlamaProje No: 110K530.

- Tuna, T.,** (2000). *From Hebdomon to Bakırköy, Bakırköy Belediyesi, Kültür Yayınları*, Istanbul.
- Turker, P. A.,** (1998). *Impact of planning and urban factor on urban water management the case of Ankara*, Master Thesis, Social Sciences Faculty, Middle East Technical University.
- TurkStat,** Turkish Statistical Institute (2010), Accessible at:
<http://www.turkstat.gov.tr/>
- Turoğlu, H.,** (2011). Flashfloods and Floods in Istanbul (İstanbul'daki Sel ve Taşkınlar), *Ankara Üniversitesi Çevre Bilimleri Dergisi* Cilt: 3, Sayı: 1, 39-46.
- United Nations,** (1987). Report of the World Commission on Environment and Development: Our Common Future.
Available at: [http:// www.sustainablecommunityinitiative.com](http://www.sustainablecommunityinitiative.com)
- United Nations,** (1993). Human Development Report, Oxford University Press,
Available at http://hdr.undp.org/en/media/hdr_1993_en_contents.pdf
- United Nations,** (2005). World Summit of High Level Plenary Meeting, 14-16 Sept.
Available at: <http://www.un.org/summit2005/>
- United Nations,** (2001). Population Division, Available at:
<http://www.un.org/esa/population/>
- UNU/IAS Report,** (2003). *Urban Ecosystem Analysis, Identifying Tools and Method*, United Nations University Institute of Advanced Studies.
- Vitousek, P. M., Harold A. M., Lubchenco J., and Melillo J. M.,** (1997). Human Domination on Earth's Ecosystems, *Science*, Vol.277.
- Walsh, C. J., Roy A. H., Feminella, J. W., Cottingham, P. D., Groffman, P. M., and Morgan, R. P.,** (2005). The Urban Stream Syndrome: Current Knowledge and the Search for a Cure, Cooperative Research Centre for Freshwater Ecology, *Water Studies Centre and School of Biological Sciences*, Monash University, Victoria, Australia.
- Ward, A., and D'Ambrosio, J. L.,** (2008). Stream Classification, *the Ohio State University Agriculture and Natural Resources Fact Sheet*, Ohio, USA.
- Watson, I., and Comert, Y.,** (2009). Istanbul buries dead after fatal floods, CNN.com/europe. Available at:
<http://edition.cnn.com/2009/WORLD/europe/09/11/turkey.floods/>
- White, M. D., and Greer, K. A.,** (2005). *The effects of watershed urbanization on the stream hydrology and riparian vegetation of Los Penasquitos Creek*, California.

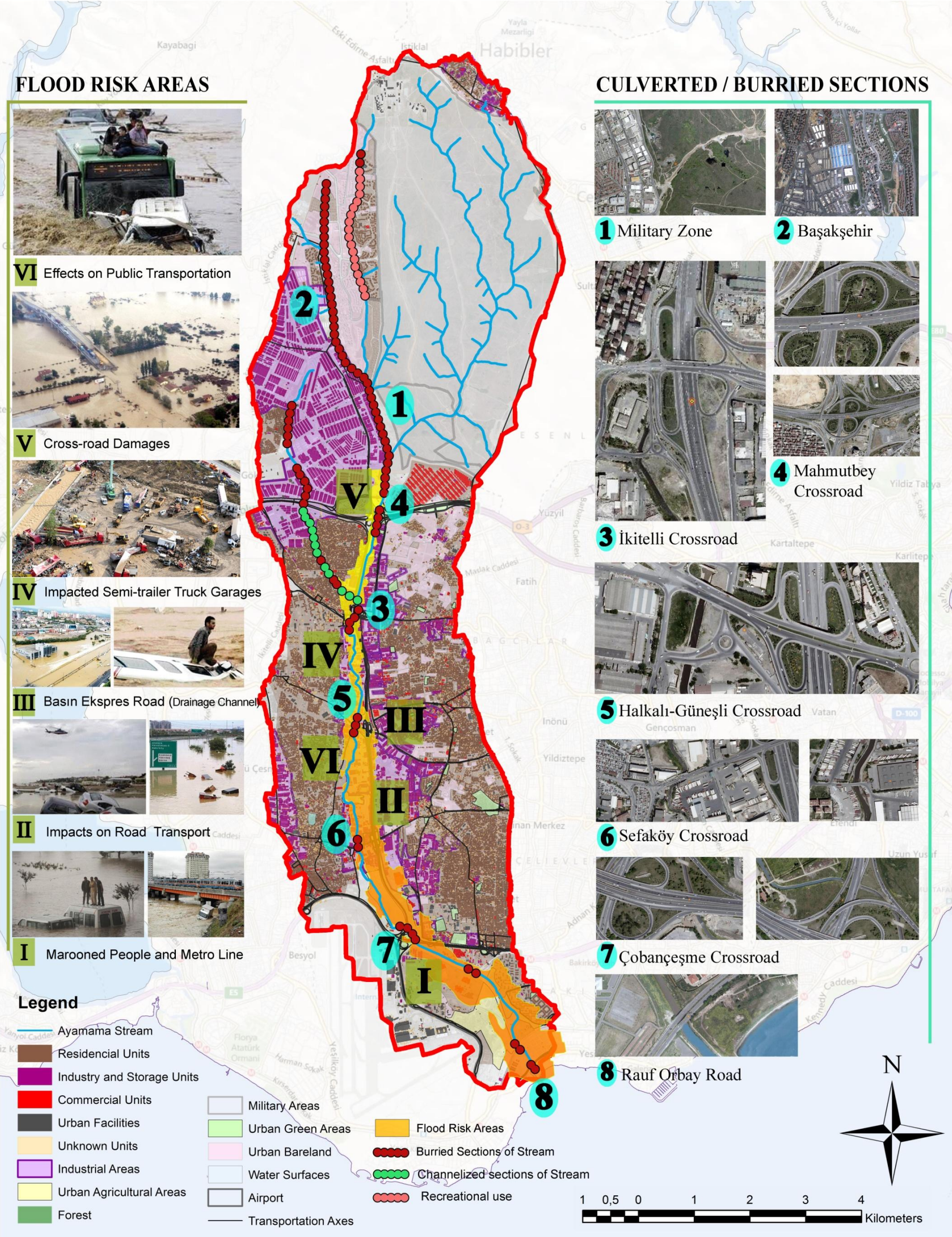
- Wild, T.C., Bernet, E.L., and Westling D.N.,** (2009). Deculverting: reviewing the evidence on the ‘daylighting’ and restoration of culverted rivers, *Water and Environment Journal*, Volume 25, Issue 3, pp 412–421.
- Wolf, A., Natharius, J., Danielson, J., Ward, B., and Pender, J.,** (1999). International River Basins of the World, *International Journal of Water Resources Development* 15(4): 387-427.
- Wolf, K., and Blahna, D.,** (2010). *Urban Ecosystem Services*, Seattle’s Urban Forest, Laos/Cambodia Study Tour: Ecosystem Services, Seattle.
- World Commission on Environment and Development:** Our Common Future Report, (1987). Available at: <http://www.un-documents.net/wced-ocf.htm>
- Yalçın, G., and Akyürek, Z.,** (2004). Multiple criteria analysis for flood vulnerable Areas, *24th Annual ESRI International User Conference* City: ESRI: San Diego, CA.
- Yücel, I.,** (2010). İklim Değişimi, Erken Uyarı Sistemleri ve Yenilikler-Taşkın Modellemesi, *2nd National Flood Symposium (II Ulusal Taşkın Sempozyumu)* Afyonkarahisar.
- Zhao, Y. W., Yang Z. F., and XU F.,** (2007). Theoretical framework of the urban river restoration planning, *Environmental Informatics Archives*, Volume 5, 241-247.
- Url-1**< <http://www.ucmp.berkeley.edu/exhibits/biomes> >, data retrieved 12.09.2011.
- Url-2**< <http://www.epa.gov/bioiweb1/aquatic/freshwater.html>>, data retrieved 02.10.2011.
- Url-3**< <http://www.physicalgeography.net/>>, data retrieved 08.11.2011.
- Url-4**< <http://www.ucmp.berkeley.edu/exhibits/biomes/freshwater.php>>, data retrieved 02.10.2011.
- Url-5**< http://unesco.uiah.fi/water/material/03_water_and_civilisation_html>, data retrieved 08.11.2011.
- Url6** < <http://www.whidbeywatersheds.org/watershed.html>>, data retrieved 15.10.2011.
- Url-7**< http://www.conservation-ontario.on.ca/about/cross_section.html>, data retrieved 05.12.2011.
- Url-8**< <http://en.wikipedia.org/wiki/Danube>>, data retrieved 05.12.2011.

- Url-9< <http://www.swfwmd.state.fl.us/education/watersheds>>, data retrieved 07.11.2011
- Url-10< <http://www.waterhistory.org>>, data retrieved 02.11.2011.
- Url-11< <http://www.derm.qld.gov.au>>, data retrieved 01.10.2011.
- Url-12< <http://samuelbekx.wordpress.com/2008/11/15/randstad-bezoek>>, data retrieved 22.10.2010.
- Url-13< <http://www.reuters.com>>, data retrieved 12.11.2010.
- Url-14< <http://en.wikipedia.org/wiki/Seine>>, data retrieved 15.03.2012.
- Url-15< <http://en.wikipedia.org/wiki/Budapest>>, data retrieved 15.03.2012.
- Url-16< http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch12s12-2-3.html>, data retrieved 14.10.2010.
- Url-17< <http://www.ruimtevoorderivier.nl>>, data retrieved 23.10.2010.
- Url-18< <http://www.hazinedaroglu-group.com/ProjectDetail.aspx?PID=47&CID=6>> data retrieved 02.04.2012.
- Url-19< http://en.wikipedia.org/wiki/European_route_E80>, data retrieved 02.04.2012.
- Url-20< http://tr.wikipedia.org/wiki/Ayamama_Deresi>, data retrieved 01.04.2012.

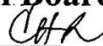
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APPENDIX B: Water Quality Certification of the Castro Valley Creek Daylighting Project at the Castro Valley Library Site, Castro Valley, Alameda Country, USA.

 Linda S. Adams Secretary for Environmental Protection	California Regional Water Quality Control Board San Francisco Bay Region <i>WT 11</i>  1515 Clay Street, Suite 1400, Oakland, California 94612 (510) 622-2300 • Fax (510) 622-2460 http://www.waterboards.ca.gov/sanfranciscobay	 Arnold Schwarzenegger Governor
Date OCT 03 2006 File No.: 2198.11 (LGP) Site No.: 02-01-C0910 ACOE File No.: 30391S Mr. George Sukkar Deputy Director, Engineering & Construction Alameda County Public Works Agency 399 Elmhurst Street Hayward, CA 94544		
Subject: Water Quality Certification for the Castro Valley Creek Daylighting Project at the Castro Valley Library Site, Castro Valley, Alameda County.		
Dear Mr. Sukkar:		
Legal Support	We have reviewed the application materials submitted by the Alameda County Flood Control and Water Conservation District (Applicant) for the Castro Valley Creek Daylighting project, located along Castro Valley Creek (Flood Control District Zone 2, Line J) from Castro Valley Boulevard to Norbridge Avenue near the center of the unincorporated community of Castro Valley (Project) and hereby issue certification as described herein. The Applicant has applied to the United States Army Corps of Engineers (ACOE) for authorization of this Project under Clean Water Act (CWA) Section 404 Nationwide Permit No. 27 (Wetland and Riparian Restoration and Creation Activities) and Nationwide Permit No. 33 (<i>Temporary Construction, Access and Dewatering</i>). You applied to the San Francisco Bay Regional Water Quality Control Board (Water Board) in accordance with CWA Section 401 for water quality certification verifying that the project will not violate State water quality standards.	
Scope of the Project	Project Description: The following project description is summarized from application materials submitted on July 12, 2006, August 3, 2006, and August 14, 2006. The purpose of the Project is to serve as a mitigation credit for the loss of concrete-lined open creek channel resulting from the Intermodal Transportation Corridor Improvements Project (Water Board Site No. 02-01-C0809) in the City of Union City, so that there will be no net loss of creek channel. The Project will daylight the buried segment of Castro Valley Creek, extend the existing riparian corridor, and compliment the proposed public library site.	
Primary Goal		
<i>Preserving, enhancing, and restoring the San Francisco Bay Area's waters for over 50 years</i>		
 Recycled Paper		

The Project is divided into two reaches; the lower reach or the southern half of the Project, is defined by a box culvert approximately 12-foot wide by 6-foot deep by 300-foot long. This reach will be restored through demolition and reconstruction of the exposed creek bed together with numerous soil lift areas with willow stakes, and multiple vortex, log, and rock weirs. The creek banks will be laid back to a 1:1.5 ratio with limited use of large rock riprap at the toe of the bank and/or terraced with log crib walls to minimize bank erosion and to protect the foundation of the library building (as established in the attached diagrams). The channel will be sized to provide temporary flood storage while providing the natural stream sinuosity and a natural stream cross section with appropriate bankfull channel dimensions. The daylighted segment has been designed to provide flood protection at or above current capacity and to minimize erosion.

Flood Protection

The upper reach, or northern half of the Project, is a 600-foot previously reconstructed channel with timber crib-walls, an earthen creek bed and a mix of native and non-native riparian vegetation. Project work in this reach will include clearing non-native trees mostly along the top of the creek banks and replanting with native species.

Native Vegetation Use

Additional Project features include a pedestrian bridge about 5 foot wide and 50 feet long that will be incorporated into the creek restoration work. A proposed playground along the westerly downstream portion of the restored creek may be included as part of the Project.

Recreational amenities

Impacts: The Project will permanently impact approximately 900 feet of Castro Valley Creek. The lower reach of the Project involves demolition and removal of a 300-foot long concrete box culvert to daylight Castro Valley Creek. This section of the Project site is nearly devoid of vegetation, with the exception of two large Western Sycamore trees growing near the culvert inlet which will be flagged and protected during construction activities. Approximately 100 cubic yards of rock riprap will be added to the toe of the creek banks for erosion control. Temporary placement of 10 cubic yards of sand bags will be needed for the coffer dam that will temporarily impact 25 linear feet of Castro Valley Creek.

Length of Daylighting**Erosion Control**

The 600-foot upper reach is a bio-engineered creek channel; restoration work will consist of clearing invasive under-story species, thinning the existing willow trees, removing a few non-native trees mostly along the top of the creek banks, and replanting the area with native species. Work will be done by hand to preserve existing native species.

Main Project at Larger Scale

Mitigation: This project is compensatory mitigation (Water Board Site No. 02-01-C0809) for culverting 490 linear feet of the Line M Channel in Union City, as part of the Intermodal Transportation Corridor Improvements Project in Union City and is designed to restore native vegetation and more natural stream functions to the Project reach of Castro Valley Creek. The Applicant estimates that this 50-foot wide by 900-foot long Project reach is capable of sustaining 134 mature trees and 50 percent ground cover. Average tree spacing will be less than 20 feet. The 600-foot upstream reach of Castro Valley Creek will be improved by removing as many as 30 non-native trees and replaced at a ratio of 1:1. The 300-foot lower reach will be fully restored with native tree, shrub, and herbaceous species. The completed Project will provide improved riparian habitat along this segment of Castro Valley Creek.

Riparian Vegetation

Impact

CEQA Compliance: As a small habitat restoration project, the Project is categorically exempt from review under the California Environmental Quality Act (CEQA) pursuant to Section 15333 of the CEQA Guidelines.

Wetland Tracker System: It has been determined through regional, state, and national studies that tracking of mitigation/restoration projects must be improved to better assess the performance of these projects, following monitoring periods that last several years. In addition, to effectively carry out the **State's No Net Loss Policy for wetlands**, the State needs to closely track both wetland losses and mitigation/restoration project success. Therefore, we require that the Applicant (or Discharger) use a standard form to provide Project information related to impacts and mitigation/restoration measures. An electronic copy of the form and instructions can be downloaded at: <http://www.waterboards.ca.gov/sanfranciscobay/certs.htm>. Project information concerning impacts and mitigation/restoration will be made available at the web link: <http://www.wetlandtracker.org>.

**Watershed
Approach**

Certification: I hereby issue an order certifying that any discharge from the referenced Project will comply with the applicable provisions of sections 301 (Effluent Limitations), 302 (Water Quality Related Effluent Limitations), 303 (Water Quality Standards and Implementation Plans), 306 (National Standards of Performance), and 307 (Toxic and Pretreatment Effluent Standards) of the Clean Water Act, and with other applicable requirements of State law. This discharge is also regulated under State Water Resources Control Board Order No. 2003 - 0017 - DWQ, **"General Waste Discharge Requirements for Dredge and Fill Discharges That Have Received State Water Quality Certification"** which requires compliance with all conditions of this Water Quality Certification. The following conditions are associated with this certification:

**Water
Quality
Certification
(Legal
Indicators)**

1. No debris, rubbish, creosote-treated wood, soil, silt, sand, cement, concrete, or washings thereof, or other construction related materials or wastes, oil or petroleum products or other organic or earthen material shall be allowed to enter into, or be placed where it may be washed by rainfall or runoff into Castro Valley Creek. Any of these materials placed within or where they may enter Castro Valley Creek by the Applicant or any party working under contract, or with the permission of the Applicant shall be removed immediately. When operations are completed, any excess material shall be removed from the work area and any areas adjacent to the work area where such material may be washed into Castro Valley Creek. During construction, the contractor shall not dump any litter or construction debris within the riparian/stream zone. All such debris and waste shall be picked up daily and properly disposed of at an appropriate site;
2. All Standard and Special Conditions of the ACOE permit authorization under Nationwide Permit No. 27 (*Wetland and Riparian Restoration and Creation Activities*) and No. 33 (*Temporary Construction, Access and Dewatering*) shall be fully implemented;
3. The Applicant shall adhere to the conditions imposed by the California Department of Fish and Game in the Streambed and Lake Alteration Agreement (Notification No. 1600-2006-0501-3) issued for the Project;

4. The Project shall be constructed as described in the submitted application materials, including the *Castro Valley Creek Daylighting Project at the Castro Valley Library Site, Castro Valley, Alameda County Mitigation and Monitoring Plan* (Mitigation and Monitoring Plan) (Staff for Alameda County Flood Control and Water Conservation District, July 12, 2006 and revised August 14, 2006);
5. The Applicant shall submit a final design 90 days before commencement of construction for Executive Officer's approval demonstrating that the Project is consistent with the conceptual design that was submitted in the application materials, Water Board staff will respond within 30 days after the final design is received;
6. Riparian tree plantings shall be monitored for a minimum period of ten years, until the performance criteria of 134 trees (average tree spacing will be less than 20 feet) and 50 percent shrub and herbaceous cover (native and non-native species) has been established as specified in Section 7.2 of the Mitigation and Monitoring Plan are achieved; **Vegetation Monitoring**
7. Riparian trees shall be planted and maintained as specified in Section 9.1 of the Mitigation and Monitoring Plan; **Annual Report of Monitoring**
8. Annual reports shall be submitted to the Water Board by December 31st, in years 1, 3, 5, 7, and 10, summarizing each year's monitoring results, including the need for any remedial actions (e.g., re-planting, channel stabilization). The annual reports shall compare data to previous years and detail progress towards meeting final performance criteria. At the end of year ten, a comprehensive final report shall be prepared that includes summaries of the monitoring data and representative photos. Annual reports and the comprehensive final report shall include photographs from the photo-documentation points specified in Condition 9. The final report shall document if the site meets the final performance criteria. If the criteria are not met, the report shall identify measures to be undertaken, including extension of the monitoring, maintenance, and the reporting period until the criteria are met;
9. To document channel and bank conditions in the upper and lower Project reaches, the Applicant shall establish a minimum of 4 photo-documentation points in each reach. The Applicant shall prepare site maps with the photo-documentation points clearly marked. Following construction, the Applicant shall photographically document the immediate post-construction condition of the Project reach and submit a report to the Water Board, including the post-construction photographs, and the map with the locations of the photo-documentation points;
10. Annual reports shall include an evaluation of the geomorphic stability of the creek channel. The evaluation shall include an assessment of any scour visible on the creek banks, a visual assessment of the channel for any signs of head cuts or nick points, a visual assessment of any significant aggradation of the channel in the Project reach, and an assessment of the stability of the log cribwalls;

11. All disturbed areas of bed and bank shall be stabilized, winterized, and vegetated with appropriate native vegetation by October 15th, with the exception of live stakes;
12. The Project reach of Castro Valley Creek needs to demonstrate basic geomorphic stability and conformance with the original design at the end of year 10, if not the Applicant shall work with the ACOE, CDFG, and the Water Board to prepare an analysis of the cause of the instability and develop remedial actions;
13. The Applicant is required to use the standard Wetland Tracker form to provide Project information describing impacts and mitigation/restoration measures within 14 days from the date of this certification. The completed Wetland Tracker form shall be submitted electronically to wetlandtracker@waterboards.ca.gov or shall be submitted as a hard copy to the address on the letterhead to the attention of Wetland Tracker;
14. This certification action does not apply to any discharge from any activity involving a hydroelectric facility requiring a Federal Energy Regulatory Commission (FERC) license or an amendment to a FERC license, unless the pertinent certification application was filed pursuant to California Code of Regulations (CCR) Title 23, Subsection 3855(b) and that application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought; and
15. Certification is conditioned upon full payment of the required fee as set forth in 23 CCR **Project Funding** Section 3833. **The total fee required for certification of the restoration project is \$500.00.** Water Board staff received payment in full on July 12, 2006.

Please be aware that any violation of water quality certification conditions is a violation of State law and subject to administrative civil liability pursuant to California Water Code (CWC) Section 13350. Failure to respond, inadequate response, late response, or failure to meet any condition of a certification or waiver may subject the Applicant to civil liability imposed by the Water Board to a maximum of \$5,000 per day of violation or \$10 for each gallon of waste discharged in violation of this action. Any requirement for a report made as a condition to this action (i.e., conditions 5, 8, 9, 10 and 13) is a formal requirement pursuant to CWC Section 13267, and failure or refusal to provide, or falsification of such requirement report is subject to civil liability as described in CWC Section 13268.

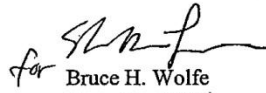
If you have any questions, please contact Leslie Perry at (510) 622-2312, or via e-mail at lperry@waterboards.ca.gov. All future correspondence regarding this Project should reference Site No. 02-01-C0910.

Mr. Sukkar

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Castro Valley Creek Daylighting Project
At the Castro Valley Library Site

Sincerely,


for Bruce H. Wolfe
Executive Officer

Attachments:

- A. Castro Valley Creek Cross Section D-D
- B. Castro Valley Creek Cross Section E-E
- C. Castro Valley Creek Daylighting Overlay PDF

Cc (without attachments):

Stakeholders

SWRCB-DWQ, Attn: Oscar Balaguer

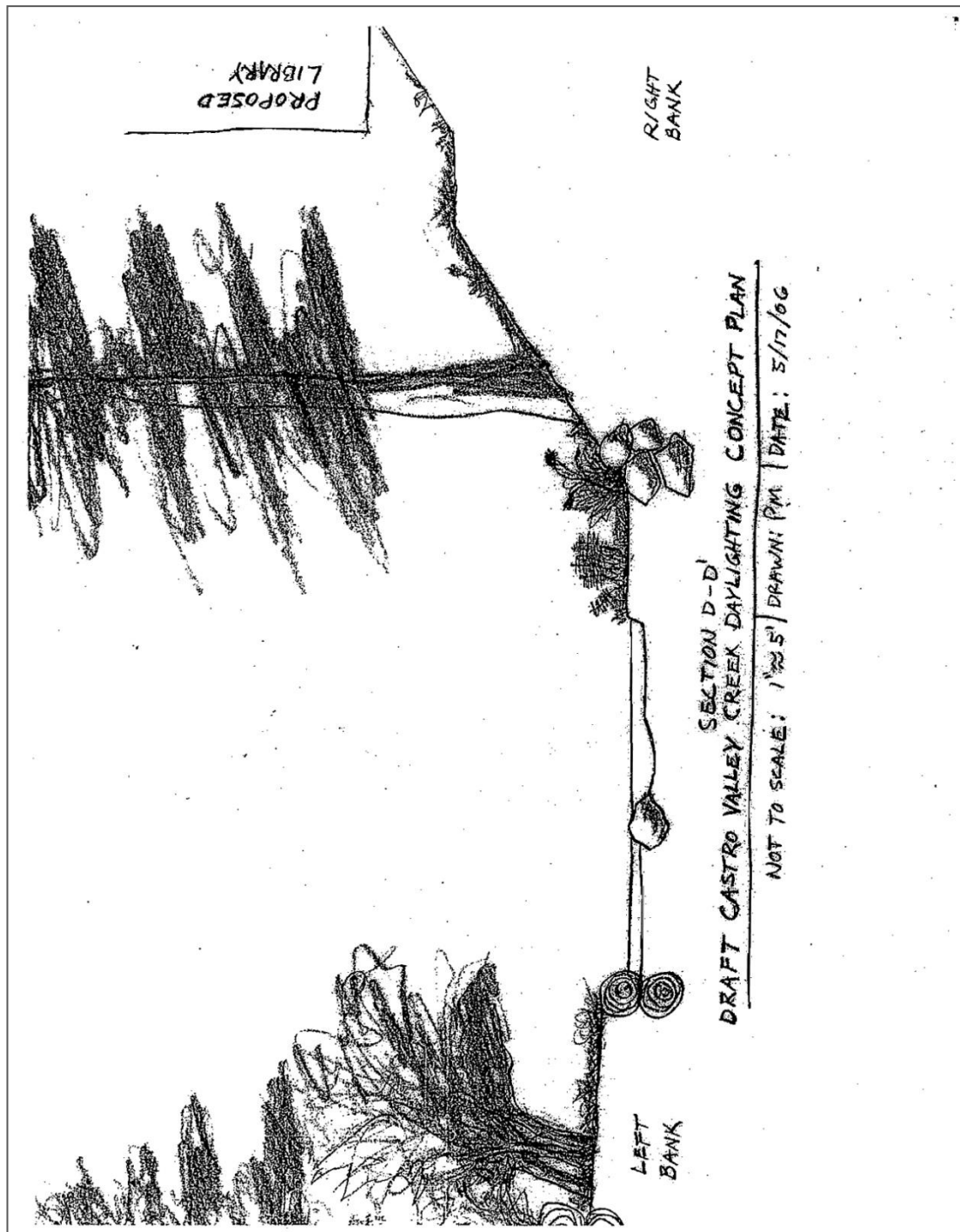
ACOE, San Francisco District, Attn.: Holly Costa, 333 Market Street, San Francisco, CA 94105

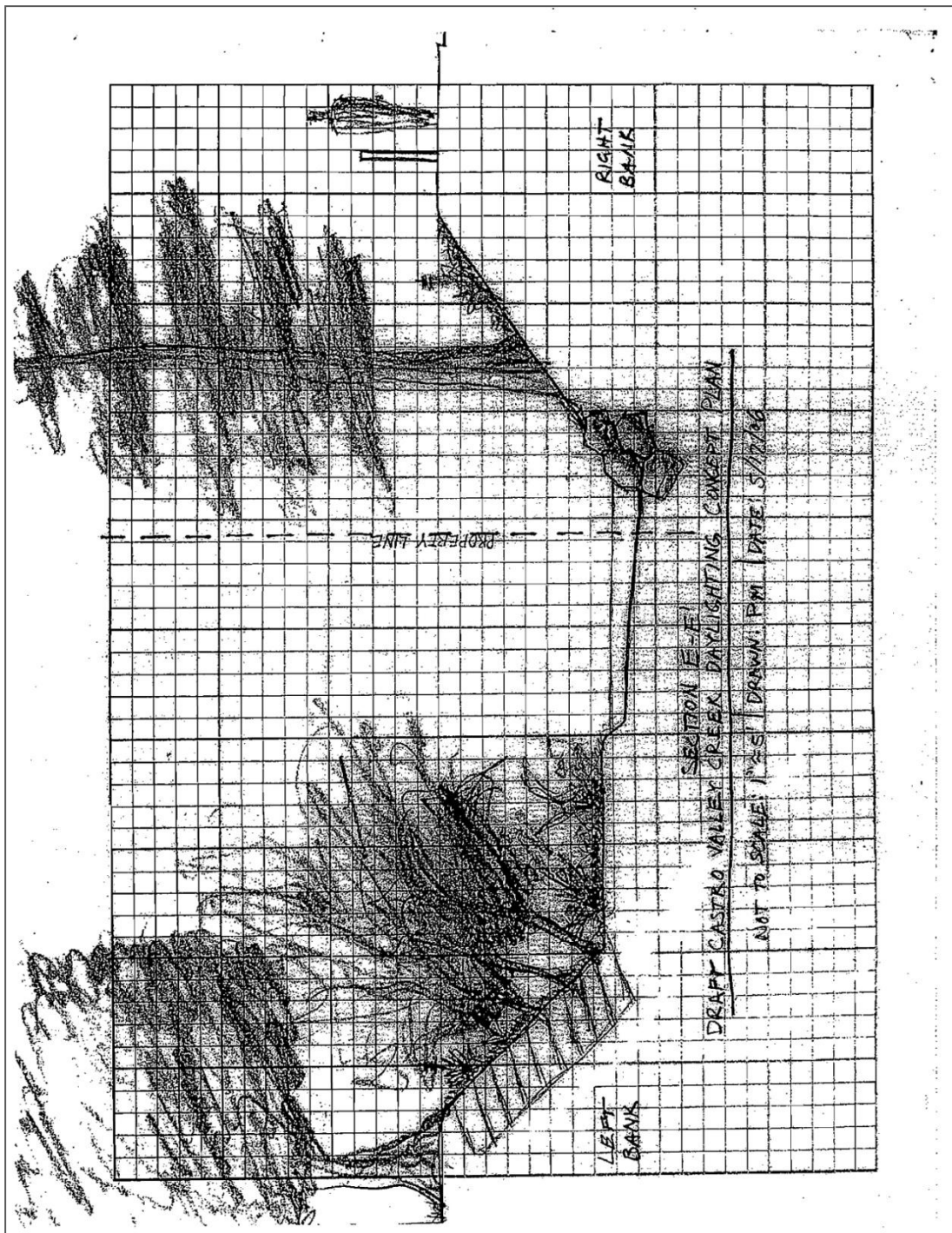
CDFG, Central Coast Region, Attn.: Marcia Grefsrud, P.O. Box 47, Yountville, CA 94599

U.S. EPA, WTR-8 Mr. Tim Vendlinski, 75 Hawthorne Street, San Francisco, CA 94105

Alameda County Flood Control and Water Conservation District, Paul Modrell, 399 Elmhurst Street, Hayward, CA 94544

City of Union City, Joan Mollay, 34009 Alvarado-Niles Road, Union City, California 94587





CURRICULUM VITAE



Name Surname: Meltem DELİBAS

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B.Sc.: Ankara University, Department of Landscape Architecture

Professional Experience and Rewards:

- The Best Graduation Degree at Ankara University (1st degree in the Department of Landscape Architecture)
- TUBITAK (*The Scientific and Technological Research Council of Turkey*) Domestic Master Scholarship (2 years)
- TUBITAK-SUPER (*Sustainable Urban Planning for Ecosystem Services and Resilience*) Project No 110K350 working as scholarship (March 1, 2011)
- University of Groningen- The Netherlands, AB Socrates/ Erasmus Exchange Program (30.08.2010-12.02.2011)
- Republic of Turkey Ministry of Environment and Forestry, Eco-City Design, National Project Concept Competition (The 3rd Award at M.Sc Category)

PUBLICATIONS/ PRESENTATIONS ON THE THESIS

- Tezer A., and **Delibas M.**, 2011: Healthy Rivers for Urban Sustainability: A Spatial Management Approach. *The 2nd Conference on Healthy Rivers and Sustainable Water Resource Management*, October 20-22, 2011 Chongqing, China.
- **Delibas M.**, 2011: Sustainable Urban Streams for a Healthy Riverine Systems Case Study on Danube River. *244 ET- International Training Programme: Regional Development in Euphrates- Tigris Region*, September 27- October 7, 2011 Istanbul, Turkey. The 2nd Phase: December 5-9, 2011 Stockholm, Sweden.