ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

SUSTAINABLE PERFORMANCE MEASUREMENT MODEL FOR URBAN REGENERATION PROJECTS

Ph.D. THESIS

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Department of Architecture

Construction Sciences Programme

SEPTEMBER 2020

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KENTSEL DÖNÜŞÜM PROJELERİ İÇİN SÜRDÜRÜLEBİLİR PERFORMANS ÖLÇME MODELİ

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To my spouse and children,

FOREWORD

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September 2020 Emre ILICALI
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ABBREVIATIONS

AHP	: Analytical Hierarchy Process
BREEAM	: Building Research Establishment Environmental Assessment Method
BS	: British Standards
BSC	: Balanced Scorecard
CBPP	: Construction Best Practice Program
CPSFs	: Critical Project Success Factors
ÇŞB	: Çevre ve Şehircilik Bakanlığı (Turkish Ministry of Environment and Urban Planning)
DB	: Design-Built
DBB	: Design-Bid-Built
DEA	: Data Envelopment Analysis
EDGE	: Excellence in Design for Greater Efficiencies
EFQM	: European Foundation for Quality Management Excellence Model
EPS	: Earnings per Share
EU	: European Union
FAHP	: Fuzzy Analytical Hierarchy Process
GDP	: Gross Domestic Product
IEQ	: Indoor Environmental Quality
IPD	: Integrated Project Delivery
ISO	: International Standard Organization
IT	: Information Technologies
IUSIL	: International Urban Sustainability Indicators List
KPI	: Key Performance Indicator
KS	: Kolmogorov-Smirnov
LEED	: Leadership in Energy and Environmental Design
MBNQA	: Malcolm Baldridge National Quality Award
PMI	: Project Management Institute
PQR	: Project Quarterback Rating
ROE	: Return on Equity

ROI : Return on Investment

SMART : The Strategic Measurement Analysis and Reporting Technique System

SKPIs : Sustainable Key Performance Indicators

TS : Turkish Standards

UN DESA : United Nations Department of Social and Economic Affairs

SYMBOLS

Aw	: Normalized Group Decision Matrix
CI	: Consistency Index
CR	: Consistency Ratio
D	: Weighted Total Vector
E	: Consistency of The Eigenvector
H0	: Null Hypothesis
H1	: Opposite Hypothesis
RI	: To Random Index
Wi	: Relative İmportance (Priority) Vector
χ2	: Chi-Square
λmax	: Maximum Eigenvalue
α	: Cronbach Alpha Coefficient
p	: Significance Level

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SUSTAINABLE PERFORMANCE MEASUREMENT MODEL FOR URBAN REGENERATION PROJECTS

SUMMARY

The rapid urbanization of today’s world requires integrated policies to improve the lives of households. It could be claimed that the best way to address such problems in major cities is through sustainable urban regeneration where economical, ecological and social impacts of urbanization are examined and practiced thoroughly.

The main purpose of this study is to develop a sustainable performance measurement model for urban transformation projects. This model will provide an opportunity to measure the performance of urban regeneration projects with a multi-criteria hierarchical approach consisting of key performance indicators. The first of the specific objectives is to identify sustainability performance indicators. Another specific objective is to determine the importance weights of the components that make up the performance measurement model using the Analytic Hierarchy Process method.

The thesis study provided the formulation of the sustainable performance measurement model and key performance indicators for the urban transformation projects through the data obtained from the AHP method and field studies. The components of the performance measurement model were obtained from project performance indicators and sustainable indicators specific to urban regeneration projects in the literature. Also, performance components were presented for expert evaluations in field studies and their validity was evaluated accordingly.

These results demonstrate a low-level utilization of performance measurement systems in the overall construction sector, which also indicate the need for a thorough, practical performance measurement model proposed for the purpose of this thesis.

The most important motivating factors for adopting performance measurement systems were respectively: expected benefits of performance measurement, recommendations by consultants, client needs and expectations and requirements by international project partners. Other factors for adopting a performance measurement system voluntarily, such as becoming one of the best companies on a national and international scale and initiative of employees were ranked below. These results strongly suggest that performance management in construction projects is usually performed when it is mandatory and/or it is required by a third-party. This is another indication of a need for enhancing measurement practices in the overall management system. Also, most of the experts participating in the survey responded that they intend to utilize performance measurement systems in their future projects.

Original value-added parts of the proposed model include; primary focus on performance indicators instead of factors affecting performance, complementary approach on previous performance measurement models, specifying model weights using AHP approach including a validation process and final verification of the developed model in real-life projects. It should also be noted that the proposed model in this study is primarily specific to urban regeneration projects.

For the purpose of the study, 32 participants with expertise in different disciplines of construction and urban regeneration were involved in the model development phase. Validation of the proposed model was executed by contributions from 21 different experts. Finally, 5 experts from 3 different urban regeneration projects was involved in the model verification process by providing feedback.

The results obtained using AHP methodology indicate that Health & Safety (H & S) performance dimension (0,23), Financial performance dimension (0,20), Environmental performance dimension (0,18) are the most important parameters for measuring the performance of urban regeneration projects.

It should be emphasized that in this study, Health and Safety performance was ranked as the most important parameter for measuring the success of urban regeneration projects, which usually carry a high level of Health and Safety risk. Also, focusing on Environmental dimension in the survey results clearly indicate that sustainability issues should be the main topic when defining success in construction projects. These results reveal that there is a need for more sophisticated solutions for performance management in urban regeneration projects with more focus on Health & Safety and Sustainability. Most of the proposed KPI's determined as the output of this study are quantitative, which could be a good indication of the tendency of technical staff to rely on measurable results for project performance.

The model developed in this study can be used as a baseline for future research and may be improved in the context of alternative project types, stakeholders and/or organizations.

KENTSEL DÖNÜŞÜM PROJELERİ İÇİN SÜRDÜRÜLEBİLİR PERFORMANS ÖLÇME MODELİ

ÖZET

Günümüz dünyasında yaşanan hızlı kentleşme, yaşam kalitesini iyileştirmek adına entegre politikalar gerektirmektedir. Şehirlerin planlama kapasitesinin üzerinde olan bu hızlı kentleşme sürecinde ekonomik çıkarların önceliklendirilmesi bir çok sosyal ve çevresel konuda eksikliklere ve sorunlara neden olmaktadır. Büyük şehirlerde bu tür sorunları çözmenin en iyi yolunun, kentleşmenin ekonomik, ekolojik ve sosyal etkilerinin ayrıntılı olarak incelendiği ve uygulandığı sürdürülebilir kentsel dönüşüm politikaları ile sağlanabileceği öngörülmektedir. Bu bağlamda kentsel dönüşüm projeleri, geniş kapsamları, yüksek bütçeleri ve kentsel yaşam üzerindeki sosyal, ekonomik ve ekolojik etkileri nedeniyle inşaat sektörünün önemli bir alanı olarak kabul edilmektedir. Sürdürülebilirlik ve kentsel dönüşüm ilişkisi üzerine dünya literatüründe birçok çalışma yer alsa da kentsel dönüşüm projelerinin sürdürülebilirlik açısından değerlendirilmesi üzerine yapılan çalışmalar sınırlıdır.

Sürdürülebilir yaşam alanları ve kentlerin gelişmesi için sürdürülebilirlik prensiplerinin kentsel dönüşüm projelerine uygulanması gerekmektedir. Kentsel dönüşümün sürdürülebilirlik açısından değerlendirilmesi ise mevcut sorunların tespit etmesi ve ilerleyen zamanda daha doğru stratejiler geliştirilmesine fayda sağlaması açısından önem teşkil etmektedir. Sürdürülebilirlik ilkelerini uygulamak ve bu kadar karmaşık bir programda çalışmasını sağlamak için kentsel dönüşüm projeleri için belirli bir sürdürülebilir performans ölçüm modeline önemli bir ihtiyaç vardır. Bununla birlikte, kentsel dönüşüm projelerinin performansını değerlendirmeye yönelik yaklaşımlar ve modeller konusunda fikir birliği yoktur.

Literatür taramasında, geçmiş araştırmaların çoğunun, günümüz inşaat sektörünün tüm başarı ölçütlerini kapsamayan, performans ölçümü için yalnızca belirli anahtar performans göstergelerini içerdiği bulunmuştur. Sürdürülebilir kalkınmadaki sorunlar genellikle önerilen modellerde eksiktir. Ayrıca mevcut çalışmaların çoğu kentsel dönüşümde sürdürülebilir performans gibi belirli alanlara odaklanmamaktadır. Yine literatürde önerilen kriterler ve modeller için gerçek projelerde doğrulama eksikliği de ele alınması gereken bir diğer önemli konudur. Bu tez kapsamında bu konuları ele almak için kapsamlı ve yapılandırılmış bir yaklaşım benimsenmiştir. Nihayetinde, karar vericilerin kentsel dönüşüm projelerinde sürdürülebilir performansı ölçmeleri için metodolojik araç geliştirilmiştir. Buna ek olarak, önceden belirlenmiş bir dizi kriter ve temel göstergeyi kullanarak performans ölçümü, kıyaslama analizine olanak tanımaktadır.

Bu çalışmanın temel amacı kentsel dönüşüm projeleri için sürdürülebilir bir performans ölçme modeli geliştirmektir. Bu sayede, kentsel dönüşüm projelerinde verimli çözümler sunularak sorunların daha geniş bir perspektiften incelenmesi amaçlanmaktadır. Bu model kapsamında, temel performans göstergelerinden oluşan çok kriterli hiyerarşik bir yaklaşımla kentsel dönüşüm projelerinin performansını sürdürülebilirlik bağlamında ölçme imkanı sağlanacaktır. Çalışma kapsamında belirlenen hedeflerden ilki sürdürülebilirlik performans göstergelerini belirlemektir. Sürdürülebilir performans göstergeleri belirlenirken sürdürülebilirlik ekonomik, çevresel ve sosyal olmak üzere 3 boyutu ile ele alınmıştır. Bir diğer hedef ise, matematik ve psikolojiye dayalı, karmaşık kararları düzenlemek ve analiz etmek için yapılandırılmış bir teknik olan Analitik Hiyerarşi Süreci (AHP) yöntemini kullanarak performans ölçme modelini oluşturan bileşenlerin önem ağırlıklarını belirlemektir.

Tez çalışması kapsamında, AHP yöntemi ve saha çalışmalarından elde edilen verilerle temel performans göstergelerinin formülasyonu sağlanarak, kentsel dönüşüm projelerine yönelik sürdürülebilir performans ölçme modeli geliştirilmiştir. Performans ölçme modelinin bileşenleri, literatürde kentsel dönüşüm projelerine özgü proje performans göstergeleri ve sürdürülebilirlik göstergelerinin ayrıntılı incelenmesi sonucunda elde edilmiştir. Ayrıca saha çalışmalarında uzman değerlendirmeleri yapılarak söz konusu performans göstergelerinin geçerlilikleri değerlendirilmiştir. Çıkan sonuçlara göre, genel olarak inşaat sektöründe performans ölçüm sistemlerinin düşük düzeyde kullanıldığı belirlenmiştir. Bu sonuç, bu tez kapsamında önerilen kapsamlı, pratik performans ölçüm modeline duyulan ihtiyacı göstermektedir.

Saha çalışmaları sonucuna göre, performans ölçme sistemlerinin benimsenmesi için en önemli motivasyon faktörler sırasıyla şöyledir: performans ölçümünün beklenen faydaları, danışmanların önerileri, müşteri ihtiyaçları ile beklentileri ve uluslararası proje ortaklarının beklentileri. Bu sonuçlar, inşaat projelerinde performans yönetiminin genellikle zorunlu olduğunda ve/veya üçüncü tarafça gerekli olduğunda gerçekleştirildiğini kuvvetle göstermektedir. Bu, genel yönetim sisteminde kullanılabilir performans ölçüm uygulamalarının geliştirilmesinin ne kadar önemli olduğunun bir başka göstergesidir. Ankete katılan uzmanların çoğu, gelecekteki projelerinde performans ölçme sistemlerini kullanmayı planladıklarını belirtmektedir.

Model geliştirme aşamasında yapılan saha çalışmalarında 32 adet inşaat ve kentsel dönüşüm alanında farklı disiplinlerinde uzmanlığa sahip katılımcı yer almıştır. Önerilen modelin doğrulanması 21 farklı uzmanın katkılarıyla yürütülmüştür. Son olarak, 3 farklı kentsel dönüşüm projesinden 5 uzman geri bildirim sağlayarak model doğrulama sürecine dahil olmuştur.

Model için hedef kullanıcı grubu, kentsel dönüşüm projelerinden uzmanları içermektedir. Ancak önerilen model, kamu görevlileri de dahil olmak üzere kentsel dönüşüm projelerinin tüm paydaşları tarafından kullanılabilir. Kapsamlı bir literatür çalışması ve konu uzmanlarından gelen geri bildirimlerin ardından, sürdürülebilir performansı ölçmek için birçok faktör önerilen modele dahil edilmiştir. Modelin bu unsurları kentsel dönüşüm, proje yönetimi ve sürdürülebilirliğin bir sentezini sunmaktadır.

Tez kapsamında geliştirilen model, boyutlar, kriterler ve göstergelerle hiyerarşik olarak geliştirilmiştir. Saha Çalışması-A kapsamında, 1-7 ölçeğinde anahtar performans göstergelerinin önem ağırlıkları belirlenmiştir. Modelin bileşenlerinden olan kriterler ve boyutların da ikili karşılaştırmalar yapılarak önem sıraları tespit edilmiştir. Saha Çalışması-A'nın katılımcıları, kentsel dönüşüm projelerinde çalışan geniş bir yelpazedeki farklı disiplinleri temsil etmektedir. Saha Çalışması-A'da elde edilen sonuçlar genel olarak inşaat sektöründe performans ölçüm sistemlerinin düşük düzeyde kullanıldığını ortaya çıkartmaktadır. Ayrıca bu çalışma kapsamında çıkan sonuçlara göre daha önceki projelerinde proje performans ölçme sistemini kullanan uzmanlar için motivasyon faktörleri tercih oranlarına göre; performans ölçümünün beklenen faydaları (% 21,62), danışmanlık firmalarının tavsiyeleri (% 16,22) ve müşteri gereksinimleri (% 13,51) olarak sıralanmaktadır.

AHP metodolojisi kullanılarak elde edilen sonuçlar, Sağlık ve Güvenlik (H & S) Performans Boyutu (0,23), Finansal Performans Boyutu (0,20), Çevresel Performans Boyutu (0,18)'nun kentsel dönüşüm projelerinin performansını ölçmek için en önemli parametreler olduğunu göstermektedir. Bu çalışmada, Sağlık ve Güvenlik Performansı'nın, genellikle yüksek düzeyde Sağlık ve Güvenlik riski taşıyan kentsel dönüşüm projelerinin başarısını ölçmek için en önemli parametre olarak belirlenmesinin önemi özellikle vurgulanmalıdır. Ayrıca, anket yine ön plana çıkan çevresel performans boyutu, inşaat projelerinde başarıyı tanımlarken sürdürülebilirlik konularının ana konu olması gerektiğini açıkça göstermektedir. Bu çalışmanın sonuçları, kentsel dönüşüm projelerinde performans yönetimi için daha fazla sağlık ve güvenlik ve sürdürülebilirlik odaklı, kapsamlı çözümlere ihtiyaç olduğunu ortaya koymaktadır.

Sonraki adım olan Saha Çalışması-B kapsamında, geliştirilen modelin kullanılabilirlik, pratiklik ve işlevsellik açısından geçerliliği incelenmiştir. Bu çalışmanın sonucuna göre önerilen model uzmanlar tarafından kentsel dönüşüm projeleri için sürdürülebilir performansın ölçülmesinde faydalı, pratik ve uygulanabilir olarak değerlendirilmiştir.

Son olarak, geliştirilen kentsel dönüşüm projeleri için sürdürülebilir performans ölçüm modelini test etmek amacıyla Saha Çalışması-C gerçekleştirilmiştir. Geliştirilen sürdürülebilir performans ölçme modeli ile 3 kentsel dönüşüm projesinin performansı ölçülmüş ve modelin performans ölçmedeki başarısı değerlendirilmiştir.

Bu çalışma kapsamında önerilen kriterler ve anahtar performans göstergeleri, gelecekte karar vericilerin performansı artırmaya yönelik geri bildirimleri, ve ihtiyaçlarına göre uyarlanabilir. Ayrıca tez kapsamında hazırlanan model, projelerdeki performansı ölçmek için mevcut sistemlere uyarlanabilir veya daha da geliştirmek için bir kılavuz olarak kullanılabilir.

Bu tez kapsamında yapılan sürdürülebilir performans ölçme modelinin geliştirilmesine yönelik çalışmaların orijinal katma değerli bölümleri şöyledir: Performansı etkileyen faktörler yerine performans göstergelerine odaklanılması, önceki performans ölçme modellerine tamamlayıcı yaklaşım, doğrulama süreci ve geliştirilen modelin nihai doğrulanmasını da içeren gerçek projelere entegre edilerek sonuçların incelenmesi. Ayrıca, bu çalışmada önerilen modelin öncelikle kentsel dönüşüm projelerine özgü olduğu unutulmamalıdır.

Bu çalışmada geliştirilen model gelecekteki araştırmalar için bir temel olarak kullanılabilir ve alternatif proje türleri, paydaşlar ve/veya kuruluşlar bağlamında geliştirilebilir.

1. INTRODUCTION

It is a known fact that in the construction industry, more complex and big projects are on the agenda todayand it is becoming more important to reach the goals in terms of time, cost and quality. Most of the efficiency problems related to construction sector today are directly or indirectly related with performance measurement.In addition to that growing competition in the business world has forced the construction industry to measure performance beyond financial quantitative performance indicators (Tekçe, 2010).

In the literature about performance, it has been found that the studies related to performance measurement are generally focused on the project level, since the construction activity is project-based by nature. (Akkoyun & Dikbas, 2008). There are limited studies on the project performance of overall construction sector, (Chan & Chan, 2004; Fang, Huang, & Hinze, 2004; Jones & Kaluarachchi, 2008; Lam, Chan, & Chan, 2007; Lin & Shen, 2007; Pillai, Joshi, & Rao, 2002; Sharma, 1995; Yeung, Chan, & Chan, 2008; Yeung, Chan, Chan, & Li, 2007) in urban transformation projects (Chan & Chan, 2004; Fang, Huang, & Hinze, 2004; Jones & Kaluarachchi, 2008; Lam, Chan, & Chan, 2007; Lin & Shen, 2007; Pillai, Joshi, & Rao, 2002; Sharma, 1995; Yeung, Chan, & Chan, 2008; Yeung, Chan, Chan, & Li, 2007).

There is no one-size-fits-allperformance measurement and assessment method used for the project, firm and industry levels in the construction industry.

Some of the suggested future research topics inldues; Determining the current applications in the industry and developing non-financial qualitative performance measurement and evaluation methods, developing techniques for the application of performance measurement systems, designing more dynamic and flexible performance measurement systems and solving the problems of transferring the performance measurement models to the administrative models in the field of performance measurement and evaluation. (Bassioni, Price, & Hassan, 2004).

This thesis aims to develop a sustainable performance measurement model for urban regeneration projects based on the understanding that any phenomenon is uncontrollable if it cannot be measured. Developed sustainable performance measurement model shall be based on the performance dimensions of the previously generated models to provide contextual validity.

Following topics are explained in Introduction section:

- A brief background information regarding the conceptual approach (i.e. Background Information).
- Identification of the academic and sectoral gaps within the scope of the thesis.
- The studies to be carried out for achieving the aims and objectives (i.e.the method of the thesis).
- Scope of the thesis, challenges encountered during workings, any limits for research progress and actions taken to remove these barriers (i. e. The Aim and Objectives).
- Lastly, the organization of the thesis is presented. The methodology diagram (see Figure 2.1) is used to explain the organization of the thesis.

1.1 Background Information

Construction industry has an important role on national economies. Itstimulates economic growth via the demand for inputs it uses to produce goods and services. Thus construction sector is a major contributor for employment and important driving force for overall economic growth (Berk, Biçen, & Seyidova, 2017). Tsolas (2001) stated that financial indicators should include the reflection of the construction industry’s success (Tsolas, 2011). The construction sector has a massive impact on the economy in terms of share on 15% of global GDP and 9% of Turkey’s GDP. During periods of rapid economic expansion, construction output usually grows faster than other sectors, but during periods of stagnation, the construction industry is the first to suffer (Ramachandra, Rotimi, & Rameezdeen, 2014). Even though, these significant contributions of the construction industry in the economy, many research indicate the falling performance of the construction industry (Bassioni, Price, & Hassan, 2005; Kagioglu, Cooper, & Aoudad, 2001; Lee, Cooper, & Aouad, 2000; Smith, 2001).

It is a well-known fact that in today's construction sector, more and more complex projects are on the agenda, and it is becoming more important to achieve the goals in terms of time, cost and quality in the known nature of the industry. Therefore, one of the important requirements of being competitive is controlling the performance of the process and monitoring the progress (Tekçe, 2010). The competitive environment mandates organizations to measure financial performance (Akkoyun & Dikbas, 2008). Performance measurement dependent on exact indexes, efficiency, and effectiveness is commonly used for examining the performance of construction firms (Tsolas, 2011).

Construction is defined as an inefficient sector due to its unique characteristics. This failure is explained by cost, time-out, poor quality, customer dissatisfaction, and low profitability. Many researchers and authors have stated that the productivity of the construction industry has declined over the last few decades compared to other economic sectors (Arditi, 1985; Rojas & Aramvareekul, 2003).

Population, production, housing needs, technical infrastructure systems, education-culture-arts-management organizations in concentrated centers of the world cities are constantly growing. At the same time, urban areas are experiencing economic, technological, social and cultural transformations together (Topal, 2004). This rapid growth in the cities of developing countries is far ahead of these countries' urban management and planning capacities. Therefore unmanaged and unplanned urban growth disrupts these cities (Yazar, 2006). Cities are becoming potential centers for many social, environmental and economic problems, such as inequality, unemployment, poverty, inadequate infrastructure and services, traffic congestion, violence, crime and diseases (Blowers & Pain, 1999; Jian, De-nong, & Yu-kun, 1999).

With a series of events such as rapid urbanization and construction, decreasing green areas, increasing need for energy, unlimited and unconscious consumption of natural resources, intensive use of fossil-based energy resources and increasing greenhouse gas emissions, ozone layer wear and so on, our world has to face many ecological problems today (Yıldız, 2018).

As a result, especially in big cities, historical and cultural and ecological values have been destroyed, and physical and social infrastructures became insufficient.

Considering sustainability as a whole with its economic, environmental and social dimensions including:

- Improvement in land development,
- Improvement in environmental quality,
- Elimination of urban degradation,
- Meeting socio-economic needs,
- Strengthening existing social communication networks,
- Involvement of vulnerable groups,
- Reducing the negative effects of urbanization on the living environment, it has become a very important concept to realize by these principles (Yıldız, 2018).

The world today faces far-reaching challenges that affect all and the rightful minds should be concerned with the way the world is moving forward. Trends such as unplanned urbanization, scarcity of natural resources and economic uncertainty each require holistic solutions. In recent years, rising demand for “green” and “smart” cities originated from the debate on how to challenge with climate change. As a developing country, Turkey incorporates various opportunities for the Real Estate sector. To comply with EU norms, numerous legislations for building energy efficiency and sustainability have been considered.

Additionally, the Turkish Urban Regeneration Program, one of the biggest urban restructuring programs in the World, is gaining pace year by year, which is expected to result in the reconstruction of more than 7.000.000 dwelling units until 2023 (ÇŞB, 2019). If administered properly, this could be a very important opportunity for Green Development and sustainable cities. There are and will be incentives for green and smart cities with high efficiency, which protects the environment, enhances the economy and enliven social life, hence improving quality of life.

According to World Urbanization Prospect Report, globally, more people live in urban areas than in rural areas, with 54 percent of the world’s population residing in urban areas in 2014 (UN DESA, 2014). In 1950, 30 percent of the world’s population was urban, and by 2050, 66 percent of the world’s population is projected to be urban. The urban population of the world has grown rapidly since 1950, from 746 million to 3.9 billion in 2014. According to the report, As the world continues to urbanize, sustainable development challenges will be increasingly concentrated in cities, particularly in the lower-middle-income countries where the pace of urbanization is fastest. Integrated policies to improve the lives of both urban and rural dwellers are needed (UN DESA, 2014).

A progressive urban renewal and transformation have started in Turkey after May 2012 when the Law of Transformation of Areas under the Disaster Risks (No. 6306) and related legislation was adopted. The law aims to renew 7 million dwellings in Turkey by 2023. However, financial resource and sharing problems emerged with the magnitude of financial needs (about 500 billion USD) and the major earthquake risk resulted in the acceleration of planning processes. These problems are being solved by an improvement in the development of rights and increasing the number of constructions. Besides, due to the delay of the process, the transformation is limited only at the building scale, whereas the benefits of Regional level urban regeneration shall be missed. Eventually, this type of urban transformation will bring problems triggered by population growth such as traffic congestion, insufficient infrastructure, loss of green space and inefficient use of resources, etc.

It could be claimed that the best way to address such problems in major cities is through Sustainable Urban Regeneration where economical, ecological and social impacts of an urban regeneration project are examined thoroughly. The sustainable built environment which includes Green Buildings and sustainable infrastructure plays a key role to achieve this goal.

However, such a great undertaking has already its problems, regarding property laws, funding, human resources, and social rights. Additionally, awaiting a huge scale earthquake risk in the Marmara region limits the available time to develop innovative solutions.

To implement sustainability principles and make them work in such a complicated program, there is a significant need for a specific sustainable performance measurement model for urban regeneration projects. This research will aim to satisfy this need by utilizing sustainable performance indicators and developing a sustainable performance measurement model which shall be applicable urban regeneration projects. The model aims to examine the issues from a broader perspective, providing efficient solutions in urban regeneration projects.

1.2 Problem Statement

The world is experiencing an enormous population increase than it has seen in history, and on the other hand, it is becoming urbanized at the same speed. The problems caused by urbanization, which developed in an unplanned way from the beginning, have grown together with more environmental degradation, more unhealthy structures, economic and socially unqualified physical environments that have emerged with the aging of cities (Yıldız, 2018).

The solution to these problems experienced by cities can be evaluated as urban transformation. According to Keleş (1998), an urban transformation has been defined as follows: changing, transforming, improving and revitalizing urban areas that are worn over time for different reasons, sometimes abandoned, unidentified, unqualified and non-standard, following with the socio-economic and physical conditions of the day (Keleş, 1998).

Urban regeneration projects can be realized in line with sustainability principles to improve the environmental quality, address the problem of urban degradation, meet various socio-economic needs, strengthen existing social communication networks, improve the inclusion of vulnerable groups and change the negative impacts on the living environment.

Here it is important to determine whether an urban regeneration activity is sustainable. Considering that the concept of sustainable urban transformation sometimes overlaps with many concepts such as sustainable structure, sustainable development, and sustainable urban development, it can be said that the world literature is very rich in this sense, but the number of comprehensive studies based on the measurement of sustainable urban transformation is quite limited (Yıldız, 2018).

In the interviews with the experts experienced in urban regeneration projects, an imminent need for a structured performance measurement model, incorporating key performance indicators jointly decided for widespread use, has been emphasized.

This research focuses on analyzing performance indicators and performance measurement approaches and conceptual frameworks in the literature and developing a sustainable performance measurement model for urban regeneration projects.

The thesis aims to develop a comprehensive model that combines all performance dimensions and criteria of generic performance measurement models and performance measurement conceptual frameworks developed for the construction industry and defines related key performance indicators used to measure urban regeneration projects' performance.

Up to date, many researchers have pointed out problems that cause inefficiency in the construction industry. These problems cause negative performance results both in the process and in the product. In the literature, a thorough performance measurement model or system for urban regeneration projects has not been found. Existing performance measurement models focus only on different aspects of performance. The need for a thorough performance measurement model for urban regeneration, which combines sustainability principles with other aspects of performance, is one of the main objectives in structuring the thesis and determining the way the problem is handled. Some of the limitations of previous studies are listed below:

(1) There are numerous publications related to the performance measurement of urban transformation projects that in the literature (Ali, Al-Sulaihi, & Al-Gahtani, 2013; Cheng, Tsai, & Lai, 2009; Egan, 1998; Jin, Deng, Li, & Skitmore, 2013; Kagioglu, Cooper, & Aoudad, 2001; Latham, 1994; Nudurupati, Arshad, & Turner, 2007; Wang, Lin, & Huang, 2010; Yeung, Chan, & Chan, 2009; Yu, Kim, Jung, & Chin, 2007),

(2) Key performance indicators identified in publications are insufficient in project-specific performance measurement (Aladağ & Işık, 2016; Chan & Lee, 2008; Hemphill, Berry, & McGreal, 2004; Hunt, Lombardi, Rogers, & Jefferson, 2008; Işik & Aladağ, 2017; Michael, Noor, Zardari, & Figueroa, 2013; Shen, Ochoa, Shah, & Zhang, 2011; Yıldız, 2018),

(3) Most of them do not include validation of identified indicators or models (Aladağ & Işık, 2016; Chan & Lee, 2008; Hunt, Lombardi, Rogers, & Jefferson, 2008; Işik & Aladağ, 2017; Yıldız, 2018) and most importantly,

(4) Developed models are not usually tested in suitable projects (Aladağ & Işık, 2016; Chan & Lee, 2008; Hunt, Lombardi, Rogers, & Jefferson, 2008; Işik & Aladağ, 2017; Yıldız, 2018).

In addition to above the environmental, economic and social aspects of sustainable performance are usually ignored and/or properly adopted.

Companies have difficulty in comparing the urban regeneration projects they carry out and producing data for future studies. Although the importance of performance measurement of urban regeneration projects is indicated by many experts and academicians (Aladağ & Işık, 2016; Chan & Lee, 2008; Hemphill, Berry, & McGreal, 2004; Hunt, Lombardi, Rogers, & Jefferson, 2008; Işik & Aladağ, 2017; Michael, Noor, Zardari, & Figueroa, 2013; Shen, Ochoa, Shah, & Zhang, 2011; Yıldız, 2018), a useful, practical and functional performance measurement model is needed for urban regeneration projects. The thesis study identified all these shortcomings and studies were carried out to fill the gap under this topic.

The problem area is selected due to lack of studies in performance measurement of urban regeneration projects, to enhance the comparability of the projects in the industry, and in order to propose a model for measuring the sustainable performance.

Even though there are many sources of performance measurement in the international literature and there is an increasing interest in many countries, the attempts and researches on measuring performance even at the industry level, the level of knowledge and practices related to the measurement of performance is insufficient. The lack of scientific research is one of the reasons for the thesis. This thesis aims to contribute to the development of practices related to performance measurement in urban regeneration projects, especially for developing countries.

In the context of this thesis, the scope of the model to be developed to measure the performance of urban regeneration projects shall be determined using the data from projects.

1.3 The Aim and Objectives

The main purpose of this study is to develop a sustainable performance measurement model for urban regeneration projects. This model will provide an opportunity to measure the performance of urban regeneration projects with a multi-criteria hierarchical approach consisting of key performance indicators. The first of the specific objectives is to identify sustainability performance indicators. Another specific objective is to determine the importance weights of the components that make up the performance measurement model using the Analytic Hierarchy Process method.

The thesis aims to develop a sustainable performance measurement model for urban regeneration projects with a defined methodology. In this respect, the objectives are as follows;

- Understanding the current practices of performance measurement in the construction sector determining the performance criteria of the sustainable performance measurement model by following the steps described in the methodology hierarchically in the level 2 performance dimensions, level 3 performance criteria and key performance indicators that constitute the level 4 hierarchy.
- Determining the importance weights of the components of the sustainable performance measurement model by the Analytic Hierarchy Process method.
- Investigating the validity of the sustainable performance measurement model.
- Testing the multi-criteria performance measurement model.

The thesis study provided the formulation of the sustainable performance measurement model and key performance indicators for the urban regeneration projects through the data obtained from the AHP method and field studies. The components of the performance measurement model were obtained from project performance indicators and sustainable indicators specific to urban regeneration projects in the literature. This approach is important to ensure contextual validity. Also, performance components were presented for expert evaluations in field studies and their validity was evaluated accordingly.

After the completion of the analysis studies in the research steps determined in the methodology, the indicators and weights were determined using AHP principles and a performance measurement model was proposed.

In summary, the main purpose included; “development of a sustainable performance measurement model” that will allow “performance evaluation for urban regeneration projects” from a “sustainable” perspective. In the case of urban regeneration projects, this method is distinguished from the similar proposals, by providing project level results using field studies and expert evalutions from projects, thus providing a unique approach.

1.4 The Scope and Limitations

The thesis provides the opportunity to measure the sustainable performance of urban regeneration projects with predetermined performance dimensions, criteria, and indicators. The model and relevant key performance indicators that will be the outcome of this study can be used in a large spectrum of urban regeneration projects. The performance indicators used in project evaluations, determination of sustainable performance indicators due to the characteristics of urban transformation projects and determination of their importance in measuring performance are within the scope of the thesis.

The scope and limitations of the thesis can be defined as;

- The number of experts in the Field Study-A are 32, in the Field Study-B are 21, and in the Field Study-C are 5. The strength of validation can be increased with more participants.
- Total of 3 urban regeneration projects have been selected for testing and verification of the model. Additional projects could be implemented to enhance the verification level.
- The scope of the model can be expanded to company and /or industry level.
- Potential for differentiation of performance components in the project-specific due to the unique characteristics of each project.
- Focus on performance measurement instead of performance management.

Besides, the questionary of Field Study-A is very long. The reason for giving the current practices, weighting the KPIs and AHP process in the same questionnaire can be explained as follows:

As a study is carried out in the context of urban regeneration projects, it will be not easy to found the experts to participate in the survey and to respond to the survey form for a certain period. The fact that KPIs are included in the same questionnaire is a guiding unique.

The limit in Field Study C is the difficulty in finding the project to which the model can be applied.

1.5 The Organization of the Thesis

The organization of the thesis and a summary of each chapter are explained below and shown in Figure 1.1.

Section 1 is introduction which consists of the background information (Section 1.1), problem statement (Section 1.2), aim &objectives (Section 1.3), the scope and limitations (Section 1.4), the organization of the thesis (Section 1.5) .

The methodology is defined in Section 2, the process of the research is explained in Section 2.1. Thesis methodology is explained as aparts, activities, and outputs (i.e. Figure 2.1) in Section 2.2.

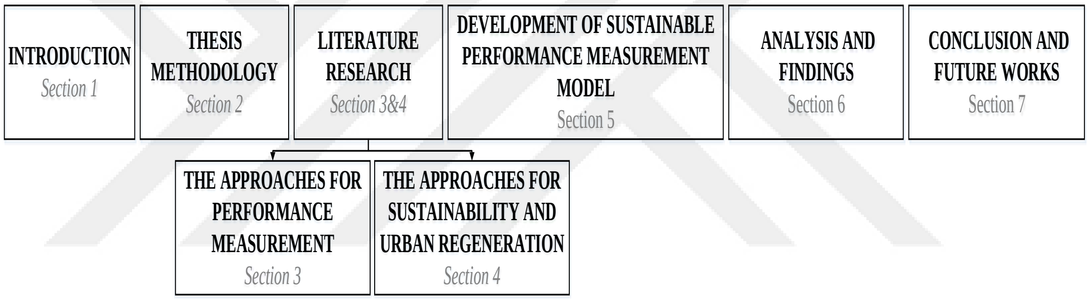

Figure 1.1 : Structure and outline of the thesis.

Next, methodologies used for Literature Review (Section 2.2.1) and Analytical Hierarchy Process (AHP) (Section 2.2.2) are detailed. In Section 2.3, field studies are explained further. The first Field Study investigates the profiles of the experts and the performance measurement perspectives in the context of urban regeneration projects. Pair-wise comparison matrices are developed to determine the importance weights. The data obtained from the Field Study-A is used for the completion of the model. A questionnaire for the validation of the model was developed (Section 2.3.1). the results of this validation study is presented in Section 2.3.2. Validation included the evaluation of the model parameters (dimension, criteria, indicators) and importance weights in terms of usability, practicality and functionality. Verification of the developed model is given in Section 2.3.3. In this section, experts from recent urban regeneration projects used and compared the proposed model to measure performances in real projects.

Full literature review is presented in Section 3 & 4. Firstly, performance measurement is defined and performance measurement methods explained (Section 3.1). Next, the importance of performance measurement and its place in the construction sector is discussed and information is provided about the levels of performance measurement, frameworks, and research techniques (Section 3.2). The frameworks and levels of performance measurement are described in more detail in Section 3.3 and Section 3.4 to provide a basis for the progress of the thesis. Since the proposed model to be developed within the scope of the thesis is intended to be used for urban regeneration projects, Section 3.5 includes a more detailed discussion to determine the dimensions, criteria, and indicators that will structure the model at the project level.

Next, the literature review goes on with the focus of sustainability and urban regeneration projects in Section 4. A seperate section is dedicated for urban regeneration projects which have special characteristics, objectives, and outputs that should be examined with a special focus. Likewise, sustainability is discussed seperately in Section 4.1. The importance of sustainable performance approach in the construction sector and the criteria for sustainable performance are examined in Section 4.2. The adoption of sustainability and sustainable performance measurement in urban regeneration projects, and literature review for sustainability in urban regeneration projects is analysed in Section 4.3.1 and Section 4.3.2. The keywords looked out here were performance measure* or performance assess* or performance evaluation.

Finally in Section 4.3.3, relative research in the literature about "Sustainable Performance Measurement of Urban Regeneration Projects" was investigated with specific focus on similar and different approaches.

In thesis organization, the model development process is carried out in Section 5. In Section 5.1, the steps of Sustainable Performance Measurement Model for Urban Regeneration Projects are discussed. In Section 5.2, dimensions, criteria and indicators (performance components) for sustainable performance measurement of urban regeneration projects are listed stepwise. The dimensions that make up the model are explained by their criteria and indicators respectively. The meaning of the indicators and criteria for expert evaluations and their measurement methods are described in following sections: Section 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7.

Next, most important issues in performance measurement are underlined in Section 6. Field Study-A: Statistical Procedure and Analysis have been presented at Section 6.1. This section includes (1) analysis and findings related to the experts participating in the study (Section 6.1.1), (2) analysis and findings on existing practices and established attitudes regarding performance measurement at level of urban regeneration projects (Section 6.1.2), (3) analysis and findings of key performance indicators used in sustainable performance measurement model (Section 6.1.3), (4) application of analytic hierarchy method (AHP) (Section 6.1.4).

In Section 6.2, Field Study-B Statistical Procedures and Analysis have been presented. The characteristics of the sample group and the validity of the sustainable performance measurement model for urban regeneration projects are given in Section 6.2.1 and Section 6.2.2 respectively. At the end of the Section 6, Field Study-C Statistical Procedure and Analysis have been presented (Section 6.3). Similarly, the characteristics of the sample group and the verification/testing of the sustainable performance measurement model for urban regeneration projects are provided in Section 6.3.1 and Section 6.3.2 respectively.

In Section 7, Comments and conclusions are provided with the presented future work. This section contains the following subsections:

(1) General evaluations for current status of performance measurement in urban regeneration projects (Section 7.1),

(2) Evaluation of sustainable performance measurement model for urban regeneration project (Section 7.2),

(3) Verification of the proposed sustainable performance measurement model for urban regeneration model (Section 7.3).

2. THESIS METHODOLOGY

This section contains the steps followed followed in research process (2.1 Process of Research) and the details of the basic methodology developed for adressing the defined problem (2.2 Thesis Methodology).

2.1 The Process of Research

In this part, research metodology and approaches are explained and data collection and analysis methods are discussed. The developed model included sustainable performance indicators, which are expected to be a contribution to the literature and construction sector overall.

For urban regeneration projects, the methodology of development of "Sustainable Performance Measurement Model" is explained in this section.

In the methodology, respectively;

1. Indicators of sustainable performance measurement model for urban regeneration projects were determined by using the findings of literature research.
2. Utilising the AHP (Analytical Hierarchy Process) method and Field Study, importance weights of the indicators were determined and performance measurement model was finalized The detailed steps for develepment of "Sustainable Performance Measurement Model" shall be explained at Section 5.
3. The validation and verification of the model were conducted through field studies.

Research is defined as the process of discovering, defining, understanding, explaining, predicting, modifying and evaluating certain aspects of a particular phenomenon (Blaikie, 2003). The process in this thesis involves many conceptual and empirical interactions as well as regular research steps, seperated from each other. The background information of the concept, problem statement, the aim of the thesis is explained in “Introduction”. The literature research conducted about performance measurement of construction projects and sustainable performance measurement of urban regeneration projects is presented in Sections 3 & 4.

In the research process, existing theoretical base and previous research about the identified problem are the most important steps in the development of appropriate methodology and approach to the problem from an alternative but complementary perspective (Tekçe, 2010). It is emphasized that the researcher can reach a new conceptual structure and theory by analyzing and then synthesizing the concepts and ideas found in the literature (Remenyi, Williams, Money, & Swartz, 1998).

The general methodological approach applied in the thesis is a realist approach with its epistemological deductive which depends on whether theory (deductive) or data (inductive) is determined by priority, and positivist ontological character. The epistemology explaines that the how the researcher can “accept the truth in accessing information; ontology defines what is the knowledge and acceptance of reality is.

The performance measurement model developed and tested within the scope of the thesis is based on developing a prior conceptual structure with normative refinement in order to provide a more comprehensive, integrated response of the complementary dimensions / components of the previously developed performance measurement models and approaches to the performance measurement problem. According to modern knowledge theory or epistemology, hypotheses, observations derived from deduction from a theory are compared with data collected from experiments or questionnaires.

In the light of this information, thesis put forward a survey which includes the model’s content to weight the indicators for development of the model.

2.2 Thesis Methodology

According to Walker (1997), quantitative approach provides strong evidence to researchers about answering the questions how much and how many for explanation of unknown (Walker, 1997). In this thesis, it has been possible to scientifically determine which variables are more important and in what extent. While conducting the quantitative research, “literature surveys” and “field-survey” studies an which were defined in detail by Fellows & Liu, 2015 were used. The steps, objectives and outputs of the methodology to be used to achieve the objectives described in the introduction are summarized below. The methodology of the thesis was formulated in accordance with the process of the research in (i.e. 2.1). In this section (i. e. 2.2.1) and (i. e. 2.2.2) the methodology of the thesis is explained in subsections.

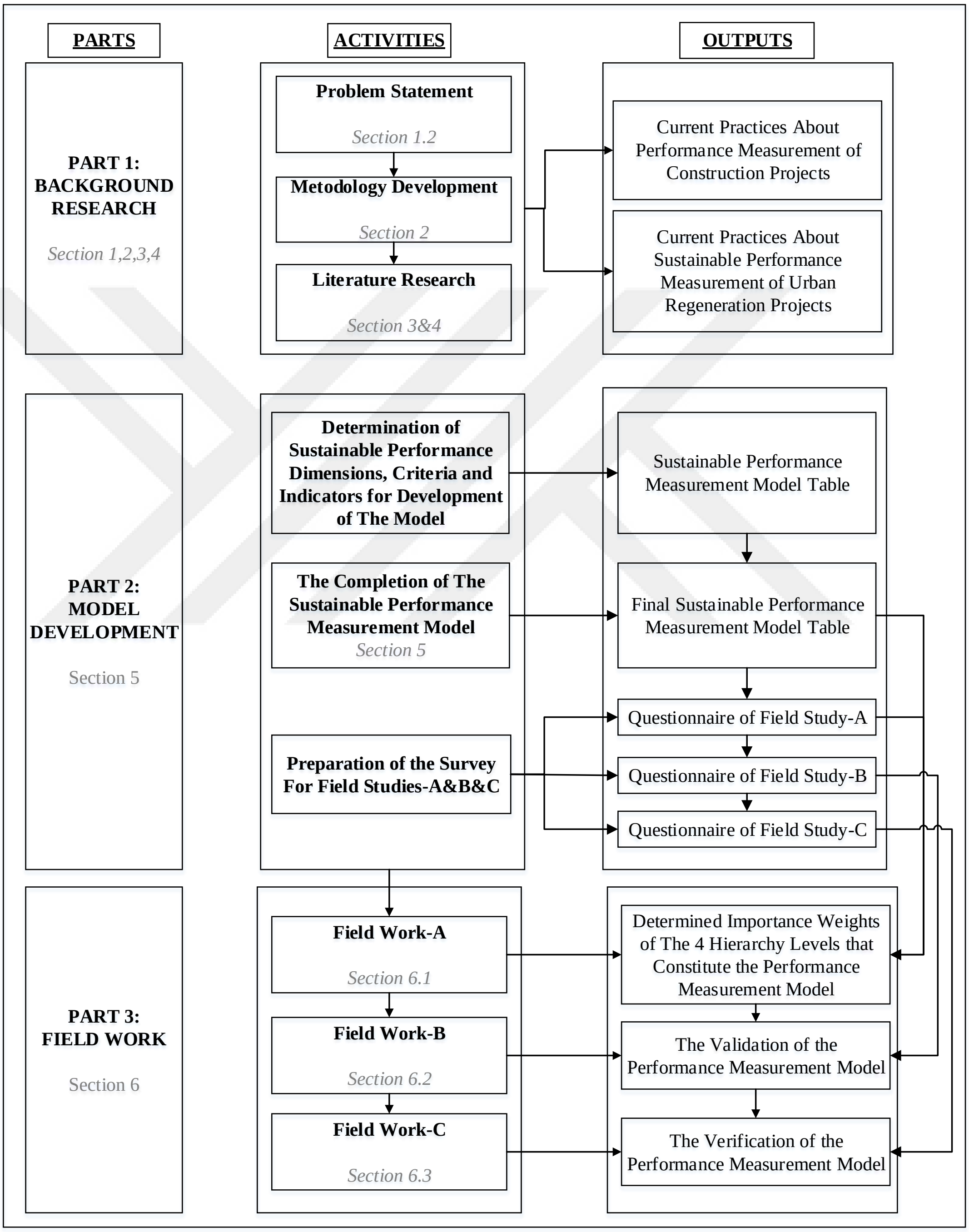

Figure 2.1 : Thesis Methodology.

In Figure 2.1, the methodology of the thesis is shown. On the first block, parts of the thesis are presented together with corresponding the general thesis sections (chapters).

In the second block, the actions taken in each part is given and section numbers are presented. On the last block, the relevant outputs of each activity and relationships of outputs each other are given.

Part 1: Background Research, includes the problem statement, determination of the methodology and literature review. The outputs of the literature review contribute the determination of sustainable performance dimensions, criteria, and indicators.

Afterwards, in Part 2: Model Development, the dimensions, criteria and indicators of the proposed performance measurement model were determined. Indicators identified for this stage of performance measurement and key references are listed. Also, necessary measurement techniques for indicators are presented. At the same time, a questionnaire was prepared to provide input to the Field Study-A. With the completion of Field Study-A, a model was completed through AHP analysiss. Next surveys were prepared for Field Study B and Field Study C for validation and verification of the model. This section is integrated with the following sections.

Lastly, in Part 3: Field Study, questionnaries are conducted to expert stakeholders from urban regeneration projects including academics, contractors, architects, govermental and non-govermental experts). The survey questionnaire aims to measure the experience levels of the experts and their perspectives on current practices for performance measurement in urban regeneration projects were examined. In order to determine the weights of the indicators, pair-wise comparison matrices were presented at part 2 and the importance weights determined by the experts during Field Study-A were listed. Importance weights were analyzed using AHP in order to determine which indicators, criteria and dimensions were crucial to measure the sustainable performance of an urban regeneration project. Using this analysis, the indicators obtained from the literature and sector were compared with the results obtained from the model. Upon completion of the model, the accuracy of the given data was validated. This validation enabled us to obtain more, information about usability, functionality and practibility of the proposed model After the validation of the developed model was completed, the verification process started. The questionnaire developed in Part 2 was used as input for this action. Four different urban regeneration projects were selected and at least one expert from each project used the proposed model to assess his/her project. The success of the model was examined by comparing the performances obtained without using the model v.s. the performance output obtained using the model.

2.2.1 Literature review

The process called literature review in academic research, includes finding, examining, reading, sorting, summarizing and synthesizing the previously published works (Demirci, 2014). In other words, literature is the process of researching a specific subject in detail and collecting the data related to that subject systematically.

The literature review helps to select and understand the research problem as well as to place the research in a historical perspective. It is a process consisting of literature review, data collection, discussion about the collected data, establishing the relationship between the collected data and the classification of information. It helps to determine whether The research topic is up-to-date and there is a strong research question to support it.

Acquiring a scientific depth and identity with the literature search is a requirement of any academic work. Research conducted without taking into consideration the previous studies on the subject may result in significant deficiencies in originality, competence, response for the needs of the target audience and contributions to science.

Demirci (2014), listed the sources that could be used in literature review as follows:

(1) Articles Published in Scientific Journals, (2) Books, (3) Conference Proceedings Theses, (4) Encyclopedia and dictionaries. Subject Matter Experts can also be a part of this list (URL 1).

The problem in literature research is to handle the information produced by using data collected for other purposes in accordance with the research conducted (Tekçe, 2010). In this research, literature research has been an important stage in the identification and handling of the problem.

First of all, main goal was to understand the information areas and to review important past studies on “performance measurement” and “performance measurement in the construction sector” issues, with a focus on performance measurement at project level.

Other focus areas on literature review were sustainability and urban regeneration. The differences between previous studies and developed study in the thesis were tried to be identified. Throughout these topics, determination of commonly used project performance measurement indicators was also another major objective.

The literature review has provided the compilation of the theoretical background and the available information on the subject. The literature review enabled the access to relevant information by the use of different sources. This was particularly important in terms of gathering the necessary information to develop a model for sustainable performance measurement for urban regeneration projects and revealing the different dimensions, criteria and indicators of the subject for field researches.

2.2.2 Analytical Hierarchy Process (AHP) method

In this section, the Analytical Hierarchy Process (AHP) method, which is used as part of the research methodology, is explained in detail in terms of its process, its principles, its algorithm and its adaptation to use in the research.

AHP application in determining the weights of sustainable performance measurement model components is discussed at Section 6.1: Fieldwork- A Statistical Procedures and Analysis, as a subsection of Section 6: Results and Analysis.

Analytic Hierarchy Process (AHP) is a methodology for multi-criteria decision making, developed by Thomas L. Saaty (1980). AHP allows decision makers to model complex problems in a hierarchical structure that illustrates the relationship between the main objective of the problem, criteria / attributes / sub-criteria, and alternatives (Saaty, 1980). As AHP enables quantitative and qualitative considerations to take part in the decision process, Saaty, Luis, and Vargas (2000) defines AHP as a process based on the decision-makers' subjective thoughts, experiences, and the use of options in binary comparison matrices after they are subdivided into problems and problems (Saaty, Luis, & Vargas, 2000).

The strength of AHP is its success in systematically organizing concrete or abstract factors and providing a relatively simple but structured solution to decision-making problems (Skibniewski and Chao, 1992). AHP, has been used in many applications over the last two decades (Cheong et al., 2008; Ho, 2008). AHP is a frequently used method in the analysis of complex decision problems due to its simplicity, flexibility, ease of use and comfortable interpretation (Yılmaz, 2005).

The steps of AHP

1) The first stage of AHP is the formation of decision hierarchy. After dividing the problem into small pieces, the importance of the two elements compared is determined and the level of significance is judged. This system plays an important role in concept formation in human perception, classification of samples and logical reasoning.

2) Second stage is formation of comparison matrixes. Binary comparisons are designed to establish decision criteria and priority distributions of alternatives. To put it more clearly, the elements in the hierarchy are compared in pairs to determine their relative importance relative to the element on the upper level (Saaty, 1980; Saaty et al., 2000).

AHP uses a hierarchical model of objectives, criteria, possible sub-criteria levels and options for each problem. There are approaches in the infrastructure of AHP method.

The first one, reciprocity Pair-wise comparison is done by grading the criteria in row i (i = 1, 2,…, m) based on each criterion represented by m columns. The term ai / aj in the matrix indicates how much more important the criterion i is to achieve the objective than the j criterion. For example, if this value is 7, it is understood that criterion i is strongly important than criterion j. In this case, the criterion j is also 1/7 important compared to the criterion i. In other words, aij = k is expressed as aji = 1 / k to ensure consistency. In addition, all diagonal elements (aij) of matrix A must be 1 since they rank the criteria attached to them. Secondly, X and Y options should not be too much difference each other. For example, one of the sub-criteria for the problem of selecting a doctor in a hospital is experience while the other should not be the hair color of the doctor. The selected criteria and sub-criteria should be chosen in accordance with the nature of the problem or purpose identified and not so different from each other. Lastly, when selecting criteria, it should not lose its meaning by adding or subtracting its sub-criteria (Kuruüzüm & Atsan, 2001).

It is stated that if the number of options to be evaluated exceeds the magic number of nine, the decision maker will be overwhelmed (Brownlow & Watson, 1987; Forman, 1990). However, in the hierarchical model developed in this study, the biggest comparison matrix is among the criteria of the environmental performance dimension and matrix’s dimension is 9x9.

The use of group decision in AHP in decision-making is based on two different approaches (Aczél & Saaty, 1983; Ramanathan & Ganesh, 1994; T. L. Saaty, 1980). The first approach is to combine the judgments of the experts, and the second approach is to combine the individual weights of importance. In this study, the aggregation of individual judgments approach is based.

Assessments by each expert should be translated into a single weight of significance for each factor. The geometric mean method is the most commonly used method for combining expert judgment (Aull-Hyde, Erdogan, & Duke, 2006). Another benefit of using the geometric mean method is that it reduces the effect of extremely low or extremely high values that cause controversy in the arithmetic mean method (Taleai & Mansourian, 2008).

3) After the "pair wise comparisons matrix" is generated, priority vectors for each performance dimension or criterion are determined for indicating the significance of the criteria.

Two of the most common prioritization procedures of AHP are the Eigen Vector Method (EM) and the Geometric Mean method. In this thesis, eigen vector method is used.

Finding the priority vector:

In a pair-wise comparison matrix, each column element is summed, and each element is divided into this sum to obtain a normalized binary correspondence matrix($A_{w)}$. In this matrix, the sum of the columns is equal to 1. In the normalized binary comparison matrix (A_w), the arithmetic mean of the elements in each row is obtained by obtaining the relative importance (priority) vector (W_i). The sum of the elements in this vector is equal to1. The elements in the pair-wise comparison matrix are multiplied by the relative priority vector to give the weighted total vector (D). Each element of this vector (D) is used for measuring the consistency of the vector E by dividing the corresponding element in the relative importance vector (W_i).

4) At the last stage, it is necessary to calculate the consistency ratio for each comparison matrix to determine whether the decision-maker behaves consistently when comparing the factors (M. Dağdeviren, Diyar, & Mustafa, 2004). The consistency ratio (CR) obtained from the product of the pair-wise comparisons matrix and the significance distribution vector must be less than 0.10 (10%).

In the thesis, AHP is not used for the purpose of choosing between multiple choices or decisions, but instead as a part of the methodology to determine the importance weights of a group of factors.. It is not primarily utilised for the selection of the best alternative that meets the criteria, but rather used to determine the relative importance weights of the model components.

The advantages of AHP;

- AHP allows objective / subjective considerations to be included in the decision-making systematically in qualitative / quantitative information.
- AHP provides an easy-to-implement decision-making methodology that allows decision-makers to accurately determine their preferences for the goal.
- AHP allows the research problem to be handled through a logical hierarchy. With a structure / process that simplifies complex problems, it facilitates decision-makers' understanding of the definition and elements of the decision problem.
- It allows to measure the degree of consistency of the decision-maker's judgments.
- The AHP, as an effective multi-criteria decision-making method, allows to take into account expert judgment, experience and acceptance.

The disadvantages of AHP;

- Not based on theory (Dyer & Wendell, 1985),
- Changing the order of decision alternatives when any decision alternative is added to or removed from the problem (Tekçe, 2010),
- The very precise expression of subjective judgments causes misconceptions (Ramanathan, 2001),
- As the number of tiers in a decision hierarchy increases, so does the number of binary comparisons and more time and effort is needed to build the AHP model (Kuruüzüm & Atsan, 2001).

The reasons for selecting AHP in this study are (1) being in accordance with the scope of the thesis with the advantages mentioned above, (2) AHP and hibrit methods of

AHP (such as Fuzzy AHP) has a wide range of applications (Kuruüzüm & Atsan, 2001) such as following concepts:

- AHP-Selection of project and contractor (Fong & Choi, 2000),
- AHP-Selection of site (Yang & Lee, 1997),
- AHP-Planining of resource (Udo, 2000),
- AHP-Investment evaluation (Mohanty & Venkataraman, 1993),
- Fuzzy AHP (FAHP)-Selection of design and construction proposals (Alhazmi & McCaffer, 2000),
- FAHP-Selection of procurement mehod (Cheung, Lam, Leung, & Wan, 2001).
- FAHP-Identifying factors affecting worker productivity in the construction sector from an administrative perspective (Doloi, 2008).
- AHP-Evaluating the performance of information technologies / information systems in construction companies (Stewart & Mohamed, 2001).

2.3 Field Studies

In this section, related to the subject discussed in the thesis; sampling characteristics, principles for designing questionnaires, procedures for collecting and analyzing the data, which are used in all field researches, are explained for;

• Obtaining in-depth information and determination of the relative importance weights of the model components (Field Study-A),

• Investigation of the validity of the model (Field Study-B),

• Testing the model (Field Study-C),

Sampling characteristics, principles for designing questionnaires, procedures for collecting and analyzing the data, which are used in all field researches, are explained.

For all field studies carried out, the data obtained was checked by the researcher for missing, errors, omissions, inconsistencies and made consistent, readable and complete.

According to Blair, Czaja, and Blair (1996), field research is the most important research method in systematic investigations (Blair, Czaja, & Blair, 2013). Field research questionnaires include the purpose of making generalizations from a particular sample to the population through interviews, cross-sectional in a certain section or longitudinal (Babbie, 1990; Creswell & Creswell, 2017). In this respect, in this thesis, the survey method in the field research was carried out by studying a sample in the population as stated by Creswell (2017); it was chosen to provide a quantitative definition of trends, attitudes and opinions.

Sampling for the generation of the model was selected among experts and academicians who worked in urban regeneration projects or sustainable construction projects. One of the most important issues of the sampling process is the determination of the number of units to be sampled or the sample size. Whether the population is homogeneous or heterogeneous affects the determination of the sample size. In order to accurately estimate the characteristics of a homogeneous universe (typical universe of events), a a smaller sample size sufficient. As the heterogeneity of the universes to be studied increases, in order to reach accurate results, it is necessary to increase the sample size (Özdamar et al., 1999). The number of the participants are determined as 32 by network selection.

Zikmund (2000) described the design of the questionnaire as the most critical stage of the research process (Zikmund, 2000). The questionnaire form consisted of closed-ended questions consisting of two or more options, ranking questions, questions to be evaluated by rating scale, elimination questions, and open-ended questions.

In the questionnaire form, 1 = Not important (2 and 3 intermediate values) 4 = Important (5 and 6 intermediate values) 7=Very Important, 7-point Likert scale was used in the design of the questions.

The survey method is a form of collecting data from the primary source. The basis of the survey method is to obtain information systematically from the units that make up a population or sample (Özdamar et al., 1999). The communication method to be used in the survey method will be in three ways: mail, telephone and personal interview. The participants were reminded by repeated mailings or other ways of establishing relationships.

At the end of the Field Study, analysis results, charts and graphs were prepared with MS Office Excell 2013 program. Descriptive and inferential statistics were obtained for the data obtained from Field Study-A. Descriptive statistics include frequency distributions, central tendency measures such as arithmetic mean, median, mode, and distribution measures such as standard deviation and coefficient of variation. Starting from descriptive statistics, a series of statistical analysis procedures such as chi-square ($\chi 2$) independence test, Friedman test (non-parametric two-way analysis of variance) and Cronbach's Alpha criteria were used to test the reliability of the scales.

2.3.1 Field Study-A

With the Field Study-A;

It is aimed to determine the reletive importance weights of performance dimensions (Level 2)" and "performance criteria (Level 3)", and "key performance indicators (Level 4)" of the sustainable performance measurement model.

Designing the survey

Within the scope of the Field Study A, first, information about the participants was collected (Part I). For the second stage, current practices regarding performance measurement at project level have been evaluated. Within the scope of Part III, the importance of key performance indicators was gathered with the 7-point Likert scale. In Part IV, performance dimensions and criteria were evaluated with binary comparisons and data were collected for the AHP process. In the last part, comments and suggestions were collected. Field Study-A questionnaire is given in Appendix A.

Data analysis procedures

At the stage of statistical analysis of the data obtained, necessary analyzes were made using the SPSS 15 and MS Office Excel 2013 package program. Based on the analysis results obtained, graphs were prepared with the MS Office Excell 2013 program. SPSS 15 has been preferred because it allows the grouping of data, examining the relationships between variables, and statistical evaluations and MS Office Excell 2013 program allows the organization of visually smoother graphics and charts. Descriptive statistics were obtained for the data obtained from the Field Study-A. Descriptive statistics include frequency distributions, arithmetic mean, median, mode, standard deviation, coefficient of variation and etc. After descriptive statistics in the analyzes, a series of statistical analysis procedures such as Cronbach's Alpha were used in testing hypotheses, chi-square ($\chi 2$) independence test, Friedman test (nonparametric two-way analysis of variance test) were conducted. The statistical procedures applied to the data obtained in the Field Study are explained in detail in **Section** 5 - Findings and Analysis.

2.3.2 Field Study-B

Validity reflects the consistency of research methodology and is a function of contextual validity, structural validity, and statistical outcome validity (Buelens, Bouckenooghe, De Clercq, & Willem, 2005; Scandura & Williams, 2000). With the Field Study-C, it was aimed to investigate the validity of the model.

Designing the survey

The experts who participated in the study were asked to evaluate the "sustainable performance measurement model" in terms of different features. The questionnaire consists of questions used to develop the performance measurement model, including the evaluation of performance dimensions, performance criteria, performance indicators and their importance for project performance.

Field Study-B questionnaire is given in Appendix B and information obtained with questions is given in Table 2.1.

Table 2.1 : Information obtained through Field Study-C- questionnaire form questions.

Information about the experts who answered the questionnaire	PART I-1,2,3,4,5
Evaluation of performance dimensions and performance criteria, which constitute the sustainable performance measurement model, by taking into account the key performance indicators	PART II-6
Evaluation of sustainable performance measurement model according to usability, practicality and applicability criteria	PART II-7
Comments and suggestions	PART III-8

For the answers to the question number 6 in the questionnaire, 6-interval Likert scale was used so that 1 = not important (2 and 3 intermediate values) 4 = important (5 and 6 intermediate values) 7 = the most important. Four-point Likert scale was used to evaluate the usability, practicality and applicability of the performance measurement model with question number 7 so that 1: Not useful / Not practical / Not applicable 2: Less useful / Less practical / Less applicable 3: moderately useful / moderately practical / moderately applicable 4: Useful / practical / applicable 5: Very useful / very practical / Applicability is very high.

Data analysis procedures

In the research, the statistical hypothesis tests for the variables obtained from the sample from the population (population) for the said variables are evaluated with a certain confidence. Hypothesis testing involves deciding whether a difference observed in the sample is in the population or whether the difference is due to chance (Fox, 1969).

The null hypothesis was developed by calculating the decision p-value in the test. The probability of occurrence of test statistics calculated from the p values observed is the probability of taking extreme values in accordance with the equal or opposite hypothesis. The p value indicates the probability that the null hypothesis is correct and requires the rejection of the null hypothesis if the given region is less than or equal to the total probability value at the given significance level.

The procedures to be applied for the data obtained from the Field Study-C are described below;

In cases where research and analysis are required with small sample size (usually n <30 units), the use of multivariate statistics applications is not statistically significant. However, other techniques such as t-distribution give meaningful results even when the sample size decreases up to 12. While doing this, the normality of the distribution should be evaluated together (Van Belle, 2002).

Normality assessment for Field Study-C 5th and 6th questions was done using the Kolmogrov-Smirnov test (with Lilliefors significance correction) with SPSS software. Since the sample size is small, the Kolmogorow-Smirnov normality test can be used instead of the chi-square goodness of fit test. The Kolmogorov-Smirnov (KS) Test is used to test whether a sample data obtained fits a particular distribution (uniform, normal or poison). In principle, the Kolmogorov-Smirnov single-sample test test is based on the comparison of the cumulative distribution function of the sample data with the proposed cumulative distribution function.

In the said tests, it is stated that the data came from a normally distributed population with the H0 hypothesis, while the distribution of the population with the H1 hypothesis is not normal.

Student-t test (single sample t test) was conducted for the questions in the Field Study-C 5th, 6th and 7th. Since the Field Study-C is n <30, all tests were performed at appropriate levels based on the t-distribution based on the significance level of p = 0.05. The arithmetic means of the responses, 95% confidence interval and lower limit values determined according to t-distribution were calculated with MS Excel Office 2003 program.

If the single sample t-test (according to the t distribution) p significance value is below 0.05, H0 is rejected. The Ho hypothesis has been rejected. The sample arithmetic averages for performance dimensions and performance criteria are not statistically equal to 4, i.e. different from 4. Based on the test result, when the averages are examined, it is found to be greater than 4.

The main purpose in the analysis here is; The aim of this study is to determine the minimum and maximum values of the mean population obtained with the 5th question of the Field Study-C according to the distribution of t and to determine the interval in which the evaluation is made with 95% confidence for all the components that make up the model, and to obtain important evidence for the validation of the performance measurement model. In the hypotheses here, the threshold value "4" in the scale used to collect the data is 1 = Not important (2 and 3 intermediate values) 4 = Important (5 and 6 intermediate values) 7 = The highest degree of importance; It is used because the "4 = important" rating is chosen as a limit value.

For the same purpose, "3 = moderate evaluation" was determined as the threshold value, since the 4-point Likert scale was used in the hypothesis tests regarding the evaluation criteria of the multi-criteria performance measurement model, question 6 and question 7. Null hypothesis and opposite hypothesis 6. and. 7. It was constructed for the questions as follows.

H0: The arithmetic averages obtained from the sample for the evaluation criteria of the sustainable performance measurement model are equal to the population (population) averages.

H1: The arithmetic averages obtained from the sample for performance dimensions and performance criteria are different from the population (population) averages.

All hypothesis tests, normality assessment, single sample t test and reliability analysis are detailed in chapter 5. In small samples, since it is not appropriate to use z distribution, confidence intervals are calculated according to t distribution. In cases where the sample number is n <30, t-table values are used for confidence intervals to be determined for arithmetic averages. The significance level was taken as 0.05, bilaterally tested (since the H1 hypothesis is not equal, the test would be bilateral. If the H1 hypothesis was "greater" or "less than", the critical value corresponding to α = 0,025 in the student-t table) It was used in the calculations of confidence interval by taking 2.08. Since the variables taking values that are too small or too large from the average value indicate significant differences from the general trend; Getting different results in both directions is considered to be an important result. Therefore, two-way testing is more common.

Since the advantage of the bidirectional test has been verified in a one-way test, the interpretation can be made to include one-way test results (Özdamar, 2001). Both test statistics are critical ratio (z) and t-test; they are used to decide whether the difference between the two statistics reflects the population difference or whether it is significantly different from a value (predicted or accepted) in the population (parent mass) (Borg and Gall, 1983). In both test statistics, the standard deviation of the sample is used instead of the unknown standard deviation of the population. Although z and t-test statistics have the same usage areas, z-test is significant in samples with n> 30, and t-test is significant in all small or large samples (Johnson, 1980).

Also known as the small sampling theory, the t-dispersion test, also known as Student's t-distribution, provides great convenience for researchers as it allows working with small samples as well. Taking advantage of the "t" distribution in cases where the t-test sample size is small and standard deviations for the main mass are unknown; It is an analysis method developed to test the hypotheses whether the average value of a group differs from the predetermined value in terms of a variable examined. Since there is only one sample in the study, one sample t-test (one-sample t test) was used.

Cronbach's Alpha coefficient, for certain components, for each component examines the correlation coefficient between the given value and the average value calculated for all components and is calculated as the average of the average internal correlations (Sekaran, 2003). As Cronbach's Alpha coefficient approaches 1, internal consistency reliability increases (Zikmund, 2000). Gronlund and Linn (1990) and Ebel and Frisbie (1991) emphasized that the data obtained with the reliability measurement tool is a feature.

Field Study - C was done with question 6 and 7; The reliability of the responses to the query regarding the evaluation criteria of the sustainable performance measurement model was evaluated with the Cronbach's Alpha coefficient. A number of statistical analysis procedures, such as the (α) model (Cronbach's Alpha Coefficient), have been applied to examine the reliability levels of the scales. This method investigates whether the k problem in the scale expresses a homogeneous structure. Depending on the alpha (α) coefficient, the reliability of the scale is interpreted as follows (Kalaycı, 2009). $0.00 \leq \alpha < 0.40$ (unreliable), $0.40 \leq \alpha < 0.60$ (unreliable), 0.60 0.α <0.80 (highly reliable) and $0.80 \leq \alpha < 1.00$ (highly reliable) Zikmund (2000), validity of a measuring instrument defined what is desired to be measured as the ability to measure.

Ticehurst and Veal (2000), on the other hand, defined validity as how much the information collected in a research reflected the studied phenomenon. It is clear that there will be a problem if the measuring tool does not have the ability to measure what is desired to be measured.

2.3.3 Field Study-C

In this section, the sampling features, the method and stages of the Field Study-C, data collection, the design of the used questionnaire and the approaches used in the analysis are explained. Findings obtained as a result of the analyzes will be explained and evaluated in Section 6. With the Field Study-C; It is aimed to test performance measurement model.

Designing the survey

The experts whom take part at Field Study-C were asked to score their project according to sustainable performance measurement model for urban regeneration projectsrojects by using a rating of 1 to 5 (1: Very Bad 2: Bad 3: Average 4: Good 5: Very Good).

After determining their performance scores using Level 3 criteria or Level 4 indicators, they were asked to make the overall performance assessment for their projects using the 1 to 5 rating again (1: Very Bad 2: Bad 3: Average 4: Good 5: Very Good). The model was generated in MS Office Excel 2003 for experts to easily indicate their performance scores.

Data analysis procedures

MS Office Excel Program was used to analyze the data obtained during the testing of the model. Total performances of the projects are calculated by multiplying the importance weights of different levels by the performance score given in Appendix D.3, D.4, and D.5. The distribution of the scores related to the performance dimensions and performance criteria of the 3 projects were analyzed. By multiplying the importance weights obtained with AHP and the performance scores determined by the experts of the model components; The measured project performance score was compared with the performance scores determined by senior managers for the total performance of their projects. Based on the 3rd level performance criteria, the total project performance score is calculated with the equation in (2.1);

$$y = \Sigma\ (xij*Wi*Wij) \tag{2.1}$$

xij: the score awarded to the relevant level 3 performance criterion.

Wij: 2nd level performance dimensions importance weight.

Wi: The importance weight of the 3rd level performance criterion.

y: total project performance

In testing the sustainable performance measurement model for urban regeneration projects, the margin of error between measured performance and actual performance was calculated by the formula given in (2.2).

$$\%Error= [|Measured\ Performance|/(Actual\ Performance)]*\%100 \tag{2.2}$$

3. APPROACHES FOR PERFORMANCE MEASUREMENT

3.1 Performance Measurement

Performance measurement is the process of obtaining, examining, reporting the information of an organization, group, and individual or a system and component of a system (Behn, 2003). According to Moullin (2007), performance measurement should be defined according to the reason why performance measurement is needed. Moullin defines performance measurement as the process of study for determining the management quality of an organization and the worth that given to the customer and others (Moullin, 2007). Neely, Adams, and Kennerley (2002) approach the performance level at operational concentration and specify the performance measurement as the process of examining the efficiency and effectiveness of prior activities (Neely, Adams, & Kennerley, 2002).

For controlling the management, performance measurement is used as a mechanism (Hertenstein & Platt, 2000). So, performance measurement might be understood as the process of reaching the goals and strategies of individuals or organizations (Evangelidizs, 1992). Performance measurement involves understanding and translating the organization's vision and strategies in line with specific goals that motivate employees to add value (Tekçe, 2010). Administrators want to measure their performance to understand how well their organizations perform or can show. Performance measurement gives managers an understanding of whether their strategies can be implemented and encourages consistent practices (Neely, 1998).

In organizational based, there are lots of reasons to measure performance such as controlling the current position (Eccles, 1991), delivering the position (Sinclair & Zairi, 2000), confirming and enforcing the priorities (Sinclair & Zairi, 2000). Neely (1998), evaluated the reasons for these four categories.

According to Neely, Gregory, and Platts (1995), performance measurement is the determination of efficiency and productivity of an activity (Neely, Gregory, & Platts, 2005). The criteria which are used for the determination of the efficiency and productivity of activity are accounted for indicators of performance (Neely et al., 2005). Performance can be measured as quantitative and qualitative (Tekçe, 2010). There are three dimensions of measurement, effectiveness (Drucker, 1987), productivity (Drucker, 1987), and ability (Neely, Mills, Platts, Gregory, & Richards, 2004; Sink & Tuttle, 1989).

The first sight of performance measurement in history can be seen in 1880's for planning and controlling the American railway systems (Tekçe, 2010). In the 1900's, financial performance measurement systems which are currently used were developed (Chandler, 1977; Robert S. Kaplan, 1984). Afterwards these systems began to be used for planning purposes (Johnson & Kaplan, 1987). In the 1980's the philosophy of quality management had started to spread and many firms were encouraged to develop and use performance measurement systems for projects (Tekçe, 2010).

According to Amaratunga and Baldry (2002), a performance measurement system should be understandable by all parties and include both financial and nonfinancial indicators (Amaratunga & Baldry, 2002). These systems need to supply correct information at the correct time (Amaratunga & Baldry, 2002; Andy Neely, Richards, Mills, Platts, & Bourne, 1997). Additionally, these systems should be a part of a base that provides gathering the information and analyzes them (Tekçe, 2010). It is highlighted that indicators should enable to make a comparison (Amaratunga & Baldry, 2002; Zairi, 1992).

The performance measurement systems can be evaluated as traditional and modern systems. Traditional performance measurement systems are generated from financial reports and accounting systems (Boulton, Libert, & Samek, 2000). The complexity of new systems leads to frequent use of the traditional performance measurement systems currently (Tekçe, 2010). Traditional performance measurement systems may be listed as earnings per share (EPS), return on investment (ROI), and return on equity (ROE). They have been used for over 100 years (Johnson & Kaplan, 1987; Rappaport, 1981).

Modern performance measurement approaches can be listed as following: balanced scorecard (Kaplan & Norton, 1992), the performance prisms (Neely & Adams, 2002), Skandia navigator (Edvisson & Malone, 1997), performance measurement matrix (Keegan, Eiler, & Jones, 1989), the results and determinant frameworks (Fitzgerald, Johnston, Brignall, Silvestro, & Voss, 1991), the SMART pyramid (Lynch & Cross, 1991), key performance indicators (KPI) (Herbert S. Robinson, Anumba, Carillo, & Al-Ghassani, 2005).

The following section presents a detailed explaination for performance measurement systems used in construction industry.

3.2 Performance Measurement in Construction Industry

Performance measurement has been a common phenomenon in the construction industry for a long time. This popular topic was examined in numerous research studies (Ali, Al-Sulaihi, & Al-Gahtani, 2013; Cheng, Tsai, & Lai, 2009; Egan, 1998; Jin, Deng, Li, & Skitmore, 2013; Kagioglu, Cooper, & Aoudad, 2001; Latham, 1994; Nudurupati, Arshad, & Turner, 2007; J. Wang, Lin, & Huang, 2010; Yeung, Chan, & Chan, 2009; Yu, Kim, Jung, & Chin, 2007)

Through the use of performance evaluation techniques, the primary objectives of performance measurement are inspected and the efficiency of production is improved by detailed analysis of obtained information (Thanassoulis, 2001). Increments in the efficiency of construction sector may be sustained with functional performance measurement (Yang, Yeung, Chan, Chiang, & Chan, 2010).

Due to the necessity, there are remarkable studies for performance management in the construction area. Due to its inefficiency, the important aspect of performance measurement has spread into the construction industry, just like other industries (Kagioglu et al., 2001; Lee et al., 2000; Smith, 2001). According to Lin and Shen (2007), the reasons of increased number of studies in this subject are (1) performance measurement techniques are more rapidly enhancing than other industries, (2) construction projects are more complex than before, (3) in construction, there are more improvements in management and technology (Lin & Shen, 2007). Also, the concept of competition and challenging market conditions bring performance measurement into prominence (Love & Holt, 2000). Bassioni, Price, and Hassan (2004) stated that many research has been triggered due to the insufficient financials based traditional measurement system and the spread of non-financial measures (Bassioni, Price, & Hassan, 2004).

Even though there is no unique performance measurement method, researchers agree that development of performance measurement at some level is necessary. The low performances can be analyzed with the project-based approach which considers the problems resulting from the specific conditions of each project, and process-based approach which evaluates performance problems associated with the construction process (Kashiwagi, Sullivan, Greenwood, Kovell, & Egbu, 2005). According to Costa and Formoso (2004a), performance measurement among construction firms,have been increasing but not reached to a sufficient level. The declaration of contractors about having difficulties in the determination and selection of performance indicators can be seen as the primary reason for this situation (Costa & Formoso, 2004).

Researchers are focused on performance measurement area in construction to measure the success of project management. Calculation of performance can be conducted using the success indicators (Demirkesen-Çakır, 2016). Meanwhile, some researchers (Demirkesen-Çakır, 2016) focused on knowledge areas provided in (PMBOK Guide of PMI, 2013) and (Project Management Institute, 2004). Critical success factors are not limited to the knowledge areas, but also mentioned on several studies with different approaches (Horta, Camanho, Johnes, & Johnes, 2013; Konchar & Sanvido, 1998; Lim & Mohamed, 1999; Pocock, Hyun, Liu, & Kim, 1996; Sanvido, Grobler, Parfitt, Guvenis, & Coyle, 1992; Songer & Molenaar, 1997).

Yang et al. (2010) highlighted that the literature studies between 1998 and 2009 show that performance measurement can be approached at three levels (1) Project level (Abbasian-Hosseini, Hsiang, Leming, & Liu, 2014); (2) Organizational level (Li, Chiang, Choi, & Man, 2013); and (3) Stakeholder level (Horta et al., 2013). Additionally, project level has been stated as focusing on the safety, environmental and technological performance (Yang et al., 2010).

Alternatively, performance measurement can be investigated at the industry level. Industry Level performance can be defined as the performance of whole construction firms (Horta, Camanho, & Da Costa, 2009). Besides, industry-based research use the perspectives of productivity (Vogl & Abdel-Wahab, 2014), management of public (Lin & Tan, 2013) and organizations (Liu, Zhao, & Liao, 2012).

European Foundation For Quality Management Excellence Model (EFQM); Balanced Scorecard (BSC) model; and Key Performance Indicators (KPI’s) model are widely used for the framework of performance measurement in construction (Yang et al., 2010). Also, in the construction sector, other methods of performance measurement include gap analysis; integrated performance index; statistical methods and data envelopment analysis (DEA) method.

Table 3.1 : Performance measurement levels, framework, and research techniques.

CRITERIA	SUBCRITERIA	KEY REFERENCES
Levels of performance measurement in construction	Project Level	(Chan & Chan, 2004; Fang, Huang, & Hinze, 2004; Jones & Kaluarachchi, 2008; Lam, Chan, & Chan, 2007; Lin & Shen, 2007; Pillai, Joshi, & Rao, 2002; Sharma, 1995; Yeung, Chan, & Chan, 2008; Yeung, Chan, Chan, & Li, 2007)
	Organizational Level	(Bassioni et al., 2004, 2005; El-Mashaleh, Edward Minchin, & O'Brien, 2006; Horta et al., 2009; Jin et al., 2013; Kaplan & Norton, 1992; Lin & Shen, 2007; Luu, Kim, Cao, & Park, 2008; Punniyamoorthy & Murali, 2008; Robinson, Carrillo, Anumba, & Al-Ghassani, 2002; Westerveld, 2003; Yu et al., 2007)
	Stakeholder Level	(Ahadzie, Proverbs, & Olomolaiye, 2008b, 2008a; Dainty, Cheng, & Moore, 2003; Wong & Wong, 2008)
Frameworks of performance measurement in construction	European foundation for quality management excellence model (EFQM)	(Bassioni et al., 2005; Westerveld, 2003)
	Balanced scorecard (BSC) model	(Kagioglu et al., 2001; Kaplan & Norton, 1992; Luu et al., 2008; Herbert S. Robinson et al., 2005; I. Yu et al., 2007)
	Key performance indicators (KPI) model	(Ahadzie et al., 2008a, 2008b; Chan & Chan, 2004; Dainty et al., 2003; Horta et al., 2009; Lam et al., 2007; Lin & Shen, 2007; Robinson et al., 2002; Yu et al., 2007)
Research techniques for performance measurement in construction	Gap analysis	(Jones & Kaluarachchi, 2008)
	Integrated performance index	(Pillai et al., 2002; Punniyamoorthy & Murali, 2008; Sharma, 1995; Yeung et al., 2007; Yu et al., 2007)
	Statistical methods	(Ahadzie et al., 2008a, 2008b; Fang et al., 2004)
	Data envelopment analysis (DEA)	(El-Mashaleh et al., 2006; Horta et al., 2009; Wong & Wong, 2008)

3.3 Frameworks of Performance Measurement in Construction

3.3.1 European Foundation for Quality Management Excellence Model (EFQM)

The purpose of qualitative methods can be summarized as achieving the business excellence. There are popular quality models such as Deming Model, Malcolm Baldridge National Quality Award (MBNQA) and European Foundation Quality Model (EFQM). EFQM is established by the European Foundation For Quality Management and includes 9 main and 2 sub-criteria. The philosophy of the model is based on diverting the employees’ skills to results via several processes. In general approach, EFQM enables parties to realize the position of the organization, limitations, gaps, and solutions.

So, EFQM can be seen as a quality management method specifically developed for organizations. Robertson (1997), defines 18 indicators for measuring the performance of a contractor (Robertson, 1997). Also, the usage of EFQM in the construction industry is examined in the research of Watson & Seng, 2001. Another study for focusing on the usage of EFQM in construction sector evaluated the determination of key performance indicators from the strategy level to the operational level (Beatham, Anumba, Thorpe, & Murray, 2002).

There is also a hybrid method that is a combination of EFQM and BSC for contractors’ performance in Tasmania (Samson & Lema, 2002). This study examines the validity of the developed EFQM method.

As a conclusion, it can be said that EFQM is focused on quality and generally used for performance measurement of firms in the construction industry. Limitations of the EFQM can be listed as:

- Due to being detailed, the implementation process is time-consuming.
- EFQM’s criteria are not including the factors that innovation, development, partners, etc. (Azhashemi & Ho, 1999).
- Thoughts about quality-based models are not the best choice in terms of continuity of strategies as a continuous development framework (Kaplan & Lamotte, 2001).

3.3.2 Balanced Scorecard (BSC) model

Balanced scorecard model is first developed by Brown & Root/Halliburton Engineering and Construction Company (Kaplan & Norton, 1992). BSC model evaluates customers, innovation, internal processes and financial subjects with different perspectives within performance measurement frameworks. Design and implementation issues were added later in BSC (Oliver & Palmer, 1998). BSC is categorized and used for performance measurement of construction projects (Kagioglu et al., 2001). There is an approach for framework about risk management and generated by usage of BSC for research and development projects (Wang et al., 2010). International construction companies are in a study that was adapted to the BBC for performance measurement (Jin et al., 2013). Using a balanced framework that is adopted from BSC, is another example of supply chain's performance measurement.

Briefly, BSC is focused on customers and leads to the development of frameworks that are generated according to needs. BSC is criticized from four perspectives: Inadequate (Schneiderman, 1999) and not covering the leadership issue, lacks in the involvement of stakeholders in performance measurement (Nørreklit, 2003). Also according to Bassioni et al. (2004), BSC implementations are relatively new and still ongoing research. Two of the important performance factors, social and environmental, are not taken into account in BSC (Tekçe, 2010).

3.3.3 Key Performance Indicators (KPIs)

According to Tekçe (2010), performance indicators and performance measure/metric are used interchangeably. A performance indicator is a piece of measurable evidence to prove that the desired result is achieved with a planned effort. Mbugua et al. (2000) stated that if a definite measurement can be made and value can be obtained for a target, then this situation might be called as performance measurement (Mbugua, 2000). Performance indicators are less precise than performance measures (Jackson & Palmer, 1989). Key performance indicators have different uses in the construction industry in different areas of project, firm and industry levels and this use is very diverse.

Key performance indicators are generally used for determining a set of indicators to measure firms' performance (Demirkesen-Çakır, 2016). The main logic behind the KPI use is based on comparison, i.e., measuring the performance and comparing it

with the best examples. Thus, project control can be accomplished (Demirkesen-Çakır, 2016). KPIs are used for the determination of management‘s approach (Cox, Issa, & Ahrens, 2003) and determination of construction companies' performance through data envelopment analysis (DEA) (Horta et al., 2009). In the project level, Wongsamut (2002) used KPIs for a water resources development project (Wongsamut, 2002).
The critics for KPIs can be listed as:

- For organizations, indicators have limited use in internal management and decision-making mechanisms (Kagioglu et al., 2001; Herbert S. Robinson et al., 2005).
- Generally, indicators can be obtained after results. Due to that, they are seen as lagging instead of leading. So, they are serving as a reflector of past, and they are inadequate for reflection of current and future situations (Ghalayini & Noble, 1996; Ward, Curtis, & Chapman, 1991).

3.4 Levels of Performance Measurement in Construction

3.4.1 Project level

Total performance of a project at any moment in its life cycle is determined by performance measurement (Lop, Ismail, & Mohd Isa, 2016; Pillai et al., 2002). Measurement is defined as a crucial step for process’s control by numerous studies (Cleland & King, 1988; De Falco & Macchiaroli, 1998; Meredith & Mantel, 1995; Raz & Erel, 2000; Turner, 1993) Due to these facts, project level investigation is mainly concluded for performance measurement in construction.
Different types of projects are investigated by many researchers. One of them is design & build construction projects (Lam et al., 2007; Ling, 2004; Shrestha & Mani, 2013), design/bid/build (DBB) construction projects (Ling, 2004; Shrestha & Mani, 2013). El Asmar et al., (2013) examined numerous performance metrics to compare the projects using integrated project delivery (IPD) system and traditional systems (DB, DBB, and construction management at risk) (El Asmar, Hanna, & Loh, 2013). Also, research and development (R & D) projects is studied by (Pillai et al., 2002).
Employers and contractors have seperate objectives and each project serves different purposes and priorities. Also there is a large number of factors that affect project performance and success. The preliminary reason for the lack of a standard or structured performance measurement in construction sector is uniqueness of the constructio project (Hanna, Lotfallah, Aoun, & Asmar, 2014). However, it is possible

to build a performance measurement system for specific features of a construction and/or urban transformation project. The developed performance evaluation method can be used as a framework or guideline for related studies and projects, and also can be updated based on projects’ characteristics.

3.4.2 Organizational level

Globally, in construction sector, there are several organizational performance measurement programmes in use. Some examples include: European Foundation for Quality Management Excellence Model, key performance indicators and the balanced scorecard (Jabareen, 2009). Lin and Shen (2007) expressed that research incompany level performance measurement should focus on from random applications of diverse projects and the operation of input resources. Lin and Shen (2007) also stated that adjusted balanced scorecard (BSC) model, and the European Foundation for Quality Management (EFQM) excellence model are popular frameworks for usage in construction sector (Lin & Shen, 2007). In addition, in the late 1990s the Construction Best Practice Program (CBPP) involved a key performance indicator (KPI) framework The studies started to focus performance measurement at company level (Bassioni et al., 2005) and also the approach switched from financial items to financial and financial items (Bassioni et al., 2004). Organizational tactics, advantage on their compatibility skills and measurement of strategic performance might be developed with performance measurement (Luu et al., 2008).

One of the recent studies focus on marketing effect on architecture firms in Singapore with the aspects of marketing importance and marketing performance measurement (Low, Gao, & Mohdari, 2016).

3.4.3 Stakeholder level

As mentioned above, construction sector includes complexity and interaction between different parties including different contracting parties such as owners, contractors, and consultants (Yang et al., 2010). Performance of these actors is seen as one of the significant factors in projects’ achievement (Wang & Huang, 2006). For managers, projects’ success and performance are directly affected by team building issues such as (Dainty et al., 2003):

- leadership;
- decision making;

- mutuality and approachability;
- honesty and integrity;
- communication;
- learning, understanding, and application;
- self-efficacy; and
- external relations.

Since project managers are the key personnel for delivering a project within required targets, performance of them was monitored by (Cooke-Davies, 2001) in a study evaluationg performance of projects manager in residential project. In early stages of a project, project managers may use performance measurement for improving themselves (Ahadzie et al., 2008a, 2008b). The indicators may contribute to the assessment of the combined performance of individual units / interventions, the overall effectiveness of partnerships to improve economic prosperity, or the cost effectiveness of major regeneration activities (Hemphill, McGreal, & Berry, 2004a).

3.5 Project Performance Measurement

In Lin and Shen (2007) research, several terms are classified as performance measurementmetrics:

- environmental performance;
- human resource performance;
- technology innovation;
- procurement performance;
- safety performance;
- design performance;
- post-occupancy evaluation;
- maintenance;
- thermal and air conditioning;
- participant’s satisfaction;
- cost performance;
- quality performance; and
- time performance (Lin & Shen, 2007).

Another study defines a mathematical formulation called project quarterback rating (PQR) as a unified project-performance metric (Hanna et al., 2014). The unique score enables to compare projects with their own techniques. This study is limited with five performance areas (see Figure 3.1) which are generally used in every construction projectsand also is limited with comparison on eleven projects. (Hanna et al., 2014).

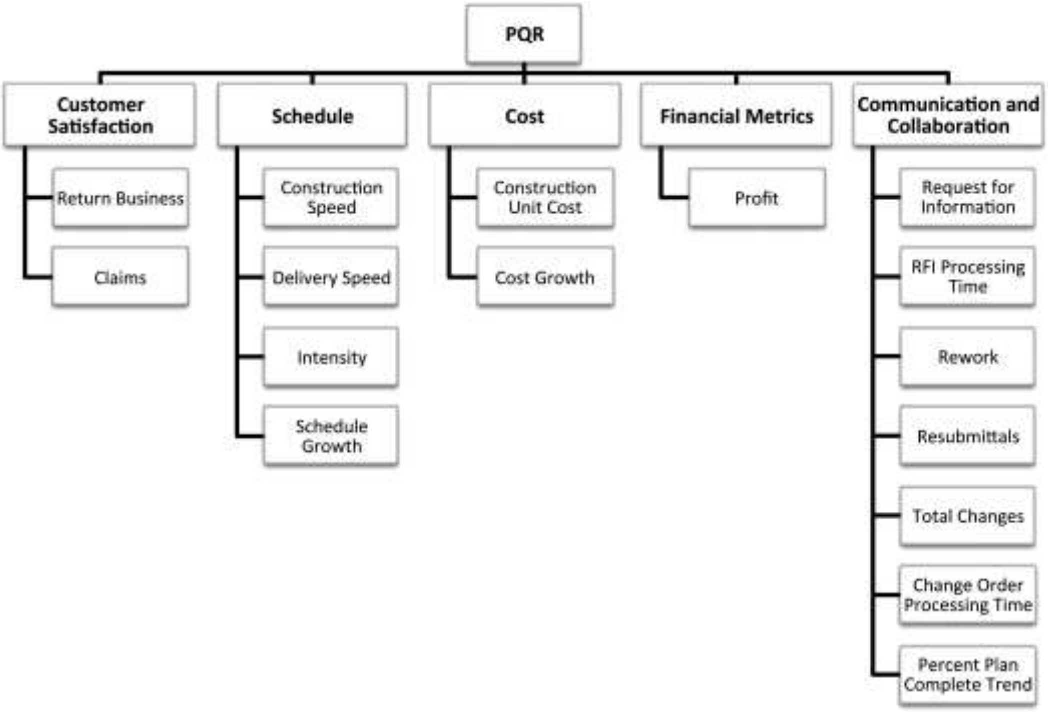

Figure 3.1 : PQR structure used by Hanna et al., 2014.

There is a another study which gathers a list of metrics for lead project managers which provides the right status for project performance (Gransberg & Buitrago, 2002). In this study, project performance metrics are examined under three concepts: relative metrics (cost growth, schedule growth, award growth), static metrics (design unit cost, construction unit cost, design-built cost, design-built unit cost) and dynamic metrics (design placement, construction placement, design-built placement, intensity).

Also, time and/or time performance have been declared by so many research as a metric for comparison of construction projects (Assaf & Al-Hejji, 2006; Chan & Kumaraswamy, 1997; Ogunlana, Promkuntong, & Jearkjirm, 1996; Rankin, Fayek, Meade, Haas, & Manseau, 2008). Also, the time factor is concentrated for the successful completion of construction projects (Al-Momani, 2000; Odeh & Battaineh, 2002). Menches and Hanna (2006) investigated the time factor as the amount of time which is given for a project (Menches & Hanna, 2006).

Additionally, Dedobbeleer and Béland (1991) expressed that the safety matter that is directly related to workers can be used as a criterion for performance measurement of construction projects (Dedobbeleer & Béland, 1991). Rankin et al., (2008) defined the safety aspect as criteria for performance measurement.

A building project includes so many planned or unplanned events, different partners, changing environment and combination of all of these. Some exact factors are seen as more crucial and called critical project success factors (CPSFs) (Sanvido et al., 1992). There are various research that examined construction projects' CPSFS (Chan, Scott, & Chan, 2004; Chua, Kog, & Loh, 1999; Cooke-Davies, 2001; Dawood, 2010; Sanvido et al., 1992; Westerveld, 2003).

Dawood (2010) describes nine key performance indicators (time, safety, client satisfaction, rework efficiency, communication efficiency, cost, planning efficiency, team performance, and productivity) in a study that aims to develop a new approach to determine the value of 4-D planning in construction projects. In addition, technical productivity is expressed as an item for performance measurement (Chan, Scott, & Lam, 2002).

Partnering in construction projects is greatly approached by so many studies, on the result of focusing the critical success factors that contribute on this area (Chan & Chan, 2004; Chan, Ho, & Tam, 2001; Cheng, Li, & Love, 2000; Black, Akintoye, & Fitzgerald, 2000; Chan, Chan, et al., 2004). Features of the contractor and contractor selection process are two of the important factors that affect the success of a construction project (Horta et al., 2013). Alzahrani and Emsley (2013) studied the impacts of contractor's attributes (Alzahrani & Emsley, 2013).

There are also some studies that focus on the effects of procurement process on project performance (Chao & Hsiao, 2012; Migliaccio, Bogus, & Chen, 2010).

Profit (Chan et al., 2002), net profit margin (Menches & Hanna, 2006) are studied as aspects of performance measurement. Also, the index that is developed by Menches and Hanna (2006) for performance measurement, includes the changes in work time and communication between members of the team (Menches & Hanna, 2006).

Another metric for performance development can be environmental sustainability (Chan et al., 2002; Rankin et al., 2008). Rankin (2008) also added the innovation aspect to performance metrics.

It is stated that numerical measurement of cost, budget accomplishment (Grau & Back, 2015; Menches & Hanna, 2006; Rankin et al., 2008), schedule expansion, percent schedule overrun (Menches & Hanna, 2006) and quality measurement and compliance with owner requirements, are the determinants for a projects' success (Konchar & Sanvido, 1998; Molenaar, 1995). Also, detailed unit cost, speed of construction and turnover can be added to this list (Konchar & Sanvido, 1998). The list for determination of project success can be expanded with number of claims (Songer & Molenaar, 1997) and the number of changes in design (Pocock et al., 1996).

Time, cost and quality, "the iron-triangle" (Atkinson, 1999) are assumed to be the basic performance measurement criteria (Barkley & Saylor, 1994). According to Kumaraswamy and Thorpe (1996), these basics should be expanded with safety matters, budget, schedule, partner's satisfaction about quality and utilisation of the technology (Kumaraswamy & Thorpe, 1996). Chan and Tam (2000) added the following terms into this list, the performance of environmental issues and commercial value (Chan & Tam, 2000). In another research, six variables (cost, time, quality, clients' satisfaction, health and safety, and functionality) were chosen for performance measurement of a project (Ali & Rahmat, 2010). The results showed that ISO 9000 standard is a beneficial tool for controlling efficiency, productivity and customer services, and also functionality is one the most important criteria of performance measurement.

Cost and cost variance are accepted as one of the popular indicators for measuring design and/or project performance (Bubshait & Almohawis, 1994; Salter & Torbett, 2003). Cost is not the only metric by itself, since there are numerous cost increases such as claim related cost increase, arbitration and litigation related increase, and other impacts associated with variation/modifications (Ali & Rahmat, 2010). So, unit cost, cost variance, percentage of variation as well as final cost should also be considered.

For project success, the first factor that should be evaluated is time/completion time (Lim & Mohamed, 2000). According to Ali and Rahmat (2010), time factor gives an important clue to project managers whether their projects are proceeding by the schedule. Time variance is also seen as a method for measuring the construction project's performance (Odeh & Battaineh, 2002; Salter & Torbett, 2003). On the client's perspective, completion of a project on time is one of the crucial needs (Latham, 1994).

Parfitt and Sanvido (1993) defines the quality in the construction sector, a sum of the all the aspects of a product, process or system that meets the required needs and goals (Parfitt & Sanvido, 1993). Features of a product, process or service are defined according to contracts, specifications and client's expectations (Ali & Rahmat, 2010). All parties must understand the owner's expectations in a project, and contract price and documents must include these requirements as much as possible, in order to reach a completed project that meets the quality expectations of the owner (Ganaway, 2006).

Locke (1970) explains satisfaction as comprising the perception and expectation of an output (Locke, 1970). In the construction sector, client's satisfaction is seen as a hard task to accomplish due to delays, extended costs, inefficient quality, inadequate parties (consultants, contractor, manufacturers, etc.) (Contract Journal, 2004). For the development of project performance, client' satisfaction is confirmed as a basic issue (Ali & Rahmat, 2010). In the construction industry, client satisfaction is associated with not only completion under budget and schedule, but also achieving the quality and performance goals. (Parasuraman, Zeithaml, & Berry, 1988; Soetanto & Proverbs, 2004).

The construction industry is one of the sectors that cause major accidents due to containing heavy and hazardous activities. Usually, accidents happen during the construction phase (Ali & Rahmat, 2010). Health and safety is defined as a factor that supports the completion of the performance of projects without accident and injury (Bubshait and Almohawis, 1994). Measuring health and safety matters is a challenging issue and there is no standard technique. Accident and injury statistics are usually used to determine the results. Health and safety measures are important in the sense that they provide reliable approaches and current strategies for risk management and determination of preventive actions (Ali & Rahmat, 2010).

Functionality is directly related to the conformance with technical performance (Chan et al., 2002). For measuring technical performance are seen mostly at pre-construction and construction phase, and stated as a success criterion for design-build projects (Songer & Molenaar, 1997).

In one of the recent studies, the authors examine the relationship between project characteristics and project performance (Hee Sung Cha & Kim, 2011). In this study, project performance indicators are developed from literature and industry survey for frequently-used performance areas; contract, cost, schedule, quality, risk, safety and environment, and productivity. The Quantification Method for Performance Area is given at Table 3.2. The limitation of this research is stated as being limited by the Korean building construction industry.

Table 3.2 : The Quantification Method for performance area (Cha & Kim, 2011).

Performance Area	KPI	Quantification Method
Contract	Cost of conflict	Total cost of conflict/no. of events
	Period of conflict	Total period of conflict/no. of events
Cost	Cost variance	Cost variance/ total cost
	Cost accuracy	Total cost/(total cost + cost variance)
Schedule	Schedule variance	Schedule variance/schedule approved
	Schedule accuracy	Schedule at completion/schedule approved
Quality	Rate of approval	Number of approvals/number of tests
	Rate of NCR generation	NCR events/total gross area
	Rate of rework	Cost of rework/total cost
	Frequency of rework	No. of reworks/gross area
Risk	Contingency rate	Contingency used/gross area
	Rate of design change	Cost of change order/total cost
Safety/environment	Rate of accidents	Number of accidents/hours of labor
	Rate of severe accidents	Number of severe accidents/hours of labor
	Rate of safety management	Number of safety trainees/total laborers
	Rate of site danger	Number of warnings/gross area
	Rate of construction waste	Amount of waste/gross area
	Rate of recycling	Recycled waste/total waste
	Civil complaints	Cost to address/no. of complaints
Productivity	Office productivity	Total cost/total office work-hours
	Labor productivity	Total cost/total labor work-hours

Another study focused on the construction projects' performance in Bangladesh, one of the developing countries (Hossain, Guest, & Smith, 2019). In this study seven (financial, time, quality, health & safety, stakeholder satisfaction, innovation, environmental) key performance areas are used and obtained from the literature.

AHP is used for determination of weights of KPIs including 41 performance indicators. This determination is done by questionnaire survey through the PPP practitioners in Bangladesh.

To sum up, it can be stated that there is a large amount of literature about performance measurement of construction projects and related concepts (Chan & Chan, 2004; Fang, Huang, & Hinze, 2004; Jones & Kaluarachchi, 2008; Lam, Chan, & Chan, 2007; Lin & Shen, 2007; Pillai, Joshi, & Rao, 2002; Sharma, 1995; Yeung, Chan, & Chan, 2008; Yeung, Chan, Chan, & Li, 2007), industries (Cox et al., 2003; Love & Holt, 2000), firms (Bassioni et al., 2004, 2005; El-Mashaleh et al., 2006; Horta et al., 2009; Jin et al., 2013; Kaplan & Norton, 1992; Lin & Shen, 2007; Luu et al., 2008; Punniyamoorthy & Murali, 2008; Robinson et al., 2002; Westerveld, 2003; Yu et al., 2007). Some of the shortcomings in the current literature, include the relatively low number of studies about performance measurement of urban regeneration projects and sustainable performance measurement of projects. Next section will focus on sustainability and urban regeneration approaches in the literature. Then a constructed indicator list for sustainable performance measurement of urban regeneration projects shall be proposed to be validated by experts.

4. THE APPROACHES FOR SUSTAINABILITY AND URBAN REGENERATION

4.1 Sustainability

The word sustainable is first summarized in 1987 in the United Nations Brundtland report as a harmonious integration of economic life and the environment. Sustainable development is defined as the process of meeting today's needs without sacrificing the opportunities to meet the needs of future generations (WCED, 1987).

Sustainability and sustainable development were the major research areas in the previous decade (Büyüközkan & Karabulut, 2018).

Sustainable Development is aimed at people and the environment. The protection of environmental components within the ecosystem, as well as the development, improvement, and protection of economic and social development policies, which are focal points of human life, are important targets. The researchers linked the social, economic and environmental dimensions to one another because of the possibility of having long-term problems in another dimension by obtaining the positive results for one dimension and argued that they should be handled as a whole. Brundtland’s report aims to present a more integrated sustainability approach that emphasizes the multiple systems in place for economic growth, social equality and better protection of the environment (WCED, 1987). Economic welfare is increasing in societies where the natural resources are protected and alternative renewable resources are used efficiently, and natural environment is consciously approached while economic activities take place. Societies in which people live in healthy environments and have reached the level of economic welfare can be defined as societies with a healthy social structure. Therefore, environmental sustainability can only be achieved with economic and social sustainability.

Economic sustainability is about developing and maintaining the required financial resources for the actualization of environmental and social sustainability (Gilbert, Stevenson, Girardet, & Stren, 1996). Economic sustainability is the capacity of keeping continuous growth in the economic system and the capacity to generate income and employment for the sustainability of the population. Besides, within a regional system, economic sustainability is the capacity to produce and maintain high added value through the most efficient admixture of resources to improve the genuineness of regional products and services.

Environmental sustainability is the capacity to reveal and enhance the value of environmental and its aspects while providing the preservation and renewal of natural resources and environmental heritage within a region. The environmental - ecological sustainability requires that renewable material resources and natural systems are not consumed faster than their rate of self - renewal. Moreover, it requires that the consumption rate of non-renewable resources must be lower than the replacement rate of renewable resources and the rate of released waste into nature does not exceed the absorption and reprocessing capacity of air, water, and soil. According to environmental sustainability is an ambiguous concept and may represent two different ideas. The first idea is the sustainability of the processes and systems of the natural environment such as the climate system and the forest ecosystem, and the second is the development of social institutions and processes to solve environmental problems. Regardless of its definition, economic and social dimensions should not be neglected to maintain the environmental sustainability.

Social sustainability is concerned with the way individuals, communities and societies live together; and how they act to achieve their own goals taking into account the physical boundaries of their space (Colantonio, Dixon, Ganser, Carpenter, & Ngombe, 2009). Social sustainability ensures the fair distribution of welfare (safety, health, education) between social classes and genders. Social sustainability within a region means that the interacted institutions at all levels and the promoted stakeholders act together to achieve the same goal. The most general definition of social sustainability is the protection and development of social conditions that will support human needs and ensure environmental sustainability and ensure the efficient use of natural resources by present and future generations. According to Ekins (2000), social sustainability is the ability to obtain and maintain a common sense of social purpose necessary to ensure the social integration (Ekins, 2000).

4.2 Sustainability Measurement Approach in Construction Sector

Kibert (1994) declared that sustainable construction could be defined as with the help of ecological principles and efficient resource usage, generation of healthy environment and/or maintenance of it (Kibert, 1994). For decades, the construction industry has a fatal impact on livebeings, resources and work environment (Bourdeau, 1999).

Sustainability and sustainable development are the major research areas in the previous decade (Büyüközkan & Karabulut, 2018). The concept of sustainability is generally focused on environmental and ecological aspects and has the perspective of conserving natural resources and transferring them to future generations. However, the concept of sustainability should be developed, which can be changed, improved, and changed for the needs of generations. Therefore, sustainability has become a need. The concept of sustainability should not only be focused on environmental issues, but also on social and economic components which turn the need for sustainability into a challenge (Büyüközkan & Karabulut, 2018).

The rapid depletion of environmental resources, the increase of cultural and social differentiation have led decision-makers to take sustainable measures and develop sustainable systems. The scientific studies developed for the sustainable anxiety and problems of enterprises and public institutions both increase awareness on this issue and constitute a permanent place in determining new sustainable strategies (Deloitte and Touche and BCSD, 1992). Sustainability should be measurable so that the concept of sustainability can be internalized and adapted to processes.

For measurable systems, measurement criteria should be determined and then analyzed to give meaningful outputs to decision-makers. According to Lobos and Partidario (2014), constructed sustainability assessment approaches needs to develop compact, formatted, linear systems rather than the systems with high complexity (Lobos & Partidario, 2014). Performance indicators can be categorized and weighted through a previously defined methodology (Goldberg, 2002; Nardo et al., 2005). These indicators can be measured quantitively and qualitatively to gain productive, useful, effective results.

Büyüközkan and Karabulut (2018) has conducted a literature review on sustainability performance evaluation and aimed the fill the literature gap between sustainability assessment and sustainability accounting. It also provides information about recent sustainability trends and applicable sustainability performance evaluation frameworks. This paper emphasize that the sustainability performance models should be moreconsistent with criteria to meet the objectives.

Evaluation of the sustainable performance of construction projects done through the Key Performance Indicators (KPIs) approach, is the most common method in the literature (Kylili, Fokaides, & Jimenez, 2016). Another recent research study focused on gathering KPIs for sustainability measurement of the building renovation projects (Kylili et al., 2016). Although it is mainly focused on renovation projects, this study provides a high level of contribution to the sustainable performance measurement literature that can be used in any type of construction project. The limitations of this study are (1) KPIs were not validated to make sure to proper usage in real projects, (2) KPIs were not verified through an application on real building renovation projects, (3) not having consensus about sub-criteria, and (4) it is not clear which sub-criteria or criteria are the most important for determination of sustainable performance of renovation projects. Through this study, KPIs used for sustainability measurement in renovation projects are grouped into eight main criteria (economic, environmental, social, technological, time, quality, disputes, and project administration) and several sub-criteria (e.g. direct cost, land use, occupational safety, innovation planning, material, site dispute, procurement).

Determination of sustainable performance indicators is the primary issue to achieve successful performance measurement. A list of sustainable indicators is obtained through thirteen studies and grouped under four dimensions (economic development, social sustainability, environmental conservation, institutional strength) in another study (Michael et al., 2013). Fifteen post-graduate students were involved in the questionnaire period and evaluated the indicators to be selected for the AHP process. The results of this study shows that the environmental dimension has more importance than other dimensions. Other indicators with high priority are listed as “employment rate”, “access to public utilities”, “air quality”, “enforcement operation”. The limitation of this research can be listed as: (1) indicator selection methodology cannot be seen as suitable for every urban regeneration project and it is not adequate due to not including indicators such as: compliance with acoustic standards, number of trainings, issues related with health and safety and so on. Since the focus of the paper is providing a systematic approach to sustainability for decision-makers, project performance focus is not properly presented. Last, the study does not include the application of the AHP model into real-life projects and provide verification of the model. Also it does not include the real experts' participation in model development.

There is another study that conducts a set of affecting factors for social sustainability projects (Chan & Lee, 2008). The focus of the study is on urban regeneration projects by analysing six critical factors (Satisfaction of Welfare Requirements'', ''Conservation of Resources & the Surroundings'', ''Creation of Harmonious Living Environment'', ''Provisions Facilitating Daily Life Operations'', ''Form of Development'' and ''Availability of Open Spaces''). The strength of the research is including the experts and ordinary people into the pilot study. The limitations of the research can be expressed as: (1) focusing only on social sustainability, not focusing on economic and environmental performance, (2) the performance indicators and measurement techniques have not been addressed due to assessment is made through effective factors.

There is also another study for the decision-making process, assessing the sustainable development through evaluation of the indicators (Hunt et al., 2008).

4.3 Sustainable Performance Measurement of Urban Regeneration Projects

4.3.1 Urban regeneration perspective

Urban regeneration is defined as a comprehensive vision and action that seeks to provide a permanent solution to the economic, physical, social and environmental conditions of a changing region to produce solutions to urban problems (Thomas, 2003). According to Lichfield (1992), urban regeneration is a compromise that results from the need for a better understanding of the processes of urban degradation and the results of the regeneration to be realized. According to Donnison (1993), urban regeneration is a new way and method for coordinating the problems concentrated in the urban collapse areas.

Urban regeneration is the re-development and revitalization of a lost economic activity; social integration in areas with social exclusion; to restore this balance in areas where environmental quality or ecological balance is lost (Roberts, 2000). According to Roberts (2000), urban regeneration should be designed to serve five main purposes; (1) establishing a direct relationship between the physical conditions of the city and its social problems, (2) responding to the physical need for constant change of many elements that make up the urban fabric, (3) revealing a successful economic development approach that increases urban welfare and quality of life, (4) aiming to meet the shaping needs of urban politics as the product of social conditions and political forces, (5) developing strategies for the most efficient use of urban areas and avoiding unnecessary urban sprawl (Roberts, 2000).

The common point of all different definitions of urban transformation is that as a result of the loss of comfort, quality, and livability of cities for many reasons, the cities enter into healing processes for the environment and the welfare of the people.

The transformations in developed and developing countries around the world differed according to their economic opportunities and social formation. In developed countries such as England, France, and Germany, urban regeneration was mostly carried out after World War II and the industrial revolution for sustainable development. Brazil, the Arab countries, in developing countries such as Turkey, are continuing today also. Developing countries take the transformation models experienced by developed countries as an example while performing the urban regeneration. While developed countries have transformed the gentrification of residential areas in the past, today, with less destruction, more sanitation, and renewal, it is working to protect the historical regions and maintain the sustainable properties of the industrial zones. However uncomfortable and disaster risk as they develop slums in developing countries such as Turkey, yet the process of rebuilding the demolished building stock higher.

Recent literature about the topic has been investigated based on the web of science databases and using keywords.Additionally, the period was chosen to cover the last decade. Table 4.1 gives brief information about the relative publications.

First of all, “Advanced Search” has been chosen among “Basic Search”, “Cited Reference Search”, and éauthor Search”, to reach quickly and efficiently to the related publications. “TS=Topic” is used as Field Tag and the research expression can be given as: (TS=("urban regeneration project*" AND ("performance measure*" OR "performance assess*" OR "performance evaluation"))). The language of research was English, documents type was Article and Review, period 2009-2019 and indexes that the search has been done was SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI. The keywords are searched on titles, abstracts, and keywords of the publications.

Over this research, a very limited study is revealed. The first study is “A fuzzy AHP model to assess the sustainable performance of the construction industry from urban regeneration perspective” and because of this study directly related to sustainable performance measurement of urban regeneration projects, it is investigated in Section 4.3.2. The second publication is “Assessing and Appraising the Effects of Policy for Wicked Issues: Including Unforeseen Achievements in the Evaluation of the District Policy for Deprived Areas in The Netherlands”. After a quick review of this paper, it was understood that urban regeneration projects are inducted about inefficient policy and property policies are necessary for performance measurement. Unfortunately, this study stays out of topic which is performance measurement of construction projects. Third and the last publication is “Risk Performance Indexes And Measurement Systems For Mega Construction Projects”. This study is aimed at adding risks to cost and schedule performance measurement through 18 indicators, to development of the efficiency of mega projects with an urban regeneration perspective.

Table 4.1 : Brief literature about sustainable performance measurement of urban regeneration projects.

Title	Year	Author	Journal	Document Type	Keywords
A fuzzy AHP model to assess sustainable performance of the construction industry from urban regeneration perspective	2017	(Işik & Aladağ, 2017)Isik, Z.; Aladag, H.	Journal of Civil Engineering And Management	Article	performance measurement; sustainable performance; urban regeneration; construction industry; multi-criteria decision making; fuzzy logic; Fuzzy Analytic Hierarchy Process (FAHP)
Assessing and Appraising the Effects of Policy for Wicked Issues: Including Unforeseen Achievements in the Evaluation of the District Policy for Deprived Areas in The Netherlands	2015	Van Twist, M.; Kort, M.; van der Steen, M.	International Journal of Public Administration	Article	complexity; performance evaluation; unforeseen achievements; wicked problems
Risk Performance Indexes and Measurement Systems for Mega Construction Projects	2010	Kim, S. G.	Journal of Civil Engineering and Management	Article	risk management; performance measurement; risk performance index; construction industry; mega construction

4.3.2 Sustainability in urban regeneration projects

Today, urban regeneration is not only perceived as the physical transformation of a region but also the impact of this physical transformation on the social, cultural and economic structure and the transformation resulting from this impact. The fact that sustainable development corresponds to urban regeneration dealing with issues in terms of economic social and environmental sustainability reveals the requirement of considering urban transformation and sustainability collectively. Strategies related to the urban area that is important in ensuring sustainable development are among the aims of urban transformation (Zheng, Shen, & Wang, 2014).

Urban regeneration can contribute significantly to sustainable urban development provided if it follows a sustainable path. However, most urban regeneration projects focus on economic renewal rather than environmental or social renewal (Couch & Dennemann, 2000). For this reason, urban regeneration projects not only improve the quality of life of the built environment and to a certain extent the citizens, but also adversely affect the society due to the lack of social, economic and environmental balance. According to Tang, it is clear that an urban regeneration focused exclusively on the property will lead to the physical renewal of the city and prevent sustainable development (Yıldız, 2018; Tang, 2002). Sustainability principles must be applied to urban regeneration to achieve a sustainable city goal. Combining the concept of sustainability with the urban regeneration process to ensure the long-term economic, environmental and social well-being of the people can be expressed in terms of sustainable urban renewal or urban transformation (Ng, Cook, & Chui, 2001).

A sustainable urban regeneration is a common outcome of sustainable architecture, sustainable urban design, and sustainable urban planning. Sustainable design can be defined as the design of products, services and built environment in harmony with the principles of social, economic and environmental sustainability (in a way that both present and future generations will have a healthy and quality life). The aim of sustainable design, sometimes seen as eco-design, green design, environmental design, or design for sustainability, is to eliminate environmental impacts effectively by a capable and sensitive design process (McLennan, 2004). According to Williams (2007), sustainable designs are system designs (Williams, 2007). They help to solve the economic, environmental and social problems as a simultaneous and single system, so real economic development and return on investment can be achieved. In this sense, an exceptional environmentally sensitive solution that cannot be sustained economically will not be preferable than a socially unconscious solution or a solution that is profitable only at the initial cost but that will threaten society and future generations both economically and environmentally.

Sustainable architecture is the design of sustainable buildings to reduce the total environmental impact during the production of building materials, during construction and throughout the life cycle of the building (Yıldız, 2018). The sustainable architecture includes all the activities carried out to reveal the buildings that are sensitive to the environment, that minimize the harmful impact on the nature of the environment and that use all natural resources such as water, energy, materials, and land consciously and efficiently. Sustainable architecture can be defined as an architectural approach that adapts to the environment, climatic conditions, society and culture in its environment; provides historical continuity, consumes minimum energy in production and usage; uses materials that can be obtained locally and recycled after use (Karslı, 2008).

Sustainable planning aims to design and develop sustainable cities which can be defined as sustainable urban sites that meets the needs of the society better than the existing cities and ensures that the urban systems are developed in a way that does not prevent the meeting of the needs of future generations or the city in which the socioeconomic benefits are harmonized with environmental and energy concerns to ensure continuous change (Ertürk, 1996; Nijkamp & Pepping, 1998).

Many researchers have examined the sustainability of urban development, land use and urban transformation (Wang et al., 2014). Besides the academia has addressed the subject of sustainable urban transformation directly or indirectly.

Zheng et al. (2014), discussed the sustainable urban regeneration under three titles; planning sub-systems in sustainable urban regeneration, stakeholder participation and evaluation of sustainable urban regeneration. The first part includes various urban design elements such as land, housing, infrastructure, cultural heritage and transportation in the urban planning subsystem. Second part describes the social subsystem of urban regeneration which consists of public, community and private sector stakeholders. In the last section, urban renewal is evaluated in terms of two subsystems.

Alker and McDonald (2003) argue that social, economic and environmental aspects that contribute to the success of sustainable development should be considered as a whole before realizing urban regeneration (Alker & McDonald, 2003). Planning for urban regeneration requires to be actualized with an understanding that transformation should not only increase the quality of life in a specific part of the city by a physical renewal but also an integrative perspective from a social, environmental and economic point of view.

Couch and Dennemann (2000) evaluated urban regeneration practices in Liverpool. They state that the economic decline was prevented by the urban regeneration process. Housing quality was improved and acces to facilities such as open spaces, public transportation were improved. Thus major goals of sustainable urban regeneration were achieved (Couch & Dennemann, 2000).

There is a large number of academic studies towards sustainability and urban regeneration conducted in Turkish academia. However, these studies usually focus on two concepts seperately or the concepts are examined together in a limited way only in terms of certain dimensions.

4.3.3 Sustainable performance measurement of urban regeneration projects

Performance assessment frameworks for urban regeneration mostly consist of indicator-based approaches (Audit Commission, 2002; Wong, 2000).

According to Hemphill, McGreal, et al., (2004), the indicators are useful for determination economic statue of regeneration actions, the performance of projects and organizations, and the effectiveness level of collaborating. Also, Hemphill, McGreal, et al., (2004) highlighted that the KPIs should contain qualitative and quantitive information about performance.

The determination of sustainable performance indicators is the primary issue to achieve performance measurement. A list of the sustainable indicators is obtained from thirteen studies and compacted into four dimensions (economic development, social sustainability, environmental conservation, institutional strength) (Michael et al., 2013). Fifteen postgraduate students were presented a questionnaire and evaluated the indicators for the AHP process. The results of this study indicates that the environmental dimension has more importance than other dimensions.

Other prior indicators are listed as “employment rate”, “access to public utilities”, “air quality”, “enforcement operation”. The limitations of this research can be defined as: (1) Indicator selection methodology cannot be seen as suitable for every urban regeneration project and do not include indicators such as: compliance with acoustic standards, number of trainings, issues related with health and safety and so on. Since the focus of the paper is on providing a systematic approach to sustainability for decision-makers, project performance focus is not properly presented. Lastly, the study does not include the application of the AHP model into real life projects and does not provide verification of the model. There is no expert participation in model development.

In another study, develops a set of affecting factors for social sustainability projects is proposed (Chan & Lee, 2008). The focus of the study is urban regeneration projects and six critical factors (Satisfaction of Welfare Requirements’’, ‘‘Conservation of

Resources & the Surroundings'', ''Creation of Harmonious Living Environment'', ''Provisions Facilitating Daily Life Operations'', ''Form of Development'' and ''Availability of Open Spaces''). The strength of the research is including the experts and citizens into the pilot study. The limitation can be gathered as: (1) focusing only on social sustainability, not focusing on economic and environmental performance, (2) the performance indicators and measurement techniques have not been addressed due to assessment is made through effective factors.

Not only the performance measurement approach, but there is also a study for the decision-making process, assessing the sustainable development through evaluation of the indicators (Hunt et al., 2008).

Urban regeneration projects; have the potential to be a driving force for the country's economy due to the construction of their construction materials, engineering, technical consultancy, and construction works. For this reason, it is very important to determine the criteria and indicators affecting the performance of real estate and urban regeneration projects to ensure the effective performance of the developing construction sector in the long term. One of the recent research examined this topic to determine sustainable key performance indicattors (Aladağ & Işık, 2016). In this research sustainable company performance is investigated under four main parameters (i.e. economic, social, environmental, innovation and research & development). Additionally, this research covers the success criteria for urban regeneration projects that have different success criteria than other project types. The limitation of this study is being limited with Turkish construction data and missing statistical analyses of KPIs to develop a model.

There is research that conducted a comprehensive listing of indicators is identified on the sustainability approach for urban regeneration projects. In this research five basic performance areas are determined as the economy and work; resource use; buildings and land use; transport and mobility and community benefits (Hemphill, McGreal, et al., 2004). Also, a scoring framework is discussed to benchmarking "good" sustainable urban regeneration practice. This study cannot take into account the only sustainability approach. Even though urban regeneration projects have specific characteristics than a regular construction project, it is still a project and performance measurement model of urban regeneration projects should include the indicators which are common for regular project performance measurement. Another handicap of this study is not including a case study implementation. But, the authors were applied the model in their following study (Hemphill, Berry, et al., 2004).

Hemphill's framework was used at Langstraat's (2006) study and evaluated as efficient to evaluate the sustainable performance of regeneration projects. Also in this study, sustainability and level of success are differentiates over urban regeneration projects in Britain (Langstraat, 2006).

Shen et al. (2011) identified environmental, economic, social and governance factors with a set of 32 indicators namely the International Urban Sustainability Indicators List (IUSIL). In this paper, nine different practice cities are explored and indicators are evaluated through these practices to analyze and benchmark the different circumstances and selection of indicators (Shen et al., 2011).

5. DEVELOPMENT OF SUSTAINABLE PERFORMANCE MEASUREMENT MODEL

The model developed within the scope of the thesis was developed hierarchically with dimensions, criteria, and indicators. In the scope of Field Study A, the importance weights of key performance indicators were determined on the 1-7 scale. Criteria and dimensions from the components of the model are also determined by 1-9 comparisons in the scope of Field Study, through pairwise comparisons. Then, validation of the model developed within the scope of Field Study B was investigated in terms of usability, practicality, and functionality. Finally, the model was tested on 3 urban regeneration projects (Figure 5.1). This study aims to develop a sustainable performance measurement model for the measurement of performance for urban regeneration projects.

The most important step in the development of the model is to decide which indicators to measure and which indicators are more effective in measuring performance. According to many researchers, it is very important for the success of the model to determine the indicators for the needs and to keep the number of these indicators at the optimum level (Tekçe, 2010).

Therefore, it is very important to determine the effects of key performance indicators determined from the literature on performance measurement. Within the scope of the thesis, experts expressed their opinions on urban regeneration projects. Determining the success of an urban regeneration project is possible by gathering opinions with different experiences and expertise.

The economic, social and environmental dimensions of urban regeneration projects are discussed in the previous sections. Previous studies done by so far have focused on factors that affect performance, rather than identifying key performance indicators for performance measurement. However, the success of a project can be measured by performance indicators, not by affected factors. In addition, in past studies based on model development, the sustainable performance of urban regeneration projects is focused on environmental and ecological factors, and the budget, time, quality, etc., which should be measured in a project, have been ignored. In addition, the validation and testing stages of the models are not presented.

This study aims to obtain a performance score for measuring the performance of urban regeneration projects with the proposed model. Therefore, the relative importance weights of the indicators to be used in the measurement should be determined in order to establish the performance score (Olson & Slater, 2002).

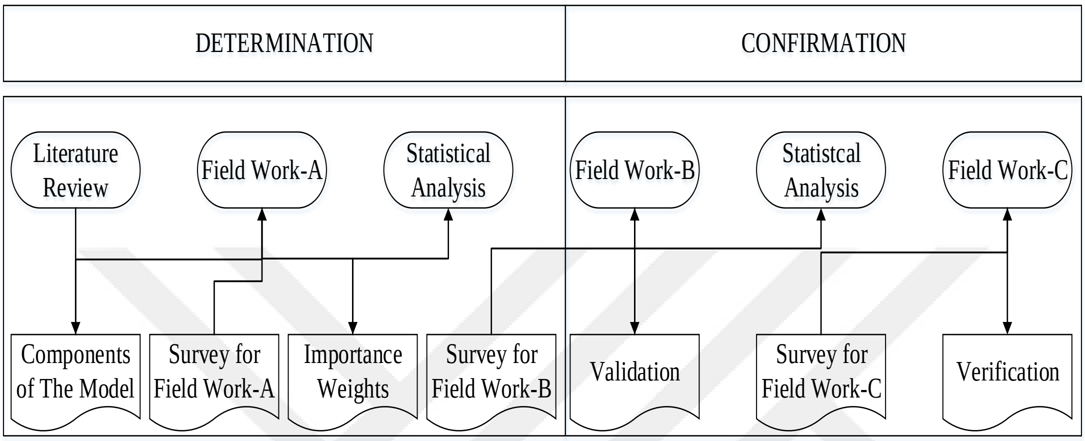

Figure 5.1 : Development stages of sustainable performance measurement model.

5.1 The Steps of Sustainable Performance Measurement Model for Urban Regeneration Projects

The model is developed under five steps; (1) structuring a sustainable performance measurement model, (2) weighting of model components (Analytic Hierarchy Process (Field Study-B)), (3) model validation, (4) testing the model (model verification), and (5) application of the model. The releated steps can be followed by Table 5.1.

Table 5.1 : Flow of Sustainable Performance Measurement Model.

STEPS	Structuring the Sustainable Performance Measurement Model	Weighting of Model Components (Analytic Hierarchy Process (Field Study-A))	Model Validation (Field Study-B)	Testing the Model (Model Verification (Field Study-C))	Application of the Model
1	Literature Review	Field Study-A Questionnaire Development	Field Study-B Questionnaire Development	Field Study-C Questionnaire Development	Determination of Methods and Tools of Measurement and Evaluation of Sustainable Performance Measurement Model
2	Determination of Level 2 Performance Dimensions, Level 3 Performance Criteria, and Level 4 Key Performance Indicators	Determination of the Importance Weights of Key Performance Indicators of Level 4	Determination of Validation Criteria Usability Practicability Functionality	Testing the Performance Measurement Model and Determining the Rate of Error	
3		Performance Dimensions, Criteria and finding significance weights with pair-wise comparisons.	Sustainable Performance Model (Validated)	Sustainable Performance Model (Verified)	
4		Sustainable Performance Model			

STEP 1: Structuring The Sustainable Performance Measurement Model

It includes the determination of different level components (performance dimensions, performance criteria and common key performance indicators) that structure the hierarchy of performance measurement model.

While determining the components of the model, performance indicators were used for the projects detailed in Section 3 and Section 4 and performance indicators for sustainable urban transformation projects were used. The extracted indicators are considered as hierarchical and are handled with a logical arrangement that will facilitate the development and implementation of the model. Besides, four urban transformation experts brainstormed and finalized the hierarchical order. In the following sections, the dimensions of the model will be discussed separately. The most important reason for this approach is to ensure the contextual validity of the model to be proposed, as previously mentioned.

The most commonly used performance criteria were found to cost, time and quality performance. The approaches of these models to performance measurement are from different perspectives as emphasized in the literature. None of the proposed conceptual frameworks explained how to measure performance in the proposed dimensions. In the thesis, it was decided that the proposed model should cover all the dimensions, even if they exist at different hierarchy levels.

In the literature, it has been proposed to make choices considering that too many indicators will cause loss of focus and that too few indicators will result in a lack of comprehensive measurement of work performance (Ashton, 1997). Because of that, the indicator list is limited with 135 and also been questioning under usability, practicability, and functionality perspective.

The components of the sustainable performance measurement model are shown in Table 5.2 with orders and notations.

Table 5.2 : The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	1	FP	FINANCIAL PERFORMANCE	1	FP1	COST/BUDGET ESTIMATION LEVEL (FP1)	1	FP1-1	Estimation level of design cost
							2	FP1-2	Estimation level of construction cost
							3	FP1-3	Estimation level of cost caused by work orders/variation orders
							4	FP1-4	Estimation level of total project cost
							5	FP1-5	Estimation level of claim/conflict number and cost
							6	FP1-6	Estimation level of reworks' cost
				2	FP2	COST/BUDGET COMPLIANCE (FP2)	7	FP2-1	Change in total project budget/cost
							8	FP2-2	Change in design cost
							9	FP2-3	Change in construction cost
							10	FP2-4	Change in cost caused by work orders/variation orders
							11	FP2-5	Amount of conflict/claim cost
				3	FP3	PROFITABILITY (FP3)	12	FP3-1	Project profit margin
							13	FP3-2	Return on investment (ROI)
							14	FP3-3	Return on equity (ROE)

Table 5.2 (continued): The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	2	TP	TIME PERFORMANCE	4	TP1	PROJECT SCHEDULE ESTIMATION LEVEL (TP1)	15	TP1-1	Estimation level of total project schedule
							16	TP1-2	Estimation level ofdesign schedule
							17	TP1-3	Estimation level ofconstruction schedule
							18	TP1-4	Estimation level of delays caused by work orders/variation orders
				5	TP2	VARIANCE/CHANGES IN PROJECT SCHEDULE (TP2)	19	TP2-1	Changes in total project schedule
							20	TP2-2	Number of revision in design schedule
							21	TP2-3	Number of revision in construction schedule
							22	TP2-4	Total delays caused by work orders/variation orders
				6	TP3	LEGISLATION/PERMIT DURATION COMPLIANCE (TP3)	23	TP3-1	Duration of the pre-construction documantation preparation
							24	TP3-2	Duration of formal approval process
							25	TP3-3	Duration of post-construction formal process
1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATIO N	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	3	QP	QUALITY PERFORMANCE	7	QP1	QUALITY IMPACT ON COST (QP1)	26	QP1-1	Cost overrun due by low quality
							27	QP1-2	Saving from improvement of quality
				8	QP2	QUALITY COMPLIANCE (QP2)	28	QP2-1	Compliance with standards
							29	QP2-2	Number of complaint/conflict related with quality
							30	QP2-3	Level/success of project monitoring system
				9	QP3	DEFICIENT WORK (QP3)	31	QP3-1	Number of deficient work
							32	QP3-2	Cost of completion the deficient work

Table 5.2 (continued): The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	4	HSP	HEALTH & SAFETY (H & S) PERFORMANCE	10	HSP1	ACCIDENT/INJURIES (HSP1)	33	HSP1-1	Number of fatal/severe accidents
							34	HSP1-2	Number of injuries
							35	HSP1-3	Number of occupational disease
				11	HSP2	LOSS OF WORKFORCE (HSP2)	36	HSP2-1	Number of days with absenteeism due to accidents/injuries
							37	HSP2-2	Number of days with absenteeism due to occupational disease
				12	HSP3	H & S COMPLIANCE (HSP3)	38	HSP3-1	Compliance with H & S Standards
							39	HSP3-2	Number of complaint related with H & S
							40	HSP3-3	Presence of H & S organization
							41	HSP3-4	Number of corrective measures for risks
							42	HSP3-5	Number of H & S training
							43	HSP3-6	Number of appropriate signage for safety and wayfinding
							44	HSP3-7	Total paid compansation
1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	5	SS	STAKEHOLDER SATISFACTION	13	SS1	CUSTOMER SATISFACTION (SS1)	45	SS1-1	Number of awards (Design, Construction, H &S, Quality, etc.)
							46	SS1-2	Number of customer's complaints
							47	SS1-3	Number and cost of disputes/conflicts/court
							48	SS1-4	Duration of dispute resolution
				14	SS2	EMPLOYEE SATISFACTION (SS2)	49	SS2-1	Number of employees' complaints
							50	SS2-2	Level of salary with respect to industry
							51	SS2-3	Level of social integration at work
							52	SS2-4	Level/Number of recreational opportunities

Table 5.2 (continued): The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	5	SS	**STAKEHOLDER SATISFACTION**	15	SS3	**COMMUNITY SATISFACTION (SS3)**	53	SS3-1	**Level of consultation activities with the local community**
							54	SS3-2	**Level of increase in life quality and urban prosperity**
							55	SS3-3	**Level of access to social services**
							56	SS3-4	**Level of identification of community needs, goals, plans and issues**
							57	SS3-5	**Level of generating new jobs or increasing the existing business, entertainment and cultural capacity for the public**
							58	SS3-6	**Level of improvement the community productivity**
							59	SS3-7	**Level of contribution to local employment, training, and education, with emphasis on the neediest and/or disadvantaged groups**
							60	SS3-8	**Level/number of activities to prevent pollution/complaint of construction activities**
							61	SS3-9	**Level of reduction of traffic disruption during construction and operation**
							62	SS3-10	**Level of net positive impact on public safety and security**
							63	SS3-11	**Level of identification/enhancement/restoring historic and cultural resources**
							64	SS3-12	**Numer /level of satisfaction of added public spaces (e.g., parks, plazas, recreational facilities, or accessible space in wildlife refuges)**
							65	SS3-13	**Number of applied policies**
							66	SS3-14	**Number of jobs proposed**
				16	SS4	**SHAREHOLDER / PARTNER SATISFACTION (SS4)**	67	SS4-1	**Satisfaction level of project shareholders**
							68	SS4-2	**The ratio of company net profit to project net profit**

STEP 2: Weighting of Model Components (Analytic Hierarchy Process (Field Study-A))

At this stage, the importance weights of the 2nd level performance dimensions and 3rd level performance criteria were determined by using the "analytical hierarchy process" and questionnaire forms. For this purpose, the AHP questionnaire was developed to be used in Field Study-A. Following the algorithm of the analytic hierarchy process, the significance weights of the level 2 performance dimensions and level 3 performance criteria were calculated with MS Office Excel 2013. The full details of these calculations are explained in Section 6.

The arithmetic means of the significance weights of the 4th level key performance indicators (135) obtained according to the analysis of the Field Study-A data were determined by normalizing the arithmetic mean values and multiplying the third level performance criteria with the significance weights.

STEP 3: Model Validation (Field Study-B)

The Field Study-B questionnaire was designed to investigate the validity of the sustainable performance measurement model. The validation criteria used for validation of the model were determined as usability, practicality, and applicability as in a similar study. 21 urban regeneration experts were asked to evaluate the model with a 5 point Likert scale in the context of the determined criteria. The sustainable performance measurement model was obtained for urban regeneration projects whose validity of the model was statistically provided. The full details of these calculations are explained in Section 6.

STEP 4: Testing The Model (Model Verification (Field Study-C))

The Field Study-C questionnaire was designed to test the sustainable performance measurement model. To test and test whether the developed model produces correct results, 3 urban regeneration projects have been determined and 3 urban regeneration experts involved in these projects have been tested with the data obtained from the performance of the projects. The total performance evaluations of the experts related to the projects and the performance values calculated using the significance weights were compared and the error rate in the measurement was determined and evaluated. Thus, the tested sustainable performance measurement model was obtained. The full details of these calculations are explained in Section 6.

STEP 5: Application of The Model

Garnett and Pickrell (2000) stated that any application and methodology that wants to find application in the construction industry should be practical and simple (Garnett & Pickrell, 2000). Key performance indicators should be defined to measure sustainable project performance. It varies from enterprise to operation and from project to project. Even though the key performance indicators and measurement methods, which are shaped by the specific characteristics of each project, are a separate research topic, a shortlist of measurement methods is presented within the scope of this study. Since the key performance indicators have quantitative and qualitative characteristics, the experts who will measure the performance can make evaluations with their subjective comments and experiences as they can use real data. Measurement methods for key performance indicators are shown in Appendix K.

The developed model has a dynamic structure and can have different performance dimensions, criteria, and indicators according to project characteristics and objectives. In other words, performance measurement experts can remove the indicators that they do not need from the model components and add the components they think they are not involved in. They can contribute to the development of the model through the feedback made during the implementation of the model. The implementation steps of the proposed model are as follows:

1) Determination of performance dimension, criteria, and indicators,

2) Determining the necessary methods for measuring performance,

3) Determining the importance weights of the model components,

4) Determining the performance following the project objectives and using the model,

5) Evaluation of project performance,

6) Systematically measuring and updating performance at specific frequencies,

7) Processing updates to the model.

Table 5.2 (continued) : The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	6	IN	**INNOVATION**	17	IN1	**RESEARCH & DEVELOPMENT (IN1)**	69	IN1-1	**Number of new technologies applied**
							70	IN1-2	**Number of new technologes/practices developed in the project**
							71	IN1-3	**Level of solutions to problem, bariers, limitations**
				18	IN2	**EDUCATION / TRAINING (IN2)**	72	IN2-1	**Total training hour**
							73	IN2-2	**Number of on-site trainings**
							74	IN2-3	**Number of off-site training**
							75	IN2-4	**Change in productivitiy after trainings**
							76	IN2-5	**Change in defect number after trainings**
				19	IN3	**COMMUNICATION (IN3)**	77	IN3-1	**Stakeholder communication level**
							78	IN3-2	**Number of survey attended**
							79	IN3-3	**Level of information exchange and feedback mechanism**
							80	IN3-4	**Number and duration of responce to feedback**

Table 5.2 (continued) : The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	7	EP	**ENVIRONMENTAL PERFORMANCE**	20	EP1	**ECOLOGICAL (EP1)**	81	EP1-1	**Level of protection or restoration of habitat**
							82	EP1-2	**Total carbon emmisions**
							83	EP1-3	**Ecological footprint**
				21	EP2	**DESIGN (EP2)**	84	EP2-1	**Level of esthetic design**
							85	EP2-2	**Level of landscape design**
							86	EP2-3	**Level of integrated design policies**
				22	EP3	**LAND USE (EP3)**	87	EP3-1	**Level of effective site selection**
							88	EP3-2	**Preservaion level of high value landscapes and its features**
							89	EP3-3	**Level of access to public transportation and public facilities**
							90	EP3-4	**Alternative transportation opportunities**
							91	EP3-5	**Level of compact development**
							92	EP3-6	**Provision of open spaces**
							93	EP3-7	**Level of regularization of population density/urban development**
							94	EP3-8	**Number of housing stock**
							95	EP3-9	**Level of increase in existing reconstruction rights**
							96	EP3-10	**Number of storm water management measures**
							97	EP3-11	**Land pollution reduction**
							98	EP3-12	**Level of accessability**

Table 5.2 (continued) : The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	7	EP	ENVIRONMENTAL PERFORMANCE	23	EP4	WASTE MANAGEMENT (EP4)	99	EP4-1	**Design for minimum waste**
							100	EP4-2	**Provision of construction waste management plan**
							101	EP4-3	**Ratio of recycled/reused waste**
							102	EP4-4	**Identification and reuse of unwanted by-products/discarded materials**
							103	EP4-5	**Storage and collection of recyclables**
							104	EP4-6	**Ratio of recycled or salvaged material**
				24	EP5	ENERGY (EP5)	105	EP5-1	**Building energy performance certificate level (EPC)**
							106	EP5-2	**Provision of building energy model**
							107	EP5-3	**Building energy efficiency level (Performance or prescripted)**
							108	EP5-4	**Utilizationlevel of renewable energy**
							109	EP5-5	**Level of measurement and verification system applied**
							110	EP5-6	**Application level ofbuilding commissioning**
							111	EP5-7	**Provision of greenpower**
							112	EP5-8	**Reduction level the net embodied energy**
				25	EP6	WATER (EP6)	113	EP6-1	**Level of reduction of water pollution (Negative impact on water)**
							114	EP6-2	**Total water use reduction**
							115	EP6-3	**Provision of water efficient landscaping**
							116	EP6-4	**Number of innovative waste water technologies applied**

Table 5.2 (continued) : The proposed sustainable performance model.

1st Dimension (Sustainable Performance of Project)	ORDER	NOTATION	2nd Dimension (Performance Dimension)	ORDER	NOTATION	3rd Dimension (Performance Criteria)	ORDER	NOTATION	4th Dimension (Performance Indicators)
OVERALL SUSTAINABLE PERFORMANCE	7	EP	ENVIRONMENTAL PERFORMANCE	26	EP7	USE OF MATERIAL (EP7)	117	EP7-1	Quantity of environmentally preferable materials used
							118	EP7-2	Regional material usage level
							119	EP7-3	Material reuse level
							120	EP7-4	Level of building life cycle impact reduction
							121	EP7-5	Number of materials with EPDs
				27	EP8	INDOOR ENVIRONMENTAL QUALITY (EP8)	122	EP8-1	Indoor air quality level
							123	EP8-2	Application of indoor air quality strategies
							124	EP8-3	Low emmisionining materials used
							125	EP8-4	Provision of construction IAQ plan
							126	EP8-5	Compliance level with daylight design requirement
							127	EP8-6	Compliance level with ligting design standard
							128	EP8-7	The chemical and pollutant source control level
							129	EP8-8	Building acoustic standards/requiements compliance level
							130	EP8-9	Noise pollution reduction level
							131	EP8-10	Air pollution prevention level
				28	EP9	COMPLIANCE WITH REGULATIONS (EP9)	132	EP9-1	Level of compliance with property rights
							133	EP9-2	Number of reported environmental issues/disputes
							134	EP9-3	Level of compliance with legal requirements
							135	EP9-4	Number of actions to improve sustainable performance

5.2 Performance Components of Sustainable Performance Measurement Model

This section provides a brief description of the components that make up the model. Because, seven performance dimensions and 28 performance criteria that structure the performance measurement model, and even each key performance indicator can be the subject of comprehensive literature research. Here, rather than a detailed literature review, the reasons for taking part in the model as a critical success indicator and brief explanations of contextual validity definition are mentioned.

The definition set of a concept is limited to the theoretical definition that reflects the meaning and clarifies the dimensions of the concepts in previous researches (Bollen, 1989). Contextual validity is a measure of the extent to which the constituted model reflects the problem area of the components of the conceptual framework (Dunn, Seaker, & Waller, 1994). Since there is no statistical test for this determination, the judgment and opinions of the researcher who knows the subject well should be applied (Garver & Mentzer, 1999).

To provide contextual validity in scientific research, a literature analysis should be performed in which the results of previous studies are compiled (Fellow & Liu, 1997). Frequency analysis and normative refinement methods were used to regulate and classify overall sustainable project performance indicators obtained through literature review (İlter, 2017). In the literature, the normative refinement method is commonly used to combine the complementary components of existing approaches to develop a more comprehensive and integrated structure (Uluatam, 2011).

In this study, the model components developed were firstly selected among those mentioned in the literature. Thus, model components were determined by applying frequency analysis and normative inference methods. Afterward, these lists were examined during interviews with two urban regeneration experts and all the contents for sustainable performance measurement that should be included in an urban regeneration project were approved.

5.2.1 Financial performance

The "Financial Performance" dimension is included in the model to evaluate the financial performance of the projects and determine their adequacy. Of course, the most important criterion for the success of a project is the performance of its financial management. In other words, every project carried out in compliance with the budget is considered successful. As detailed in Section 3 and 4, cost/financial performance is an dimension/criterion/indicator for measuring the performance of many projects (Aladağ & Işık, 2016; Ali & Rahmat, 2010; Atkinson, 1999; Barkley & Saylor, 1994; Chan & Tam, 2000; Dawood, 2010; Kagioglu et al., 2001; Konchar & Sanvido, 1998; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Love & Holt, 2000; Parasuraman et al., 1988; Soetanto & Proverbs, 2004; Tekçe, 2010; Ward et al., 1991). Since financial performance is a very general concept, this dimension is divided into sub-criteria and indicators. The frequent mention of financial performance in the literature examined has led to its being the first dimension in the developed model. The most important indicators determining the financial performance were determined as the success of the cost/budget estimation level, cost/budget compliance, and profitability.

In general financial performance is mentioned about a company's performance or success (Aladağ & Işık, 2016; Tekçe, 2010). Howewer Aladağ and Işık (2016) stated that measuring and achieving performance at the highest level of the project is one of the most important elements to achieve an increase in the company scale in sustainable performance.

Also, lifetime cost, project finance channels, repayment period, interim payment, requested costs, final estimates indicators are mentioned under the "Cost" indicator for measuring the performance of urban regeneration projects (Aladağ & Işık, 2016).

Based on this study and other literature research (see Table 5.3), 3 financial performance criteria (1) cost/budget estimation level, (2) cost/budget compliance, and (3) profitability have been determined to measure the financial performance dimension.

The first criterion is the cost/budget estimation level. In the cost/budget estimation, the life phases of the project are focused and

- estimation level of the design cost (FP1-1),
- estimation level of the construction cost (FP1-2),
- estimation level the costs to be added by work orders or variation orders (FP1-3),
- estimation level of the whole project cost (FP1-4),
- estimation level of costs of claim/conflict/disputes (FP1-5),

- estimation level of costs of reworks (FP1-6) is first added to the model to investigate the

relevant criterion (cost/budget estimation level), then the relevant performance dimension (Financial Performance), and finally the importance of measuring the overall project performance.

Secondly, cost/budget compliance is mentioned in numerous research as a criterion for measuring the success of the projects (Bubshait & Almohawis, 1994; A. Neely & Adams, 2002; Salter & Torbett, 2003; Soetanto & Proverbs, 2004). Similarly, for this criterion, life phases of the project are focused and

- change in total project budget/cost (FP2-1),
- change in design cost (FP2-2),
- change in construction cost (FP2-3),
- change in cost caused by work orders/variation orders (FP2-4),
- the amount of conflict/claim cost (FP2-5), are firstly added to the model to investigate the relevant criterion (cost/budget compliance), then the relevant performance dimension (financial performance), and finally the importance of measuring the overall project performance. In the light of interviews with experts, unlike the budget estimation criterion, the change in the cost/budget of the reconstruction works was not added among the indicators of cost/budget compliance because it increased the level of detail to measure the model and complicates the model.

Lastly, it is known that the profitability criterion is used to measure the financial performance of firms. Therefore, although it is not included in the model in measuring the project performance, it is stated in expert interviews that

- project profit margin (FP3-1),
- the return on investment (FP3-2),
- the return on equity (FP3-3) is effective in measuring the project performance and can be considered as indicators of success. Therefore, the indicators mentioned are added to the model to measure the financial performance firstly after the profitability criterion and finally the total project performance.

Sustainability is a popular topic in literature. Despite this popularity, the majority of these publications concentrate on the environment, combine sustainability with low ecological impacts, and ignore their economic and social dimensions (Büyüközkan & Karabulut, 2018). Also, the economic dimension of sustainability is mentioned as community wellbeing. But, in this research economical sustainable performance of a project is the focus.

It is suggested that measuring with key performance indicators based on cost/budget estimation level, cost/budget compliance, and profitability criteria in the financial performance dimension of the model. In Table 5.3, performance performers and key performance indicators for those measured in the financial perspective of project performances are given with the related key references.

Table 5.3 : Criteria and indicators of Financial Performance dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	**FINANCIAL PERFORMANCE**	(Aladağ & Işık, 2016; Ali & Rahmat, 2010; Atkinson, 1999; Barkley & Saylor, 1994; Chan & Tam, 2000; Dawood, 2010; Kagioglu et al., 2001; Konchar & Sanvido, 1998; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Love & Holt, 2000; Parasuraman et al., 1988; Soetanto & Proverbs, 2004; Tekçe, 2010; Ward et al., 1991)	**Cost/Budget Estimation Level**	(Aladağ & Işık, 2016; Grau & Back, 2015; Menches & Hanna, 2006; Rankin et al., 2008)	**Estimation level of design cost**	Constructing Excellence KPIs, 2008; Scottish Construction Center KPIs, 2007; Lin & Shen, 2007; Gransberg & Buitrago, 2002; Pocock et al., 1996; Bubshait & Almohawis, 1994; Salter & Torbett, 2003; Cha & Kim, 2011
					Estimation level of construction cost	Constructing Excellence KPIs, 2008; Scottish Construction Center KPIs, 2007
					Estimation level of cost caused by work orders/variation orders	Constructing Excellence KPIs, 2008
					Estimation level of total project cost	McCabe, 2001; EU (Benchmarking Study) FIEC-BRE agreed KPIs, 2005; Constructing Excellence KPIs, 2008; Costa et al., 2004; Lin & Shen, 2007
					Estimation level of claim/conflict number and cost	Kaplan & Norton, 2000; McCabe, 2001; Gomes, Yasin, & Lisboa, 2006; Gosselin, 2005; Keegan et al., 1989; Neely et al., 2002; Constructing Exellence KPIs, 2008; Songer & Molenaar, 1996
					Estimation level of reworks' cost	Constructing Excellence KPIs, 2008
			Cost/Budget Compliance	(Bubshait & Almohawis, 1994; Neely et al., 2002; Salter & Torbett, 2003; Soetanto & Proverbs, 2004)	**Change in total project budget/cost**	CII Benchmarking and Metrics (USA), 2006; Lin & Shen, 2007; Hanna et al., 2014
					Change in design cost	Lin & Shen, 2007; Pocock et al., 1996; Bubshait & Almohawis, 1994; Salter & Torbett, 2003; Cha & Kim, 2011
					Change in construction cost	Benchmarking Danish Construction, 2006
					Change in cost caused by work orders/variation orders	Constructing Excellence KPIs, 2008; EU (Benchmarking Study) FIEC-BRE agreed KPIs, 2005; Cha & Kim, 2011
					Amount of conflict/claim cost	Kaplan & Norton, 2000a, McCabe, 2001, Gosselin, 2005, Keegan et al., 1989, Neely et al., 2002, Gomes et al., 2006, Constructing Exellence KPIs, 2008; Ali & Rahmat, 2010; Songer & Molenaar, 1996
			Profitability		**Project profit margin**	Gransberg & Buitrago, 2002; Kay, 1995); Hanna et al., 2014
					Return on investment (ROI)	Constructing Exellence KPIs, 2008, Rejc & Slapnicar, 2004, Gosselin, 2005, Gomes et al., 2006, Kay, 1993
					Return on equity (ROE)	Yu et al., 2007; Samson & Lema, 2002; Gomes et al., 2006; Gosselin, 2005; Rejc & Slapnicar, 2004; Love & Holt, 2000; Kangari et al., 1992; Kay, 1993; Edum-Fotwe, Price, & Thorpe, 1996; Sommerville & Robertson, 2000)

5.2.2 Time performance

Time, cost and quality, “the iron-triangle” (Atkinson, 1999) is assumed as the basic performance measurement criteria (Barkley & Saylor, 1994). To be considered successful, the projects must be completed under budget, on time and at the desired quality. Therefore, time management, planning performance, is one of the most important concepts in the performance measurement of a project. According to Aladağ and Işık (2016), Sustainable Key Performance Indicators (SKPIs) should only be considered in the field of performance evaluation, together with Key Performance Indicators (KPIs), which measure time and production-related costs.

As detailed in Section 3 and 4, time performance is an dimension/criterion/indicator for measuring the performance of many projects (Ali & Rahmat, 2010; Assaf & Al-Hejji, 2006; Bubshait & Almohawis, 1994; Cha & Kim, 2011; Chan & Tam, 2000; Dawood, 2010; Dedobbeleer & Béland, 1991; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Ogunlana et al., 1996; Rankin et al., 2008; Tekçe, 2010).

Since time performance is a very general concept, this dimension is divided into sub-criteria and indicators. The frequent mention of time performance in the literature examined has led to its being the second dimension in the developed model. The most important indicators determining the time performance were determined as the success of the project schedule estimation level, variance/changes in the project schedule, legislation compliance.

Based on literature surveys (see Table 5.4), three-time performance criteria (1) project schedule estimation level, (2) variance/changes in the project schedule, and (3) legislation compliance have been determined to measure the time performance dimension.

The first criterion is the project schedule estimation level. In the project schedule estimation, the life phases of the project are focused, and

- estimation level of the total project schedule (TP1-1),
- estimation level of design schedule (TP1-2),
- estimation level of construction schedule (TP1-3),
- estimation level of delays caused by work orders/variation orders (TP1-4) is first added to the model to investigate the relevant criterion (project schedule

estimation level), then the relevant performance dimension (time performance), and finally the importance of measuring the overall project performance. In the light of interviews with experts, estimation level of claim/conflict duration and estimation of rework's duration was not added among the indicators of project schedule estimation level, because it increased the level of detail to measure the model and complicates the model. The power of forecasting the planned time in the project phases is an effective factor both in time management and in reducing possible risks. The projects carried out according to the estimated time period are considered as successful.

Secondly, the main criteria for measuring time performance is determined as the variance of schedule or duration between estimated and actual. Variance/Changes in project schedule is mentioned numerous research as a criterion for measuring the success of the projects (Al-Momani, 2000; A. S. Ali & Rahmat, 2010; A. P. C. Chan, Chan, et al., 2004; Chua et al., 1999; Cooke-Davies, 2001; Dawood, 2010; Ganaway, 2006; Konchar & Sanvido, 1998; Kumaraswamy & Thorpe, 1996; Menches & Hanna, 2006; Molenaar, 1995; Odeh & Battaineh, 2002; Parasuraman et al., 1988; Parfitt & Sanvido, 1993; Sanvido et al., 1992; Soetanto & Proverbs, 2004; Westerveld, 2003). A similar structure of indicators might be seen at this level and

- changes in total project schedule (TP2-1),
- number of revision in design schedule (TP2-2),
- number of revision in construction schedule (TP2-3),
- total delays caused by work orders/variation orders (TP2-4) are first added to the model to investigate the relevant criterion (variance/changes in project schedule), then the relevant performance dimension (time performance), and finally the importance of measuring the overall project performance.

According to the interviews with experts, experts concluded that the difference between variance between estimated and actual reworks' duration and claim/conflict duration would have little effect on the measurement of total project performance and should not be included in the model.

Thirdly and lastly, legislation/permit duration compliance criterion is added to the model to evaluate the serious and crucial timing issue which are especially specific for urban regeneration projects.

It is known that due to the wide impact of urban regeneration projects on society, the duration of the legal permission durations differs from projects such as housing, shopping malls, schools, hospitals and is more difficult to estimate. Therefore, compliance with the legal permit documentation periods becomes a more important concept for the pre-construction (TP3-1) due to including activities such as risky building detection and post-construction formal processes (TP3-3) of projects for urban regeneration projects. Besides, one of the stakeholders of urban regeneration projects is building owners. Therefore, the persuasion process of the building owners varies from location to location and according to the profile of the local people. Therefore, the duration of formal approval processes of a project (TP3-2) is quite difficult to predict and is one of the determinants of time performance and management of urban regeneration projects.

Table 5.4 : Criteria and indicators of Time Performance dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	**TIME PERFORMANCE**	(Ali & Rahmat, 2010; Assaf & Al-Hejji, 2006; Bubshait & Almohawis, 1994; Cha & Kim, 2011; Chan & Tam, 2000; Dawood, 2010; Dedobbeleer & Béland, 1991; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Ogunlana et al., 1996; Rankin et al., 2008; Tekçe, 2010; Yang et al., 2010)	**Project Schedule Estimation Level**	(McCabe, 2001)	**Estimation level of total project schedule**	Constructing Excellence KPIs, 2008
					Estimation level of design schedule	Constructing Excellence KPIs, 2008
					Estimation level of construction schedule	Constructing Excellence KPIs, 2008
					Estimation level of delays caused by work orders/variation orders	Constructing Excellence KPIs, 2008
			Variance / Changes in Project Schedule	(Menches & Hanna, 2006; Molenaar, 1995; Konchar & Sanvido, 1998; Odeh & Battaineh 2002; Kumaraswamy & Thorpe, 1999; Ali & Rahmat, 2010; Parfitt & Sanvido, 1993; Ganaway, 2006; Parasuraman et al, 1988; Soetanto & Proverbs, 2004; Sanvido et al., 1992; Cooke-Davies, 2002; Westerveld, 2003; Chua et al., 1999; Chan et al., 2004b; Dawood, 2010; Menches and Hanna, 2006; Al-Momani, 2000; Odeha and Battaineh, 2002)	**Changes in total project schedule**	Constructing Excellence KPIs, 2008; CII Benchmarking and Metrics (USA), 2006; EU (Benchmarking Study) FIEC-BRE agreed KPIs, 2005; Gransberg & Buitrago, 2002; Hanna et al., 2014; Odeh & Battaineh, 2002; Salter & Torbett, 2003; Soetanto et al., 2001, Samson & Lema, 2002; Lim & Mohamed, 2000; Latham, 1994
					Number of revisions in design schedule	Constructing Excellence KPIs, 2008; CII Benchmarking and Metrics (USA), 2006
					Number of revisions in construction schedule	Constructing Excellence KPIs, 2008; CII Benchmarking and Metrics (USA), 2006
					Total delays caused by work orders/variation orders	Neely et al., 2002; Constructing Excellence KPIs, 2008
			Legislation / Permit Duration Compliance		**Duration of the pre-construction documantation preparation**	
					Duration of formal approval process	
					Duration of post-construction formal process	

5.2.3 Quality performance

For a project to be considered successful, it must be completed with the specified quality. Quality can be measured in many respects with quantitative and qualitative concepts. In other words, a project is expected to meet the criteria set by standards for quality performance and management, and to have the required equipment to the shareholders. Quality performance is included in many publications as a criterion for both the measurement of project performance and the measurement of sustainable performance in urban transformation projects (Aladağ & Işık, 2016; A. S. Ali & Rahmat, 2010; Atkinson, 1999; Chan & Tam, 2000; Kagioglu et al., 2001; Konchar & Sanvido, 1998; G. Lin & Shen, 2007; Love & Holt, 2000; Molenaar, 1995; Parasuraman et al., 1988; Soetanto & Proverbs, 2004; Tekçe, 2010; Ward et al., 1991; Westerveld, 2003).

Based on literature research (see Table 5.5), 3 quality performance criteria (1) quality impact on cost, (2) quality compliance, and (3) deficient work have been determined to measure the time performance dimension.

The first criterion is the quality impact on cost. The effect of quality on cost can be seen as work orders, variation orders, change orders for reworks, completion of missing and incomplete works. These issues were also discussed in the evaluation of financial performance. However, evaluations made in the financial performance dimension include work orders, variation orders, change orders for reworks, completion of missing and incomplete works which are not causing the quality based issues. Cost/budget increases (for each phase of the project) due to lack of quality (QP1-1) and the contribution to the project budget by improving the quality (QP1-2) were first added to the model for measuring the impact of quality on cost/budget, then the quality performance dimension and finally the total project performance.

Secondly, the quality compliance criterion is determined to measure quality performance. To achieve the desired/targeted quality, compliance with the regulations, standards, and guidelines (QP2-1) is an important indicator of success. Another indicator is the number of quality disputes and complaints/feedback (QP2-2). Especially for urban regeneration projects where end-users and administrations play an active role, quality-based complaints can be a serious obstacle in project operation and performance. Finally, the monitoring of the quality processes and systematic controls, and the progress of the project, have been identified as one of the criteria showing the performance of a project. The success level of the project monitoring system (QP2-3) is the measurement method in this process. This indicator is added to the model in the Envision Manual (ISI, 2012).

Envision™ was developed by the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure as a sustainability rating system. The purpose of the Envision™ is stated as "to initiate a systemic change... to transform the way infrastructure is designed, built, and operated" by William Bertera, Executive Director, ISI (ISI, 2012). This sustainable infrastructure rating system strives to evaluate, rate and recognize infrastructure projects that contribute to the progress and contribute to a sustainable future (ISI, 2012).

Envision does not cover buildings and facilities because they are well covered by existing assessment systems but includes roads, bridges, pipelines, railways, airports, dams, chimneys, storage areas, water treatment systems and other civilian infrastructures that make up the built environment. Since urban transformation projects are evaluated not only as building projects but also as a whole together with all other infrastructure features, this principle does not prevent the contribution of Envision to the model.

Envision evaluates projects according to various credits. To structure credits and show their relationships with each other, Envision organizes them into five categories and fourteen subcategories according to their main domains. Envision's hierarchical evaluation method can be seen in Figure 5.2 as an example. The five categories include:

- Quality of Life
- Leadership
- Resource Allocation
- Natural World
- Climate and Risk.

Each of the five categories includes two to three subcategories, and each subcategory contains numerous credits. Subcategories provide a way to further group credits into a category, but should not be seen as a whole case of subcategory topic. Subcategories are as follows:

- Quality of Life: Purpose, Community, Wellbeing
- Leadership: Collaboration, Management, Planning
- Resource Allocation: Materials, Energy Water
- Natural World: Siting, Land and Water, Biodiversity
- Climate and Risk: Emissions, Resilience (Envision Manuel)

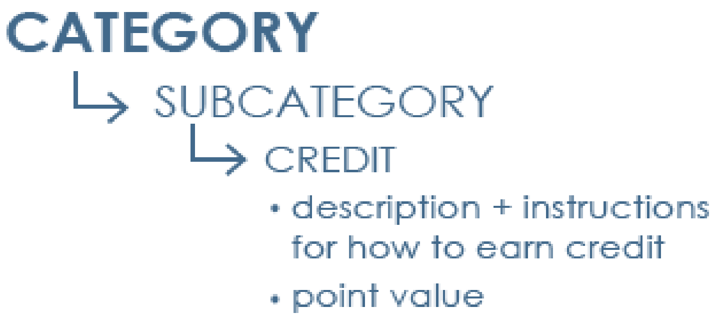

Figure 5.2 : The Envision's hierarchical evaluation method.

According to the evaluation method of Envision, two important credits were added as a reference for the level/success of the project monitoring system indicator of the sustainable performance measurement model. The first of these is the A credit under the Plan For Long-Term Monitoring And Maintenance subcategory of the Leadership category. The existence of a clear and comprehensive plan for long-term monitoring and maintenance of the works under this credit is evaluated. The second credit is the A credit under the Monitor Water Systems subcategory of the Resource Allocation category. According to this credit, the project owner and the project team evaluate the existence and characteristics of an independent organization to monitor or audit the monitoring of the whole system or to periodically control the monitoring of the project. Therefore, it is aimed to provide project monitoring mechanism regularly.

Lastly, the most obvious indicator for measuring quality performance is deficient work. Both the number of deficient work (QP3-1) and the costs associated with deficient works (QP3-2) affect all performance indicators, particularly the financial performance of the projects.

Table 5.5 : Criteria and indicators of Quality Performance dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	**QUALITY PERFORMANCE**	(Aladağ & Işık, 2016; Ali & Rahmat, 2010; Atkinson, 1999; Barkley & Saylor, 1994; Bassioni et al., 2005; Cha & Kim, 2011; Chan et al., 2002; Chan & Tam, 2000; Kagioglu et al., 2001; Konchar & Sanvido, 1998; Lin & Shen, 2007; Love & Holt, 2000; Molenaar, 1995; Parasuraman et al., 1988; Soetanto & Proverbs, 2004; Tekçe, 2010; Ward et al., 1991; Westerveld, 2003)	**Quality Impact on Cost**	(Gosselin, 2005)	**Cost overrun due to low quality**	Gosselin, 2005
					Saving from the improvement of quality	Gosselin, 2005
			Quality Compliance	(Ganaway, 2006)	**Compliance with standards**	McCabe, 2001; Kagioglu et al., 2001
					Number of complaint/conflict-related with quality	Parida & Chattopadhyay, 2007; Samson & Lema, 2002
					Level/success of project monitoring system	ISI, 2012
			Deficient Work	(Cha & Kim, 2011; Hanna et al., 2014)	**Number of deficient works**	Sommerville & Robertson, 2000; Kagioglu et al., 2001; Soetanto, 2001; Constructing Excellence KPIs, 2008; Samson & Lema, 2002
					Cost of completion of the deficient work	CII Benchmarking and Metrics (USA), 2006; Samson & Lema, 2002; McCabe, 2001; Kaplan & Norton, 2000a

5.2.4 Health & Safety (H & S) performance

The construction sector is one of the riskiest business areas and has the aim of zero accidents and injuries. For this purpose, while evaluating the success of the projects, "health and safety" is one of the main evaluation criterion. Health and safety has been evaluated in many studies as an indicator of success in evaluating project performance (Ali & Rahmat, 2010; Almahmoud, Doloi, & Panuwatwanich, 2012; Assaf & Al-Hejji, 2006; Bubshait & Almohawis, 1994; Cha, Kim, & Han, 2009; Chan & Tam, 2000; Chan & Kumaraswamy, 1997; Dawood, 2010; Dedobbeleer & Béland, 1991; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Ogunlana et al., 1996; Rankin et al., 2008; Tekçe, 2010; Yang et al., 2010; Chovichien & Nguyen, 2013; Khosravi & Afshari, 2011).

Based on literature surveys (see Table 5.6), health and safety performance is evaluated according to the criteria of (1) accident and injuries, (2) loss of workforce, (3) compliance of health and safety regulations and standards.

The first criterion is the accident and injuries. In the accident and injuries,

- number of fatal/severe accidents (HSP1-1)
- number of injuries (HSP1-2)
- number of occupational diseases (HSP1-3) are first added to the model to investigate the relevant criterion (accident/injuries), then the relevant performance dimension (health and safety performance), and finally the importance of measuring the overall project performance. In light of interviews with experts, the number of occupational disease should be considered within this group, with severe accidents and injuries.

Secondly, loss of workforce is one of the most important factors that prevent success in both projects and organizations. In the model developed to measure the performance of contractor firms, the Labor / Workday losses are also evaluated under the Occupational Health and Safety Performance criterion under the project dimension (Tekçe, 2010). The most important resource in a construction project is employees and the lack of attendance of employees due to insecure activities, injuries, accidents, occupational diseases, reducing productivity and therefore project performance. Health and safety concept in a project is mentioned numerous research as a criterion for measuring the success of the projects Menches & Hanna, 2006; Neely et al., 2002. Therefore, (1) the number of days with absenteeism due to accidents/injuries (HSP2-1) and (2) number of days with absenteeism due to occupational disease (HSP2-2) are added to the model to evaluate the overall project performance.

Thirdly, for the last criterion of H & S performance,

- compliance with H & S standards (HSP3-1),
- number of complaint related with H & S (HSP3-1),
- presence of H & S organization (HSP3-1),
- number of corrective measures for risks (HSP3-1),
- number of H & S training (HSP3-1),
- number of appropriate signage for safety and wayfinding (HSP3-1),
- total paid compensation (HSP3-1) are first added to the model to investigate the relevant criterion (H & S compliance), then the relevant performance dimension (health and safety performance), and finally the importance of measuring the overall project performance.

Envision has been added to the reference list in a criterion in the Quality of Life category, as introduced in Section 5.2.3. In the Improve Site Accessibility, Safety And Wayfinding subcategory of this category, it is assessed whether the project owners and the project team have developed a suitable sign for safety and direction finding in and around the works. Although the safety signs and directions are determined by directives and standards, they are also included in the indicator list as it is a precise and measurable indicator.

Table 5.6 : Criteria and indicators of Heath & Safety Performance dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	**HEALTH & SAFETY (H & S) PERFORMANCE**	(Ali & Rahmat, 2010; Assaf & Al-Hejji, 2006; Bubshait & Almohawis, 1994; Cha & Kim, 2011; Chan & Tam, 2000; Chan & Kumaraswamy, 1997; Dawood, 2010; Dedobbeleer & Béland, 1991; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Ogunlana et al., 1996; Rankin et al., 2008; Tekçe, 2010; Yang et al., 2010)	**Accident/Injuries**	(Bubshait & Almohawis, 1994; Parida & Chattopadhyay, 2007; Kaplan & Norton, 2000a; Sommerville & Robertson, 2000; McCabe, 2001; Costa et al., 2004; Samson & Lema, 2002; Neely et al., 2002; Gosselin, 2005; Robertson, 1997)	**Number of fatal/severe accidents**	Neely et al., 2002); Cha & Kim, 2011; DETR, 2000
					Number of injuries	Ali & Rahmat, 2010
					Number of occupational diseases	
			Loss of Workforce	(Menches & Hanna, 2006; Neely et al., 2002; Constructing Excellence KPIs, 2008; CII Benchmarking and Metrics (USA), 2006)	**Number of days with absenteeism due to accidents/injuries**	CII Benchmarking and Metrics (USA), 2006; DETR, 2000
					Number of days with absenteeism due to occupational disease	Neely et al., 2002
			H & S Compliance		**Compliance with H & S Standards**	
					Number of complaints related with H & S	Parida & Chattopadhyay, 2007
					Presence of H & S organization	Samson & Lema, 2002
					Number of corrective measures for risks	Samson & Lema, 2002
					Number of H & S training	Samson & Lema, 2002; Cha & Kim, 2011
					Number of appropriate signage for safety and wayfinding	ISI, 2012; Cha & Kim, 2011
					Total paid compensation	Samson & Lema, 2002; Parida & Chattopadhyay, 2007

5.2.5 Stakeholder satisfaction

The complex nature of construction projects is because that there are too many parties. Particularly in urban regeneration projects, the satisfaction of the administrations and the civilian population is more important for performance measurements in classical construction projects. In general, success criteria consist of measurable quantities. Therefore, performance evaluation dimensions such as:

- finance (Aladağ & Işık, 2016; Ali & Rahmat, 2010; Atkinson, 1999; Barkley & Saylor, 1994; Chan & Tam, 2000; Dawood, 2010; Kagioglu et al., 2001; Konchar & Sanvido, 1998; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Love & Holt, 2000; Parasuraman et al., 1988; Soetanto & Proverbs, 2004; Tekçe, 2010; Ward et al., 1991),
- time (Ali & Rahmat, 2010; Assaf & Al-Hejji, 2006; Bubshait & Almohawis, 1994; Cha & Kim, 2011; Chan & Tam, 2000; Dawood, 2010; Dedobbeleer & Béland, 1991; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Ogunlana et al., 1996; Rankin et al., 2008; Tekçe, 2010),
- quality compliance (Aladağ & Işık, 2016; Ali & Rahmat, 2010; Atkinson, 1999; Chan & Tam, 2000; Kagioglu et al., 2001; Konchar & Sanvido, 1998; Lin & Shen, 2007; Love & Holt, 2000; Molenaar, 1995; Parasuraman et al., 1988; Soetanto & Proverbs, 2004; Tekçe, 2010; Ward et al., 1991; Westerveld, 2003),
- occupational safety and compliance with occupational health obligations (Ali & Rahmat, 2010; Almahmoud, Doloi, & Panuwatwanich, 2012; Assaf & Al-Hejji, 2006; Bubshait & Almohawis, 1994; Cha, Kim, & Han, 2009; Chan & Tam, 2000; Chan & Kumaraswamy, 1997; Dawood, 2010; Dedobbeleer & Béland, 1991; Kumaraswamy & Thorpe, 1996; Lin & Shen, 2007; Ogunlana et al., 1996; Rankin et al., 2008; Tekçe, 2010; Yang et al., 2010; Chovichien & Nguyen, 2013; Khosravi & Afshari, 2011) are included in the performance measurement model of almost every project. However, stakeholder satisfaction is a relatively less measurable performance evaluation dimension. This can be said to be since that there are too many stakeholders and there are various indicators that determine the level of satisfaction of each. While determining the importance of the stakeholder satisfaction level dimension in the overall

sustainable performance measurement, the satisfaction levels of customers, employees, society and other stakeholders were taken into consideration.

First, the indicators that determine the level of customer satisfaction,

- number of awards (design, construction, H & S, quality, etc.) (SS1-1),
- number of customer's complaints (SS1-2),
- number and cost of disputes/conflicts/court (SS1-3),
- duration of dispute resolution (SS1-4) as selected.

In particular, the number and costs of disputes and disputes are considered as indicators of success in many publications. Also, expert interviews stated that the duration of these processes is effective in project planning and success.

Employee satisfaction is one of the benchmarks of success in many publications (Baldwin, McCaffer, & Osman, 2001; Costa, Formoso, Kagioglou, Alarcón, & Caldas, 2006; Kaplan & Norton, 2000; Liebowitz & Suen, 2000; Miller et al., 1999; Neely et al., 2002; Rejc & Slapnicar, 2004; Robertson, 1997). Measuring employee satisfaction,

- number of employees' complaints (SS2-1),
- level of salary with respect to industry (SS2-2),
- level of social integration at work (SS2-3),
- level/number of recreational opportunities (SS2-4), indicators are evaluated.

While employee satisfaction can be considered as the first indicator of the success of companies (Tekçe, 2010), it is also an evaluation factor for the smooth and efficient operation of the projects. As mentioned earlier, sustainability has three important steps: economic, social, environmental. Since the reflections of urban regeneration projects on society can be dramatic, it is determined to measure the satisfaction level of the society with the following indicators;

- level of consultation activities with the local community (SS3-1),
- level of increase in life quality and urban prosperity (SS3-2),
- level of access to social services (SS3-3),
- level of identification of community needs, goals, plans and issues (SS3-4),

- level of generating new jobs or increasing the existing business, entertainment and cultural capacity for the public (SS3-5),
- level of improvement the community productivity (SS3-6),
- level of contribution to local employment, training, and education, with emphasis on the neediest and/or disadvantaged groups (SS3-7),
- level/number of activities to prevent pollution/complaint of construction activities (SS3-8),
- level of reduction of traffic disruption during construction and operation (SS3-9),
- level of net positive impact on public safety and security (SS3-10),
- level of identification/enhancement/restoring historic and cultural resources (SS3-11),
- number /level of satisfaction of added public spaces (e.g., parks, plazas, recreational facilities, or accessible space in wildlife refuges) (SS3-12),
- number of applied policies (SS3-13),
- number of jobs proposed (SS3-14).

As can be seen, the indicators of community satisfaction criterion were chosen with a focus on the economic and social aspects of sustainability. Also, the number of indicators is quite high compared to other criteria and dimensions. According to expert interviews, all community satisfaction indicators are given in sufficient detail so as not to cause the complexity of the model. However, it will be tried to be evaluated statistically during the validation stage of the model.

Finally, the level of satisfaction of stakeholders (SS4-1) and the ratio of company net profit to project net profit (SS4-2) were added to the model to measure stakeholder satisfaction.

According to Table 5.7, most of the Envision credits are included in the reference list. For example, Quality of Life-Improve Community Quality of Life-Credit A, which assesses whether the project team has identified community needs, objectives, plans, and problems, has been a reference for the indicator of Identification of community needs, goals, plans and issues (SS3-4).

Similarly, the Quality of Life- Stimulate Sustainable Growth and Development-Credit B, which evaluates the delivery of jobs to present new entertainment or cultural opportunities or increase the capacity of existing ones, has been added as a reference to the indicator of the “Level of generating new jobs or increasing the existing business, entertainment and cultural capacity for the public” (SS3-5).

The credit (Quality of Life-Stimulate Sustainable Growth and Development-Credit C), which assesses that the delivered work has significantly increased the productivity of the community, was added as a reference to the indicator “Level of improvement the community productivity” (SS3-6).

It was added as a reference to the credit “Level of reduction of traffic disruption during construction and operation” (SS3-9) indicator, which assessed the project team developing plans to reduce traffic disruptions during construction, including monitoring and corrective action (Quality of Life-Improve Community Mobility and Acces-Credit D).

The credit (Quality of Life-Improve Site Accessibility, Safety and Wayfinding-Credit D), which assesses whether the project owners, and the project team designed the project to have a clear positive impact on public safety, was added as a reference to the indicator “Level of net positive impact on public safety and security” (SS3-10).

The credit (Quality of Life-Preserve Historic And Cultural Resources-Credit A) which assesses the extent to which the project team is working with the community to identify cultural resources with the required regulatory and resources agencies and the credit (Quality of Life-Preserve Historic And Cultural Resources-Credit D) that the project team attaches to the improvement or restoration of existing cultural resources were assessed as a reference to the indicator ” Identification/enhancement/restoring historic and cultural resources” (SS3-11).

The credit (Quality of Life-Enhance Public Space-Credit A) that assesses the impact of the project on public space (eg parks, squares, recreational facilities or wildlife shelters) that enhances the livability of the community, and the credit (Quality of Life-Enhance Public Space-Credit B) that assesses satisfaction with project plans involving public space and public stakeholders were assessed as a reference to the indicator “Numer /level of satisfaction of added public spaces“ (SS3-12).

Table 5.7 : Criteria and indicators of Stakeholder Satisfaction dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	STAKEHOLDER SATISFACTION	(Black et al., 2000; Cheng et al., 2000; Doloi, Iyer, & Sawhney, 2011; Hanna et al., 2014; Hemphill, Berry, & McGreal, 2004; Lin & Shen, 2007; Mbachu, 2008; Yeung et al., 2008; Alzahrani & Emsley, 2013)	Customer Satisfaction	(Bassioni et al., 2005; Ali & Rahmat, 2010; Parasuraman, Zeithaml, & Berry, 1988; Soetanto & Proverbs, 2004; Baldwin et al., 2001; Liebowitz & Suen, 2000; Samson & Lema, 2002; Gosselin, 2005; Gomes et al., 2006; Parida & Chattopadhyay, 2007; Costa et al., 2004; Neely et al., 2002; Scottish Construction Center KPIs, 2007; Dawood, 2010; Latham, 1994; Contract Journal, 2004; Aladağ & Işık, 2016)	Number of awards (Design, Construction, H &S, Quality, etc.)	Yu et al., 2007; Johnson, 2000
					Number of customer's complaints	Neely et al., 2002; Gomes et al., 2006
					Number and cost of disputes/conflicts/court	Samson & Lema (2002), Constructing Exellence KPIs,2008; Gomes et al, 2006; Costa t al., 2004
					Duration of dispute resolution	
			Employee Satisfaction	(Baldwin et al., 2001; Liebowitz & Suen, 2000; Kaplan & Norton, 2000a; Rejc & Slapnicar, 2004; Neely et al., 2002; Danish Trade and Industry Development Council, 1997; Constructing Exellence KPIs, 2008; Miller et al., 1999; Costa et al., 2004; Scottish Construction Center KPIs, 2006; Robertson, 1997)	Number of employees' complaints	Parida & Chattopadhyay, 2007
					Level of salary with respect to industry	Neely et al., 2002
					Level of social integration at work	Aladağ & Işık, 2016
					Level/Number of recreational opportunities	Diaz-Balteiro, González-Pachón, & Romero, 2017

Table 5.7 (continued) : Criteria and indicators of Stakeholder Satisfaction dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	STAKEHOLDER SATISFACTION	(Black et al., 2000; Cheng et al., 2000; Doloi, Iyer, & Sawhney, 2011; Hanna et al., 2014; Hemphill, Berry, & McGreal, 2004; Lin & Shen, 2007; Mbachu, 2008; Yeung et al., 2008; Alzahrani & Emsley, 2013)	Community Satisfaction	Neely et al., 2002; Gomes et al., 2006; Rejc & Slapnicar, 2004; ISI, 2002; Aladağ & Işık, 2016; Hemphill, Berry, & McGreal, 2004	Level of consultation activities with the local community	Couch & Dennemann, 2000
					Level of increase in life quality and urban prosperity	Adair, Berry, McGreal, Deddis, & Hirst, 2000
					Level of access to social services	Aladağ & Işık, 2016
					Level of identification of community needs, goals, plans and issues	ISI, 2002
					Level of generating new jobs or increasing the existing business, entertainment and cultural capacity for the public	ISI, 2002
					Level of improvement the community productivity	ISI, 2002
					Level of contribution to local employment, training, and education, with emphasis on the neediest and/or disadvantaged groups	Couch & Dennemann, 2000
					Level/number of activities to prevent pollution/complaint of construction activities	Constructing Exellence KPIs
					Level of reduction of traffic disruption during construction and operation	ISI, 2002
					Level of net positive impact on public safety and security	ISI, 2002; Aladağ & Işık, 2016
					Level of identification/enhancement/restoring historic and cultural resources	ISI, 2002; Aladağ & Işık, 2016; Hemphill, Berry, & McGreal, 2004; Hemphill, Berry, & McGreal, 2004
					Number /level of satisfaction of added public spaces (e.g., parks, plazas, recreational facilities, or accessible space in wildlife refuges)	ISI, 2002
					Number of applied policies	Hemphill, Berry, & Stanley McGreal, 2004
					Number of jobs proposed	Aladağ & Işık, 2016; Couch & Dennemann, 2000; Adair, Berry, McGreal, Deddis, & Hirst, 2000; Hemphill, Berry, & McGreal, 2004
			Shareholder / Partner Satisfaction	Kumaraswamy & Thorpe, 1996; Rejc & Slapnicar, 2004	Satisfaction level of project shareholders	Rejc & Slapnicar, 2004
					The ratio of company net profit to project net profit	Rejc & Slapnicar, 2004; Samson & Lema, 2002; Neely et al., 2002

5.2.6 Innovation

The complex structure and risky area of the construction sector make the technology more in need of support. Technological initiatives and investments allow the projects to be realized in healthier environments and more efficient employees and projects that are completed on time in compliance with the budget of the desired quality. Innovation dimension has been added to the factors determining the performance of these projects, especially due to the high number of parties involved in urban regeneration projects and the dramatic environmental, economic and social impacts. The inclusion of innovation in the performance measurement model has been indicated in many studies (Aladağ & Işık, 2016; Babcicky, 2013; Lin & Shen, 2007; Rankin et al., 2008; Saisana, 2014; Yang et al., 2010). Also,

- In the 2012 version of the BREEAM assessment communities, known as the first building environmental certification program (BREEAM, 2015),
- Earth Craft Communities, a certification system developed by various public and private sector organizations/organizations based in Atlanta,
- The LEED, introduced by the American Council of Green Buildings in 1998, added innovation among performance evaluation criteria. Although these assessment systems are generally focused on green buildings, they consist of criteria for sustainability (Council, 2013).

Based on literature research (see Table 5.8), 3 innovation criteria (1) research & development, (2) education/training, and (3) communication have been determined to measure the performance of the innovation dimension. The first criterion is the research & development. In the research & development,

- number of new technologies applied (IN1-1),
- number of new technologies/practices developed in the project (IN1-2)
- level of solutions to problem, barriers, limitations (IN1-3) are first added to the model to investigate the relevant criterion (research & development), then the relevant performance dimension (innovation), and finally the importance of measuring the overall project performance.

Project teams may get benefit from innovative technologies. In such cases, it is important to demonstrate that the implementation of the technology meets the performance expectations and that this has no adverse impact on the local or global environment, economy or community (ISI, 2012). Therefore, for the level of solutions to problems, barriers, limitations indicator, the innovation subcategory at the end of each category of the envision was added as a reference.

The second criterion of innovation in education and training. In Envision, the extent to which the project team has gathered the information needed to train operations and maintenance staff to facilitate appropriate training and operations is assessed. The following indicators are added to the model to measure firstly education and training criteria, secondly innovation dimension and lastly overall sustainable project performance.

- total training hour (IN2-1),
- number of on-site training (IN2-2),
- number of off-site training (IN2-3),
- change in productivity after training (IN2-4),
- change in defect number after training (IN2-5). Number off on-site and off-site trainings indicators are added at the end of the expert interview.

Lastly, communication which is mentioned as success criteria for performance (Aladağ & Işık, 2016; Dawood, 2010; Menches & Hanna, 2006),

- stakeholder communication level (IN3-1),
- number of survey attended (IN3-2),
- the level of information exchange and feedback mechanisms (IN3-3),
- the number and duration of feedback (IN3-4), are added to the model with success indicators.

The B credit in the sub-category Provide for Stakeholder Involvement in the Leadership category in Envision measures the extent to which the project team requests and evaluates stakeholder issues and concerns through meetings and information exchange. Although the main focus in this credit is stakeholder issues, it is added as a reference since it also focuses on measuring the level of information exchange.

Table 5.8 : Criteria and indicators of Innovation dimension with key references.

1st DIMENSION	2nd DIMENSION	KEY REFERENCES	3rd DIMENSION	KEY REFERENCES	4th DIMENSION	KEY REFERENCES
OVERALL SUSTAINABLE PERFORMANCE	INNOVATION	(Aladağ & Işık, 2016; Babcicky, 2013; Lin & Shen, 2007; Rankin et al., 2008; Saisana, 2014; Yang et al., 2010)	Research & Development		Number of new technologies applied	Cebon et al., 1996
					Number of new technologies/practices developed in the project	Neely et al., 2002
					Level of solutions to problem, barriers, limitations	ISI, 2012
			Education / Training	(ISI, 2012; Cha & Kim, 2011; Aladağ & Işık, 2016; Hemphill, Berry, & McGreal, 2004)	Total training hour	Scottish Construction Center KPIs, 2007; Neely et al. 2002
					Number of on-site trainings	
					Number of off-site training	
					Change in productivity after trainings	Neely et al., 2002
					Change in defect number after trainings	Neely et al., 2002
			Communication	(Dawood, 2010; Menches & Hanna, 2006; Aladağ & Işık, 2016)	Stakeholder communication level	Tekçe, 2010
					Number of surveys attended	Robertson, 1997; Gomes et al., 2006
					Level of information exchange and feedback mechanism	Neely et al., 2002; ISI, 2012
					Number and duration of response to feedback	Neely et al., 2002; Hemphill, Berry, & McGreal, 2004

5.2.7 Environmental performance

The construction sector has been mentioned in many publications due to its negative impact on the environment (Shen & Tam, 2002; Tam, Tam, & Zeng, 2002; Tam & Le, 2007;Tse, 1994; Tse, 2001). To achieve a better sustainability performance, several studies provide methods to reduce the barriers to the implementation of environmental management in construction (Chen, Li, & Wong, 2000; Kibert, 1994; Shen, Tam, Chan, & Kong, 2002; Tam et al., 2002).

According to Oatley (1995), most of the cities have struggled with poor environmental issues (Hemphill, Berry, et al., 2004). Sustainable urban regeneration is defined as the process that utile the economic, environmental and social aspects for increasing the quality of life (Hemphill, McGreal, et al., 2004).

Project feasibility studies should be consistent with the principles of sustainable development (Shen, Hao, Tam, & Yao, 2007). Also, sustainable principles should be among the key performance indicators to measure and compare project performances. Therefore, project performance assessment systems need to investigate and analyze the applicability of various aspects of engineering, technology, social dimension, economic benefits, and environmental impacts.

Environmental sustainability, which is one of the three important steps of sustainability, is seen in many publications in which performance evaluation criteria are specific to urban transformation projects (Tekçe, 2010; Chan et al., 2002; Rankin et al., 2008; Aladağ & Işık, 2016; Wong, 2000; Maclaren, 1996; Hemphill, Berry, & McGreal, 2004; Chiang, & Chan, 2010; Chan et al., 2002; Rankin et al., 2008; Lin & Shen, 2007; Chan & Tam, 2000.

According to Wong (2000) and Maclaren (1996). key indicators may be used for evaluating the environmental impacts. Assessment of environmental performance is possible not only by assessing ecological conditions, but also by assessing criteria for design, land use, energy, water, waste management, indoor air quality, and compliance with legal requirements.

Based on literature research (see Table 5.9), when the environmental dimension of sustainability is mentioned, ecological elements come to mind first. For this reason, the first element that shows that environmental performance is successful in projects is determined as ecological criteria. Projects can be affected by extreme weather events, temperature increases, rising sea level, decreases in precipitation, and this can have negative impacts on energy, water and waste systems (Envision-Climate and Risk-Assess Climate Threat). All this is due to climatic changes. Although the cause of climate change is very diverse, its consequences are still unclear. The protection level of organisms in the natural habitat (EP1-1), carbon emission (EP1-2) and ecological footprint (EP1-3) are among the main issues of climatic and ecological changes. Therefore, it has been identified as indicators used to measure the role of ecological factors in performance evaluation. For “Protection or restoration of habitat” indicator, several Envision and LEED credits are added as reference:

- Credits A, B, C of Preserve Prime Habitat subcategory of Natural World category evaluates the actions taken by the project regarding primary habitat and buffer zones.
- Credit A of Preserve Species Biodiversity subcategory of Natural World category assesses that the project does not affect natural habitats and movement corridors, and Credit B assesses whether it facilitates or improves movement between habitats or improves existing habitats.
- The subcategory Control Invasive Species of Natural World aims to use appropriate non-invasive species and to control or eliminate existing invasive species.
- Sustainable Sites Site Credit Development – Protect or Restore Habitat: It aims to the preservation of undeveloped natural areas and restoration of previously developed damaged lands by creating habitat and increasing biodiversity.

The criteria determined to measure the importance of environmental performance in determining overall sustainable performance continue with the ranking in the Aladağ & Işık (2016) study. Therefore the indicators:

- level of esthetic design (EP2-1)
- level of landscape design (EP2-2)
- level of integrated design policies (EP2-3) used to measure the design principle.

Envision evaluation criteria mentioned below were effective in adding design criteria to the sustainable performance measurement model.

- Climate and Risks-Avoid Traps And Vulnerabilities-Credit A: It measures the assessment and evaluation of potential changes in key engineering design variables by the project team.
- Climate and Risks-Prepare For Long-Term Adaptability-Credit A: It measures whether the project team has designed the site and infrastructure project-related systems to function in these changing climatic conditions, inadequate supply or other significant long-term changes in operational and environmental conditions.
- Climate and Risks-Prepare For Short-Term Hazards- Credit B: It assesses whether the project team has incorporated design strategies to protect against natural hazards.

Land use is a frequently evaluated criterion for the environmental dimension of sustainability (ISI, 2002; Aladağ & Işık, 2016; DETR, 1998a; 1998b, 1998c, 1998d, 1998e, 1998f; Audit Commission, 2002; Hemphill, Berry, & McGreal, 2004; Carbonaro and D'Arcy, 1993; Cullingworth and Nadin, 1994; Ravetz, 1996; Babcicky, 2013; Saisana, 2014). Efficient and producive use of land is essential to ensure long-term productivity (Lee, 2008). The most serious problems faced by the cities and inhabitants addressed by Habitat II Agenda (2002) include inappropriate land use (Yıldız, 2018). The indicators used to measure land-use criteria were determined as follows:

- Level of effective site selection (EP3-1),
    - Location and Transportation Credit Sensitive Land Protection: It aims to prevent the development in environmentally sensitive lands such as prime farmland, floodplains, habitat, water bodies and wetlands and also reduce the environmental impact of the building by promoting site selection from previously developed areas.
    - Natural World-Preserve Prime Farmland-Credit A: Evaluates whether the project owner and the project team defined the project site as agricultural land.
    - Natural World-Avoıd Adverse Geology-Credit A: Evaluates whether the project team identified earthquake failures, low coastal zones, and karst formations and aquifers.

  - Natural World-Avoid Unsuitable Development On Steep Slopes-Credit A: Evaluates whether the project follows management practices to manage erosion and prevent landslides.

- preservation level of high-value landscapes and its features (EP3-2),
  - Sustainable Sites Site Credit Development – Protect or Restore Habitat: Evaluates the preservation of natural areas, conservation of native ecosystems including soil, vegetation, and hydrology on the site.
  - Quality of Life-Preserve Views And Local Character-Credit E: Evaluates whether the contract contains provisions for the protection of high-value landscapes and landscape features.
- Level of access to public transportation and public facilities (EP3-3),
  - Location and Transportation Credit Access to Quality Transit: It aims to support development in locations where combined transportation options are available or where motor vehicle use is reduced, and reduce motor vehicle use-related greenhouse gas emissions, air pollution, and public health harmful effects.
  - Placing new buildings close to the city center will reduce transport-related energy use and greenhouse gas emissions (Säynäjoki, Heinonen, & Junnila, 2014).
  - Quality of Life-Encourage Alternative Modes of Transportation-Credit D: Evaluates the extent to which the works are structured and positioned to encourage the use of non-motorized transport.
- alternative transportation opportunities (EP3-4),
  - Location and Transportation Credit Bicycle Facilities: aims to promote bicycling as a transportation option by providing long-term and short-term bicycle storage, and bicycle network, for efficiency and reducing vehicle usage.
  - Location and Transportation Credit Green Vehicle: aims to promote alternative transportation vehicles to conventional fuel cars for reducing pollution.

- level of compact development (EP3-5),
    - Location and Transportation Credit Surrounding Density and Diverse Uses: Evaluates development in areas with existing infrastructure and surrounding amenities for promoting walkability, and transportation efficiency and reducing vehicle use.
- provision of open spaces (EP3-6),
    - Sustainable Sites Credit Open Space: aims to increase social and environmental interactions and physical activities by developing outdoor open space with vegetated areas which provide environmental benefits such as heat island effect reduction, habitat restoration and stormwater management.
- level of regularization of population density/urban development (EP3-7),
- number of housing stock (EP3-8),
- level of increase in existing reconstruction rights (EP3-9),
- number of stormwater management measures (EP3-10),
    - Sustainable Sites Credit Rainwater Management: Evaluates run-off water volume management strategies and their compatibility of natural hydrology and water balance in the region depending on the historical conditions and undeveloped ecosystem in the region.
- land pollution reduction (EP3-11),
    - Sustainable Sites Credit Construction Activity Pollution Prevention: Evaluates the environmental protection measures such as erosion and sedimentation control to reduce the construction activity pollution
- level of accessibility (EP3-12).

The construction sector is renowned for the amount of waste it produces and its failure in waste management. Excessive use of heavy and hazardous materials is a major factor in waste generation. The main factor in the assessment of waste management is to make the right decisions for minimum waste (EP4-1) (Johnson (2000); Robertson (1997); Couch & Dennemann, 2000; Hemphill, Berry, & McGreal, 2004; Babcicky, 2013; Saisana, 2014). Besides, the provision of construction waste management planning (EP4-2) is very important in the success of waste management. The ratio of recycled or reused waste (EP4-3) is one of the most measurable indicators for determining the success of waste management.

Besides, the following indicators have been added to the model as indicators of waste management to determine sustainable environmental performance.

- design for minimum waste (EP4-1),
    - Material and Resources Credit Construction and Demolition Waste Management: Evaluates design strategies such as prefabrication, modular construction for reducing the amount of total material waste generated on-site and diverting waste from landfills and incineration facilities.
- provision of construction waste management plan (EP4-2),
    - Material and Resources Prerequisite Construction and Demolition Waste Management Planning: Evaluates the construction and demolition waste management plan developed early in the design process for all materials, the waste diversion strategies for whether materials will be separated or commingled. Also, it evaluates the safe removal and disposal of hazardous materials, and on-site waste seperation.
- ratio of recycled or reused waste (EP4-3),
    - Material and Resources Credit Construction and Demolition Waste Management: Evaluates the reduction of total construction and demolition waste by recovering, reusing, and recycling materials. Also, it assesses the ratio of recycled and/or salvage nonhazardous construction and demolition materials by weight or volume.
- identification and success reuse of unwanted by-products or discarded materials (EP4-4),
    - Leadership-Pursue By-Product Synergy Opportunities-Credit A: It assesses the extent to which the project team identifies unwanted by-products or discarded materials from nearby facilities.
    - Leadership-Pursue By-Product Synergy Opportunities-Credit D: Evaluates the success of the project team in the use of the project from unwanted

products or discarded materials during design and construction or operations

- storage and collection of recyclables (EP4-5),
  - Material and Resources Prerequisite Storage and Collection of Recyclables: Evaluates the recycling infrastructure that provides waste bins and reserved areas accessible to occupants for the collection and storage of recyclable materials.
  - Resource Allocation-Divert Waste From Landfills-Credit A: Evaluates whether the project team has developed a management plan to reduce project waste and to direct waste from waste landfills and incinerators.
- ratio of recycled or salvaged material (EP4-6).
  - Material and Resources Credit Construction and Demolition Waste Management: Evaluates the reduction of total construction and demolition waste by recovering, reusing, and recycling materials. Also, it assesses the ratio of recycled and/or salvage nonhazardous construction and demolition materials by weight or volume.

According to Tse (2001), Urban sprawl is related to diverse environmental effects that are caused by higher energy consumption (Tse, 2001). To evaluate energy management in projects, building energy performance should be evaluated. In this assessment, building energy performance certificate level (EPC) (EP5-1), provision of building energy (EP5-2) model and building energy efficiency level (EP5-3) indicators are used. Additionally, relevant LEED credits are added as reference;

- building energy performance certificate level (EPC) (EP5-1), provision of building energy model (EP5-2) and building energy efficiency level (EP5-3),
  - Energy and Atmosphere Prerequisite Minimum Energy Performance and Credit Optimize Energy Performance: Option 1 evaluates the performance of the building by energy model simulation and compares with the baseline model to evaluate efficiency level.

- utilization level of renewable energy (EP5-4),
    - Energy and Atmosphere Credit Renewable Energy Production: aims to encourage self-supply renewable energy systems for reducing environmental and economic damages associated with fossil fuel energy.
- measurement and verification system applied (EP5-5),
    - Energy and Atmosphere Prerequisite Building-Level Energy Metering and Credit Advanced Energy Metering: Evaluates the applications of energy management systems and additional energy savings opportunities by using building-level energy meters or submeters that accumulated building-level data showing total building energy consumption.
- application of commissioning building energy systems (EP5-6),
    - Energy and Atmosphere Prerequisite Fundamental Commissioning and Verification: Evaluates the commissioning process that is an integrated activity set intended to ensure that the project meets both the design intent and the owner's requirements as construction and eventual operation of a building for energy, water, indoor environmental quality, and durability.
- provision of green power (EP5-7),
    - Energy and Atmosphere Credit Green Power and Carbon Offsets: Evaluates the required green power demand and/or carbon offsets to be purchased for reducing greenhouse gas emissions through renewable energy technologies and carbon mitigation projects.
- reduction level the net embodied energy (EP5-8) are first added to the model to investigate the relevant criterion (energy), then the relevant performance dimension (environmental performance), and finally the importance of measuring the overall project performance.
    - Resource Allocation-Reduce Net Embodied Energy-Credit B: Evaluate to what extent the owner and project team reduce the project's energy.

When designing or renovating a building, selecting the components of the building to be selected from low-emission elements reduces the ventilation requirements of the building and saves energy, but also improves indoor air quality (Park & Yoon, 2011; Sundell et al., 2011).

Water is the sixth criterion in evaluating environmental performance. The reduction level of water pollution (EP6-1) and total water use reduction (EP6-2), which are necessary for the effective management of water, were added to the model. The provision of water-efficient landscaping (EP6-3) is part of water management, and the use of innovative wastewater technologies (EP6-4) is a success factor in measuring sustained performance. The following references are added:

- total water use reduction (EP6-2),
  - Water efficiency Prerequisite – Credit Indoor Water Use Reduction and Outdoor Water Use Reduction: aims to reduce building, appliance, process and irrigation water usage by selecting efficient plumbing fittings, fixtures, and equipment.
- For indicators water-efficient landscaping (EP6-3) and use of innovative wastewater technologies (EP6-4),
  - Water efficiency Prerequisite – Credit Indoor Water Use Reduction: Evaluates the strategies to reduce potable water use in buildings and the alternatives to potable water such as greywater, rainwater, condensate or used process water.
  - Water efficiency Prerequisite – Credit Outdoor Water Use Reduction: Evaluates the strategies to reduce potable water use in landscape irrigation by selecting plants with low-water demand or using smart-sensor technology and the alternatives to potable water such as greywater or rainwater.
  - Resource Allocation-Protect Fresh Water Availability-Credit A: Evaluate to what extent the landlord and the project team make a water availability assessment.
  - Natural World- Protect Wetlands and Surface Water-Credit A: Evaluates whether the settlement area of the project is located within the specified distances of local pools, wetlands, coastlines or water bodies.

- o Although innovative technologies are generally evaluated in terms of innovation performance, the Innovate or Exceed Credit Requirements subcategory of the Natural World category in Envision has been added to the reference list for wastewater in this dimension.

When sustainability studies are examined (Aladağ & Işık, 2016; Hee Sung Cha & Kim, 2011; Hemphill, Berry, et al., 2004), one of the main topics in environmental improvements is the use of materials. In addition to energy, water, waste management, and sensitive designs, the selection of environmentally friendly and environmentally compatible materials is an important step towards sustainability in construction projects. Not only the selection of materials that are compatible with nature but also the selection of recyclable materials and the reuse of waste materials also contribute to sustainability. Besides, the provision of materials from close to the location where the projects are carried out reduces the operational expenses such as transportation, storage and reduces the environmental impact of these operations. Therefore, the following indicators were first added to the model to evaluate the material use criteria, then the environmental performance dimension and finally the total sustainable performance.

- number of environmentally preferable materials (EP7-1),
    - o Material and Resources Credit Building Product Disclosure and Optimization – Sourcing of Raw Materials: Evaluates the use of responsibly sourced and extracted materials that have environmentally, economically, and socially preferable life-cycle effects include regional materials, and promotes the reduction of raw material usage by selecting reused and recycled materials.
    - o Resource Allocation-Support Sustainable Procurement Practices-Credit B: Evaluates to what extent the project team defines materials from sources.
- level of usage of local regional material (EP7-2),
- level of material reuse (EP7-3),
    - o Resource Allocation-Use Recycled Materials-Credit B: Evaluate to what extent the project team identifies materials with recycling content.
- building life cycle impact reduction (EP7-4),

- Material and Resources Credit Building Life-Cycle Impact Reduction: defines and evaluates various strategies to reduce environmental damage throughout the entire life cycle of a building: restoring existing buildings, reusing building components, and reducing a building's environmental footprint through the life-cycle assessment (LCA).

- number of material with EPD (EP7-5).
  - Material and Resources Credit Building Product Disclosure and Optimization – Environmental Product Declarations: Evaluates the selection and amount of products and materials from manufacturers who have verified improved environmental life-cycle impacts with Environmental product declarations (EPDs).
  - Resource Allocation-Support Sustainable Procurement Practices-Credit C: Assesses the extent to which purchased materials are certified by reputable third-party accreditation and standard-setting bodies.

A large part of the design elements of the buildings is determined by the standards and arranged according to various restrictions and conditions.

There is also a study that investigates the following criteria that allow the assessment of structures after use: (1) indoor air quality and quantity, (2) thermal comfort, (3) lighting, (4) ergonomic factors, (5) acoustic comfort, (6) personal control (CABE, 2005). As seen, indoor environmental quality includes many parameters such as indoor air quality, indoor visual comfort (sunlight, artificial lighting, etc.), indoor acoustic comfort.

According to Sadick and Issa (2016) development in indoor environmental quality (IEQ) has a favorable influence on post occupants' well-being (Sadick & Issa, 2016). Especially in urban regeneration projects, interior quality is an important issue in terms of the satisfaction of the society and the building owners, one of the stakeholders.

Five-hour work performance, thermal comfort, indoor air quality perception, and patient building syndrome symptoms were evaluated depending on the different temperatures and relative humidity of the users, ie different indoor weather conditions (Fang et al, 2004).

Indoor air quality can have negative effects both on short term (acute) and long term (chronic) on human health (TS CR Standard-1752, 2002) (BS ISO Standard-16814, 2008). Air quality inside the building; the amount of ventilation and the materials used in the building, furnishing and the user is affected by emissions (Bako-Biro, 2004; Wargocki, Wyon, Matysiak, & Irgens, 2005).

The green building certification programs that are frequently used today include the minimum indoor air quality requirements, emission limits of materials used, indoor air quality management program and strategies.

In light of this information, the indicators listed below were first added to the model for the evaluation of indoor quality criterion and then environmental performance and finally for the evaluation of total sustainable project performance. The indicators used to measure indoor environment quality criteria were determined as follows:

- level of indoor air quality (EP8-1),
    - Indoor Environmental Quality Prerequisite Minimum Indoor Air Quality Performance: Evaluates indoor air quality level by determining the amount of fresh air each type of space requires and contributes to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).
- number of indoor air quality strategies applied (EP8-2),
    - Indoor Environmental Quality Credit Enhanced Indoor Air Quality Strategies: Evaluates the application of IAQ strategies that include the entryway systems, interior cross-contamination prevention, filtration, exterior contamination prevention, increased ventilation, carbon dioxide monitoring, additional source control and monitoring.
- number of used low emmisionining material (EP8-3),
    - Indoor Environmental Quality Credit Low-Emitting Materials: Evaluates concentrations of chemical contaminants released from materials that have harmful effects on air quality, human health, productivity and the environment.
- provision of construction IAQ plan (EP8-4),

- Indoor Environmental Quality Credit Construction Indoor Air Quality Management Plan: Evaluates the development and implementation of indoor air quality (IAQ) management plan for the construction and preoccupancy phases of the building to protect building occupants from airborne pollutants associated with the construction, and construction workers from toxins and dust during build-out.

- compliance with daylight design requirement (EP8-5),
  - Indoor Environmental Quality Credit Daylight: Evaluates sufficient daylight quality and daylight levels in all regularly occupied spaces for improving the health of building occupants and productivity in the workplace, and reducing the use of electrical lighting.
- compliance with lighting design standard (EP8-6),
  - Indoor Environmental Quality Credit Interior Lighting: Evaluates lighting quality and lighting controls for building occupants' wellbeing and comfort where high-quality lighting is required.
- level of the chemical and pollutant source control level (EP8-7),
  - Indoor Environmental Quality Credit Enhanced Indoor Air Quality Strategies: Evaluates the application of IAQ strategies that include the entryway systems, interior cross-contamination prevention, filtration, exterior contamination prevention, increased ventilation, carbon dioxide monitoring, additional source control and monitoring.
- compliance with acoustic design standards/requirements (EP8-8),
  - Indoor Environmental Quality Credit Acoustic Performance: Evaluates whether the requirements associated with HVAC background noise, sound isolation, reverberation time, and sound reinforcement and masking systems for providing effective acoustic design to occupants.
- level of reduction of noise pollution (EP8-9),
- level of reduction of air pollution (EP8-10).

The evaluation of heating, cooling, ventilation, humidity, air conditioning systems in buildings is evaluated within the “Energy” dimension. For this reason, the focus is on issues other than the evaluation of these systems in the quality of interior space.

Compliance with environmental legal obligations/regulations is considered as the final indicator of environmental performance. The first indicator was taken from the study of Aladağ and Işık (2016). The explanation for the property rights ındicator (EP9-1) is as follows: In buildings that are not appropriate for planned building usage because of stock distribution and acreage, same rights can be used actively and issueless with condominium applications” (Aladağ & Işık, 2016). Secondly, the number of reported environmental issues/disputes (EP9-2), the level of compliance with legal requirements (EP9-3) and the number of measures and actions taken to improve sustainable performance (EP9-4) were first added to the model for the assessment of compliance with legal regulations, environmental performance dimension and overall sustainable project performance.

Table 5.9 : Criteria and indicators of Environmental Performance dimension with key references.

1st Dimension	2nd Dimension	Key References	3rd Dimension	Key References	4th Dimension	Key References
OVERALL SUSTAINABLE PERFORMANCE	ENVIRONMENTAL PERFORMANCE (EP)	(Aladağ & Işık, 2016; Chan, Scott, & Lam, 2002; Chan & Tam, 2000; Hemphill, Berry et al., 2004a; Lin & Shen, 2007; Maclaren, 1996; Rankin, Fayek, Meade, Haas, & Manseau, 2008; Tekçe, 2010; Wong, 2000; Yang, Yeung, Chan, Chiang, & Chan, 2010)	Ecological (EP1)	(Aladağ & Işık, 2016; ISI, 2012)	Level of protection or restoration of habitat	Couch & Dennemann, 2000; Council, 2013; ISI, 2012
					Total carbon emissions	Council, 2013; Hemphill, Berry, et al., 2004a
					Ecological footprint	Council, 2013; Wackernagel & Rees, 1996
			Design (EP2)	Aladağ & Işık, 2016; ISI, 2012)	Level of esthetic design	Aladağ & Işık, 2016
					Level of landscape design	Aladağ & Işık, 2016
					Level of integrated design policies	
			Land Use (EP3)	(Aladağ & Işık, 2016; Babcicky, 2013; Carbonaro & D′ Arcy, 1993; Cullingworth & Nadin, 2006; DTI (Deparment of Trade and Industry), 1998; DETR, 1998c, 1998b, 1998d, 1998a, 1998e; Hemphill, McGreal, et al., 2004b; ISI, 2012; Johnston, 1998; Ravetz, 1996; Saisana, 2014)	Level of effective site selection	Aladağ & Işık, 2016; Council, 2013; ISI, 2012; Hemphill, Berry, et al., 2004a
					Preservation level of high value landscapes and its features	Council, 2013; ISI, 2012; Hemphill, Berry, et al., 2004a
					Level of access to public transportation and public facilities	Couch & Dennemann, 2000; Council, 2013; Hemphill, Berry, et al., 2004a
					Alternative transportation opportunities	Couch & Dennemann, 2000; Council, 2013; ISI, 2012; Hemphill, Berry, et al., 2004a
					Level of compact development	Council, 2013
					Provision of open spaces	Council, 2013; Hemphill, Berry, et al., 2004a
					Level of regularization of population density/urban development	Aladağ & Işık, 2016; Council, 2013
					Number of housing stock	Aladağ & Işık, 2016; Council, 2013; Hemphill, Berry, et al., 2004a
					Level of increase in existing reconstruction rights	Hemphill, Berry, et al., 2004a
					Number of storm water management measures	Council, 2013
					Land pollution reduction	Couch & Dennemann, 2000; Council, 2013; ISI, 2012
					Level of accessibility	Couch & Dennemann, 2000

Table 5.9 (continued) : Criteria and indicators of Environmental Performance dimension with key references.

1st Dimension	2nd Dimension	Key References	3rd Dimension	Key References	4th Dimension	Key References
OVERALL SUSTAINABLE PERFORMANCE	ENVIRONMENTAL PERFORMANCE (EP)	(Aladağ & Işık, 2016; Chan, Scott, & Lam, 2002; Chan & Tam, 2000; Hemphill, Berry et al., 2004a; Lin & Shen, 2007; Maclaren, 1996; Rankin, Fayek, Meade, Haas, & Manseau, 2008; Tekçe, 2010; Wong, 2000; Yang, Yeung, Chan, Chiang, & Chan, 2010)	Waste Management (EP4)	(Aladağ & Işık, 2016; Constructing Exellence, 2019; Cha, Kim, & Han, 2009)	Design for minimum waste	Aladağ & Işık, 2016; Babcicky, 2013; Couch & Dennemann, 2000; Council, 2013; Hemphill, Berry, et al., 2004a; Robertson, 1997; Saisana, 2014
					Provision of construction waste management plan	Council, 2013
					Ratio of recycled/reused waste	Couch & Dennemann, 2000; Council, 2013
					Identification and reuse of unwanted by-products/discarded materials	ISI, 2012
					Storage and collection of recyclables	Council, 2013; ISI, 2012; Hemphill, Berry, et al., 2004a; Robertson, 1997
					Ratio of recycled or salvaged material	
			Energy (EP5)	(Aladağ & Işık, 2016; Constructing Exellence, 2019; Taisei AR, 2005)	Building energy performance certificate level (EPC)	Council, 2013
					Provision of building energy model	Aladağ & Işık, 2016; Council, 2013
					Building energy efficiency level (Performance or prescripted)	Council, 2013; Hemphill, Berry, et al., 2004a
					Utilization level of renewable energy	Couch & Dennemann, 2000; Council, 2013
					Level of measurement and verification system applied	Council, 2013
					Application level of building commissioning	Council, 2013
					Provision of green power	Babcicky, 2013; Council, 2013; Saisana, 2014
					Reduction level the net embodied energy	Council, 2013; ISI, 2012; Sundell et al., 2011
			Water (EP6)	(Aladağ & Işık, 2016; Babcicky, 2013; Constructing Exellence, 2019; ISI, 2012; Saisana, 2014)	Level of reduction of water pollution (Negative impact on water)	Couch & Dennemann, 2000; Council, 2013; ISI, 2012
					Total water use reduction	Council, 2013; Robertson, 1997
					Provision of water efficient landscaping	Council, 2013; ISI, 2012
					Number of innovative wastewater technologies applied	Council, 2013; ISI, 2012

Table 5.9 (continued) : Criteria and indicators of Environmental Performance dimension with key references.

1st Dimension	2nd Dimension	Key References	3rd Dimension	Key References	4th Dimension	Key References
OVERALL SUSTAINABLE PERFORMANCE	ENVIRONMENTAL PERFORMANCE (EP)	(Aladağ & Işık, 2016; Chan, Scott, & Lam, 2002; Chan & Tam, 2000; Hemphill, Berry et al., 2004a; Lin & Shen, 2007; Maclaren, 1996; Rankin, Fayek, Meade, Haas, & Manseau, 2008; Tekçe, 2010; Wong, 2000; Yang, Yeung, Chan, Chiang, & Chan, 2010)	Use of Material (EP7)	(Aladağ & Işık, 2016; Hee Sung Cha & Kim, 2011; Hemphill, Berry, et al., 2004a)	Quantity of environmentally preferable materials used	Council, 2013; ISI, 2012; Hemphill, Berry, et al., 2004a
					Regional material usage level	Council, 2013
					Material reuse level	Council, 2013; ISI, 2012; Hemphill, Berry, et al., 2004a
					Level of building life cycle impact reduction	(Council, 2013)
					Number of materials with EPDs	Council, 2013; ISI, 2012
			Indoor Environment Quality (EP8)	(Aladağ & Işık, 2016; Hemphill, Berry, et al., 2004a; Lin & Shen, 2007)	Indoor air quality level	Babcicky, 2013; Council, 2013; Saisana, 2014
					Application of indoor air quality strategies	Council, 2013
					Low emissioning materials used	Babcicky, 2013; Council, 2013; Saisana, 2014
					Provision of construction IAQ plan	Council, 2013
					Compliance level with daylight design requirement	Council, 2013
					Compliance level with lighting design standard	Council, 2013
					The chemical and pollutant source control level	Council, 2013
					Building acoustic standards/requirements compliance level	Council, 2013
					Noise pollution reduction level	Couch & Dennemann, 2000; Yu & Kang, 2011
					Air pollution prevention level	Aladağ & Işık, 2016
			Compliance with Regulations (EP9)	(Aladağ & Işık, 2016; R. S. Kaplan & Norton, 2000; McCabe, 2001; A. D. Neely et al., 2002)	Level of compliance with property rights	Aladağ & Işık, 2016
					Number of reported environmental issues/disputes	Kaplan & Norton, 2000; McCabe, 2001
					Level of compliance with legal requirements	Neely et al., 2002
					Number of actions to improve sustainable performance	ISI, 2012

6. ANALYSIS AND FINDINGS

6.1 Field Study A - Statistical Procedure and Analysis

The data obtained as a result of the study were analyzed with the help of the MS Office 2013 Excel program by applying the statistical procedures described. Statistical analyzes & tables and responses received from Field Study A are given in Appendix D.

Starting from descriptive statistics, a series of statistical analysis procedures were applied, such as chi-square ($\chi2$) independence test, Friedman test (nonparametric two-way analysis of variance), and Cronbach's Alpha to test the reliability of the scales.

Descriptive statistics refers to the single results of the analyzed data set. Descriptive statistics also include frequency distributions, central tendency measures such as arithmetic mean, median, mode, and distribution measures such as standard deviation and coefficient of variation. These analyses were applied to understand how the data was distributed and to summarize descriptive information of the respondents. The results obtained were transferred to tables and graphs, and interpreted under the titles of a statistical procedure, analysis and findings.

All findings were tested with 95% confidence, p = 0.05 significance level (p) and bidirectional. Descriptive statistics were used to summarize the information about the sample and inferential statistics were used to make assessments related to the population (Zikmund, 2000).

The chi-square ($\chi2$) independence test was used to analyze the hypothesis of an independence-dependence relationship established between categories of nominal or ordinal variables. Chi-square test to compare the expected values of the results with the observed values for each of the k possible results (k = 1,2,3… n) used. In this concept ($\chi2$) test is used to see if the observed values differ according to two distinct characteristics and whether the two features are related (Tanis, 1987).

The statistical analysis procedure Cronbach's Alpha Coefficient was applied in the analysis of the reliability levels of the responses and the sustainable performance measurement model components for urban regeneration projects in Part III of the survey form of Field Study A. This method investigates whether the problem in the scale represents a homogeneous structure. The reliability of the scale is interpreted as follows depending on alpha (α) coefficient (Kalaycı, 2009); $0.00 \leq \alpha < 0.40$ (unreliable), $0.40 \leq \alpha < 0.60$ (low reliability), $0.60 \leq \alpha < 0.80$ (highly reliable) and $0.80 \leq \alpha < 1.00$ (highly reliable).

Gronlund and Linn (1990) and Ebel and Frisbie (1991) emphasize that reliability is a feature of the data obtained by the measurement tool and that the measurement tool does not point to its characteristics. The testing of the results produced by the measuring tool and the acceptable error rate support the validity of the generated measuring tool. For this reason, the performance measurement model will be tested with the Field Study-C while looking for validity with the evaluation criterion presented in the Field Study-B for the whole model.

In the Field Study-A Part III, the normality assessment of the important responses to the key performance indicators was performed using the Kolmogorov-Smirnov test because the sample size was small. The Kolmogorov-Smirnov (K-S) test is used to test whether a sample data obtained corresponds to a given distribution. With the help of this test, it is possible to examine whether the data collected from a sample show normal distribution (Özdamar, 2004).

In this test, the data came from a normal distribution with the H0 hypothesis, while the distribution of the population was not normal with the H1 hypothesis. The single sample was tested with Kolmogorov-Smirnov (KS) test z value and the related significance level (asymp. Sig.) with $p < 0.05$. If the H0 hypothesis (asymp. Sig.) was significant at $p < 0.05$, it was rejected and the distribution was accepted as not normal. If $p > 0.05$ value is obtained, the H1 hypothesis is accepted and the distribution does not show a significant difference from the normal distribution is interpreted (Field, 2000).

The importance weights of the key performance indicators are determined through Part III of the Field Study A- questionnaire. The importance weights of the second and third dimensions of the sustainable performance measurement model are determined by AHP. The analysis and the results of these data are given in Section 6.2 and 6.3 of the thesis.

Rate of Response

The construction industry also has a poor reputation for known low response rates in surveys. According to Takim et al., 2004 the accepted rate changes between 20%-40% (Takim et al., 2004). Xiao et al. (2000), can just reach a 20% response rate in performance measurement studies. Besides Tekçe (2010) similarly reached a 28.5% response rate. Herberlein (1978) emphasized that a 20% to 60% survey response rate is typical in the studies. Bartlett et al. (2001) stated that sufficient sample sizes, which do not contain missing data and high-quality data rather than large sample sizes, often produce more reliable information.

In this thesis, Field Study A took 1,5 months to complete. Since there were no missing data in the questionnaires in the study, no analyses were conducted due to missing data. Field Study-A response rate calculated as 49,23% (32/65).

Calculation of Margin of Error

For inferential statistical analyzes, the necessity of a large sample size is generally accepted. In general, as a practical rule o evaluate the sample as large is accepting the threshold value is greater than 30 (n> 30) (Munn and Drever, 1990; Sutrisna, 2004).

Thus, 32 responses obtained in the Field Study-A were evaluated as a sufficient number to perform inferential statistical analyses. The margin of error for 32 responses were calculated with the help of the formula (6.1) as in the Tekçe 2010 study;

$$m = z * \sqrt{\frac{p\ (1-p)}{n}} \tag{6.1}$$

m: margin of error

p: estimated variance

n: Sample size

z *: standard variable table value (α = 0.05, for z * = 1,96)

When calculating the margin of error, it is estimated that the maximum variance occurs as the worst-case scenario when p = 0.5 (Sutrisna, 2004). According to these assumptions, the margin of error is calculated as in (6.2) with the formula given in formula (6.1).

$$m = z * \sqrt{\frac{0,5(1-0,5)}{32}} * 100 \tag{6.2}$$

At a 95% confidence limit, the error margin in the sample was calculated as 17.32%. This result indicates that the results obtained from Field Study-A are within ± 17.32% range with a 95% probability.

6.1.1 Analysis and findings of the participants (Field Study A-Part I)

In this section, the findings obtained using descriptive statistics related to the respondents who participated in urban regeneration projects/construction industry and answered the questionnaire are given. The working time of the respondent in the sector and urban regeneration projects was questioned as this would increase the significance and reliability of the evaluations regarding the project performance. The findings of the participants' years of experience in the sector and the firm are summarized in Tables 6.1, 6.2 and 6.3.

Table 6.1 : Findings on the expertise of the participants.

Profession	N	%	Valid	Cumulative
Architect	13	40,63	40,63	40,63
Civil Engineer	9	28,13	28,13	68,75
Mechanical Engineer	6	18,75	18,75	87,50
Electrical Engineer	0	0,00	0,00	87,50
Landscape Architect	1	3,13	3,13	90,63
Geomatic Engineer	1	3,13	3,13	93,75
Technician	1	3,13	3,13	96,88
Urban and Regional Planner	1	3,13	3,13	100,00
Total	32	100,00	93,75	

The distribution of participants in terms of expertise is as follows: 13 (40.63%) are architects; 9 (28.13%) are civil engineers; 6 (18.75%) are mechanical engineers; 4 (12,50 %) are from other fields of expertise (1 landscape architect, 1 geomatics engineer, 1 technician, and 1 urban and regional planner). When the findings are examined, it is seen that the participants have a high proportion of architects and civil engineering backgrounds. The findings also show that the participants were selected to cover almost all disciplines from the perspective of urban transformation (See Table 6.1).

Table 6.2 : Findings of participants' experience in the construction sector.

Experience in the construction sector	N	%	Valid	Cumulative
<5 years	9	28,13	28,13	28,13
5-10 years	5	15,63	15,63	43,75
10-15 years	4	12,50	12,50	56,25
15-20 years	6	18,75	18,75	75,00
20-25 years	6	18,75	18,75	93,75
>25 years	2	6,25	6,25	100,00
Total	32	100,00	100,00	

Among the participants who answered the questionnaire 9 of them (28.13%) have under 5 years experience; 5 of them (15.63%) have experienced between 5-10 years; 4 of them (12.50%) 10-15 years experience; 6 of them (18.75%) have experienced between 15-20 years; similarly, 6 of them (18.75%) are experienced between about 20-25 years and 2 of them (6.25%) have been working in the construction sector for more than 25 years (See Table 6.2).

Table 6.3 : Findings of participants' experience in the urban regeneration projects.

Experience in the urban regeneration projects	N	%	Valid	Cumulative
<5 years	17	53,13	53,13	53,13
5-10 years	10	31,25	31,25	84,38
10-15 years	3	9,38	9,38	93,75
15-20 years	1	3,13	3,13	96,88
20-25 years	1	3,13	3,13	100,00
>25 years	0	0,00	0,00	100,00
Total	32	100,00	100,00	

The experts who answered the questionnaire had the following experiences in urban transformation projects: 17 of them (53.13%) have under 5 years experience; 10 of them (31.25%) have experienced between 5-10 years; 3 of them (9.38%) 10-15 years experience; 1 of them (3.13%) have experienced between 15-20 years; similarly, 1 of them (3.13%) are experienced between about 20-25 years and none of them (0%) have been working in the construction sector for more than 25 years. When the data obtained were evaluated, only 15.63% of the experts who participated in the study had been working in urban regeneration projects for 11 years or more and 56.25% of them stated that they had 11 years and more years of experience in the sector. In the context of this study, a performance measurement model developed for urban regeneration projects has been mentioned, to maintain the project performance perspective sufficient number of experts were provided (see Table 6.3).

The experience of the experts who answered the questionnaire in urban transformation projects is 6 years on average and 12 years in the construction sector. When the sustainable project performance measurement model for urban regeneration projects is considered, the experiences and knowledge of the participants are supportive.

6.1.2 Analysis and findings of current practices about performance measurement at project level (Field Study A-Part II)

In this section, the past experiences of the experts about project performance measurement and their motivation, the software they used and the types of data used as input are evaluated.

Table 6.4 : Findings on previous experience of experts in measuring project performance.

Number of questions in the survey form of Field Study A: 1		**N**	**%**	**Valid**	**Cumulative**
Have you experienced a project performance measurement system in your past projects?	No	21	65,63	65,63	65,63
	Yes	11	34,38	34,38	100,00
	Total	32	100,00	100,00	

34.38% of the experts who participated in the study stated that they used a project performance measurement system in their previous projects. The remaining 65.63% stated that they did not use a performance measurement system in their previous projects. Although the majority of the experts involved in the study were far from the project performance measurement culture, their forward-thinking ideas supported working with questions such as trends in measuring project performance and the types of data that should be used (see Table 6.4).

It was questioned how many of the experts who participated in the study experienced the project performance measurement system in their previous projects. One of the experts selected the option 0 because they applied a project performance measurement system in an ongoing project. It is stated that the performance of an ongoing project is calculated on the predetermined milestones. The majority of experts (63.64%) stated that they used a systematic performance measurement model in 1 to 5 projects. Only one expert has used a performance measurement system for 5 to 10 projects and two experts have used 10 projects and over (see Table 6.5).

Table 6.5 : Findings on the number of urban regeneration projects using a systematic project performance measurement model.

Number of questions in the survey form of Field Study A: 2		N	%	Valid	Cumulative
What is the number of urban regeneration projects you have been involved which use a systematic project performance measurement system?	0	1	9,09	9,09	9,09
	1-5	7	63,64	63,64	72,73
	5-10	1	9,09	9,09	81,82
	>10	2	18,18	18,18	100,00
	Total	11	100,00	100,00	

As mentioned earlier, the participants were selected not only from urban transformation experts but also from academia and industry employees, as a sustainable project performance measurement model was developed. As can be seen from the statistics, the construction sector explains that very few experts use performance measurement models. The majority of this limited number of participants experienced the project performance measurement system between 1-5 projects, which is enough to strengthen the results. Besides, the fact that 2 experts have this experience on 10 projects and further supports the evaluations made.

The motivational factors of the experts who used the project performance measurement system in their previous projects were questioned. According to the findings, motivational factors were ranked according to preference rates.

The benefits of performance measurement (21,62%), recommendations of consulting firms (16,22%) and customer ‘s requirements (13,51%) were the most preferred factors.

These are followed by enterprise initiative and leadership and request/advice from our foreign partner with a rate of 10.81%. Total quality management practices and seeking a new method (5.41%) were found to be relatively less motivational factors. The initiative of quality control manager, ISO applications, and dissatisfaction with previous performance measurement applications can be seen as a motivating factor in the chosen group of experts, although preferred by 1 person.

Table 6.6 : The motivational factors of used the project performance measurement system.

Number of questions in the survey form of Field Study A: 3		N	%	Valid	Cumulative	Rank
What was the main motivation of developing and implementing performance measurement system in the projects you have worked?	To be one of the best companies in national and international scale	3	8,11	8,11	8,11	5
	Enterprise initiative and leadership	4	10,81	10,81	18,92	4
	Initiative of quality control manager	1	2,70	2,70	21,62	7
	Customer's requirements	5	13,51	13,51	35,14	3
	Initiative of trained employees	0	0,00	0,00	35,14	8
	Benefits of performance measurement	8	21,62	21,62	56,76	1
	ISO applications	1	2,70	2,70	59,46	7
	Total Quality Management Practices	2	5,41	5,41	64,86	6
	Obligations in the countries where business is conducted	0	0,00	0,00	64,86	8
	Recommendation of the consultants	6	16,22	16,22	81,08	2
	Seeking a new method	2	5,41	5,41	86,49	6
	Request / advice from our foreign partner	4	10,81	10,81	97,30	4
	Dissatisfaction with previous performance measurement applications	1	2,70	2,70	100,00	7
	Total	37	100,00	100,00		

The criteria of the initiative of trained employees and obligations in the countries where the business is conducted were not seen by any of the experts as the main motivating factors for the previously implemented project performance measurement system (see Table 6.6). This may be attributed to the fact that the group of participants is generally selected from the Turkish construction sector and the traditional structure of the Turkish construction sector.

In short, the main motivation for using the project performance measurement system is the benefits of performance measurement. This result is consistent with the objectives of the study and increases the prevalence of the use of the study results.

Table 6.7 : Findings related to special software used by experts.

<table>
<tr><th colspan="3">Number of questions in the survey form of Field Study A: 4</th><th>N</th><th>%</th><th>Valid</th><th>Cumulative</th></tr>
<tr><td rowspan="6">Do you use specific software to process the data obtained in measuring project</td><td colspan="2">No</td><td>0</td><td>0,00</td><td>0,00</td><td>0,00</td></tr>
<tr><td colspan="2">Accounting programs</td><td>2</td><td>14,29</td><td>14,29</td><td>14,29</td></tr>
<tr><td colspan="2">Software for Performance Management (MS Excel, Logo)</td><td>7</td><td>50,00</td><td>50,00</td><td>64,29</td></tr>
<tr><td colspan="2">A specially generated performance measurement system software</td><td>4</td><td>28,57</td><td>28,57</td><td>92,86</td></tr>
<tr><td>Other</td><td>Green Building Certification Systems Scorecards (LEED Scorecard & BREEAM Scorecard, EDGE Scorecard, etc.)</td><td>1</td><td>7,14</td><td>7,14</td><td>100,00</td></tr>
<tr><td colspan="2">Total</td><td>14</td><td>100,00</td><td>100,00</td><td></td></tr>
</table>

In the Field Study A, it was tried to determine the software used by the projects to process the data obtained from performance measurement. Two of the experts (14.29%) used accounting software as a special software to process the data obtained in measuring the performance of their projects, 7 (50%) used performance management software such as MS Excell or Logo, and 4 (28.57%) using a specially prepared performance measurement system software. Also, an expert selected another option and stated Green Building Certification Systems Scorecards (LEED Scorecard & BREEAM Scorecard, EDGE Scorecard, etc.) (See Table 6.7). From this point of view, it is quite logical and reasonable that adding references to some KPIs identified in the model should be referenced from the specified evaluation systems.

Two of the experts (18.18%) who had previously used a project performance measurement system were undecided when evaluating the effectiveness of the system. The 4 (36.36%) of the experts stated that the performance measurement system or applications applied in their projects were very effective in the context of value-adding applications (considering the results and system costs) and 5 (45.45%) stated as effective. Used project performance measurement systems are considered as not to be effective or less effective. It was concluded that the majority of the participants (81.82%) benefited from the performance measurement system as a value-adding application (see Table 6.8).

Table 6.8 : Evaluation of project performance measurement system or applications.

Number of questions in the survey form of Field Study A: 5		**N**	**%**	**Valid**	**Cumulative**
Would you think that a formal performance measurement system or other methods that you implement in the projects to measure the results and performance, are effective features for a company?	Not effective at all	0	0,00	0,00	0,00
	Less effective	0	0,00	0,00	0,00
	Undecided	2	18,18	18,18	18,18
	Effective	5	45,45	45,45	63,64
	Very effective	4	36,36	36,36	100,00
	Total	11	100,00	100,00	

Table 6.9 : Data sources that provide input to the performance measurement of projects.

Number of questions in the survey form of Field Study A: 6		N	%	Valid	Cumulative
What were the source of input data in the performance measurement system?	Customer surveys	1	6,25	6,25	6,25
	Cost reporting system	1	6,25	6,25	12,50
	Project reviews / Site data	10	62,50	62,50	75,00
	Head office data	4	25,00	25,00	100,00
	Other	0	0,00	0,00	100,00
	Total	16	100,00	100,00	

When the types of data constituting input to the project performance measurement systems were examined, the majority of the experts (62.50%) stated that they used project reviews and site data. This is followed by head office data (25.00%). Customer surveys and data from the cost reporting systems used as input by 1 expert (see Table 6.9). From this point of view, it is possible to have an idea about where KPIs in project performance measurement systems can be obtained and applied in the model. The site-oriented approach and applications of the construction sector prove the most common use of this site data type.

Table 6.10 : Findings on implementation considerations of perfromance measurement system in future projects.

Number of questions in the survey form of Field Study A: 7		N	%	Valid	Cumulative
If you have not done yet, do you consider using a performance measurement system in your future projects?	No, not planned	0	0,00	0,00	0,00
	I don't have enough information	6	28,57	28,57	28,57
	Yes, if costs are low compared to benefits	12	57,14	57,14	85,71
	Yes, planned to implement	3	14,29	14,29	100,00
	Total	21	100,00	100,00	

Fieldwork In the second part of the A-questionnaire, you have a project performance measurement system in your past projects? The majority of the respondents (65.63%) answered the question “Have you experienced a project performance measurement system in your past projects?” as no in the second part of Field Study A (see Table 6.4). Since these participants had not experienced a project performance measurement system before, their use tendencies were measured in the future. On the other hand, none of the participants stated that we do not plan to use such an evaluation system. Also, 3 experts stating that they are working on and planned to be implemented. It is known that the costs of project performance measurement systems are considered as an important constraint in applications. For this reason, the majority of the participants (57.14%) stated that they would plan implementation if the costs were affordable. Six of the experts (28.57%) have abstained because they did not have sufficient knowledge about the subject (see Table 6.10). This result leads to the interpretation that the project performance measurement system developed within the scope of the thesis should be introduced more to the employees in the sector and the alternatives should be searched.

Table 6.11 : Findings on the need for an international platform to develop a sustainable performance measurement model for urban regeneration projects.

<table>
<tr><th colspan="2">Number of questions in the survey form of Field Study A: 8</th><th>N</th><th>%</th><th>Valid</th><th>Cumulative</th></tr>
<tr><td rowspan="3">Do you think about there is a need for developing a sustainable performance measurement model for measuring urban regeneration project performances by international platform?</td><td>Yes, there is a need</td><td>31</td><td>96,88</td><td>96,88</td><td>96,88</td></tr>
<tr><td>No need</td><td>1</td><td>3,13</td><td>3,13</td><td>100,00</td></tr>
<tr><td>Total</td><td>32</td><td>100,00</td><td>100,00</td><td></td></tr>
</table>

All experts who used or did not use a project performance measurement system before were asked whether there is a need for a sustainable performance measurement model for urban regeneration projects supported by an international platform.

Almost all of the experts (except 1) (96.88%) stated that such a system was needed. The model developed within the scope of the thesis is expected to reach a high prevalence of usage in the future (see Table 6.11).

The last question of the second part of the fieldwork A-questionnaire was again asked all participants. The question ("What were the source of input data in a performance measurement system?") was asked to the experts who had experienced the project performance measurement system before. Similar question ("What should be the source of input data in a performance measurement system?") were asked to the participants. Similarly, participants identified project reviews and site data as the major input data. This was followed by the cost reporting system at a rate of 25.32%. Customer surveys and head office data are reported as data types with 17.72% and 15.19% (see Table 6.12). Since each expert could select more than one option, 79 responses were collected. In 4 of these, the other option is selected and the input data types were listed as follows: Performance measurement models; for urban regeneration type of projects, design documentation and their implementation performance during the construction process; base values defined in the relevant international standards; Common Library With a Global Database.

Table 6.12 : Data sources that are considered to be input to projects' performance measurement.

<table>
<tr><th colspan="3">Number of questions in the survey form of Field Study A: 9</th><th>N</th><th>%</th><th>Valid</th><th>Cumulative</th></tr>
<tr><td rowspan="9">What should be the source of input data in a performance measurement system?</td><td colspan="2">Customer surveys</td><td>14</td><td>17,72</td><td>17,72</td><td>17,72</td></tr>
<tr><td colspan="2">Cost reporting system</td><td>20</td><td>25,32</td><td>25,32</td><td>43,04</td></tr>
<tr><td colspan="2">Project reviews / Site data</td><td>29</td><td>36,71</td><td>36,71</td><td>79,75</td></tr>
<tr><td colspan="2">Head office data</td><td>12</td><td>15,19</td><td>15,19</td><td>94,94</td></tr>
<tr><td rowspan="4">Other</td><td>Performance measurement models</td><td>1</td><td>1,27</td><td>96,20</td><td>92,69</td></tr>
<tr><td>For urban regeneration type of projects, design documentation and their implementation performance during construction process.</td><td>1</td><td>1,27</td><td>97,47</td><td>94,29</td></tr>
<tr><td>Base values defined in the relevant international standards</td><td>1</td><td>1,27</td><td>98,73</td><td>97,14</td></tr>
<tr><td>Common Library with a Global Database</td><td>1</td><td>1,27</td><td>100,00</td><td>100,00</td></tr>
<tr><td colspan="2">Total</td><td>79</td><td>100,00</td><td>100,00</td><td></td></tr>
</table>

6.1.3 Determination of the importance of key performance indicators (Field Study A-Part III)

In Part III of Field Study-A, the importance weights of the Level 4 Key Performance Indicators included in the sustainable performance measurement model for urban transformation projects were tried to be determined. Participants were asked to assess how important the key performance indicators (compiled from the literature) in the literature are used to measure the performance of different dimensions of an urban transformation project. As in Tekçe's study, a 7-point Likert scale was used (1 = Not important (2 and 3 intermediate values) 4 = Important (5 and 6 intermediate values) 7 = Highest importance. is given.

Descriptive statistics, arithmetic mean, standard deviation, minimum values, maximum values, confidence interval, mode, and median values for the obtained data were calculated for each indicator. By taking the arithmetic average of the significance scores for the 135 key performance indicators included in the questionnaire was determined as follows (Assaf et al., 1995; Thomas et al., 2005): the importance scores that each expert declared on KPIs were summed and divided by the number of experts.

The rankings of indicators according to level 3 performance criteria, rankings of indicators according to level 2 performance dimensions, and general ranking were determined using the obtained significance scores (Appendix D.2 & D.3). The overall ranking of the indicators is given in Appendix D.4.

The key performance indicators should ensure that the data obtained are normally distributed and then checked for reliability. From this point of view, the H0 hypothesis is based on the fact that the data comes from a population with a normal distribution. On the other hand, the H1 hypothesis is that the distribution of the population is not normal. The data were tested with a single sample Kolmogorov-Smirnov (KS) test with z value and its significance level (asymp. Sig.) $p<0.05$ (see Table 6.13).

Table 6.13 : The sustainable performance measurement model performance dimensions normal distribution test (Field Study-A, Part III).

Dimensions	**N**	**Kolmogorov-Smirnov (Z)**	**asymp. Sig. (p)**
OVERALL SUSTAINABLE PERFORMANCE	32	1.02	0.186
FINANCIAL PERFORMANCE	32	0.71	0.685
TIME PERFORMANCE	32	0.73	0.672
QUALITY PERFORMANCE	32	0.68	0.722
HEALTH & SAFETY (H & S) PERFORMANCE	32	0.62	0.765
STAKEHOLDER SATISFACTION	32	0.86	0.568
INNOVATION	32	0.79	0.632
ENVIRONMENTAL PERFORMANCE	32	0.83	0.589

The data obtained for all performance dimensions have a normal distribution according to the Kolmogorov Smirnov test. ($P> 0.05$). Cronbach Alpha was used to test the reliability of the responses of the participants in the Field Study-A Part-3 and the obtained Cronbach's Alpha coefficients are given in Table 6.14.

Table 6.14 : Reliability Analysis of sustainable performace measurement model.

Dimensions	Cronbach's Alpha	N of Items
OVERALL SUSTAINABLE PERFORMANCE	0.832	135
FINANCIAL PERFORMANCE	0.702	14
TIME PERFORMANCE	0.845	11
QUALITY PERFORMANCE	0.776	7
HEALTH & SAFETY (H & S) PERFORMANCE	0.743	12
STAKEHOLDER SATISFACTION	0.812	24
INNOVATION	0.733	12
ENVIRONMENTAL PERFORMANCE	0.815	55

When all the important points given to the key performance indicators were evaluated, the reliability value was found as Cronbach's Alpha 0.832. This value indicates that all the data collected about the scale was generally highly reliable. The following reliability values of dimension was found as reliability value for financial performance dimension Cronbach's Alpha (0.702-moderately reliable), reliability value for time performance dimension Cronbach's Alpha (0.845- highly reliable), reliability value for quality performance dimension Cronbach's Alpha (0.776-moderately), reliability value for health & safety performance dimension Cronbach's Alpha (0.743-moderately reliable), reliability value for stakeholder satisfaction dimension Cronbach's Alpha (0.812-highly reliable), reliability value for innovation dimension Cronbach's Alpha (0.733-moderately reliable), reliability value for environmental performance dimension Cronbach's Alpha (0.815- highly reliable).

6.1.4 Determination of importance weights of performance model's components-Analytical Hierarchy Process (Field Study A-Part IV)

In Part IV of the Field Study A, the following targets are aimed:

(1) Determination of the relative importance weights of "performance dimensions (level 2)" and "performance criteria (level 3)" of the sustainable performance measurement model and

(2) Determination of the importance weights of the "key performance indicators of the (level 4)" within the sustainable performance measurement model.

The questionnaire has been prepared in such a way as to enable pairwise comparisons of performance dimensions and performance indicators included in the model. The data were analyzed using MS Office Excel by following the application steps in the "Analytical Hierarchy Process" algorithm described in Section 2.2 of the Methodology of the thesis. With this analysis, the relative importance weights of both performance dimensions (level 2) and performance criteria (level 3) of these performance dimensions were tried to be calculated.

6.1.4.1 Application of the Analytical Hierarchy Process (AHP)

The hierarchical structure of the formulated sustainable project performance measurement model was applied to the experts in a questionnaire containing 224 comparison matrices using classical AHP format (9-point scale and pair-wise comparisons). The model used in AHP application is shown in Figure 6.1. The steps followed in implementing the AHP algorithm are described below;

Step 1. Model construction and problem structuring: Proposed key performance indicators of the environmental performance which is one of the main performance dimensions of sustainable project performance for urban regeneration projects, the determined based on a literature study were discussed through a pilot survey. Finally, 135 KPIs were determined to measure the success of environmental performance. An AHP model structure that includes criteria and sub-criteria (i.e. KPI's of the environmental performance of an urban regeneration project) has been configured. In this context, the developed AHP model structure is shown in Figure 6.1.

Step 2. Construct pairwise matrices of the components: the experts were asked to make pairwise comparisons between determined criteria above. However, due to the large number of KPIs, pairwise comparisons between them were too complex to be applicable. Hence, they were rated using a 7-point Likert scale. Afterward, the Average weights of the KPIs are normalized and included in the model. The normalized averaged weights of KPIs are given and calculated with the formula (6.3):

$$a_{w11} = \frac{a_{11}}{\sum_{i=1}^{m} a_{i1}} \tag{6.3}$$

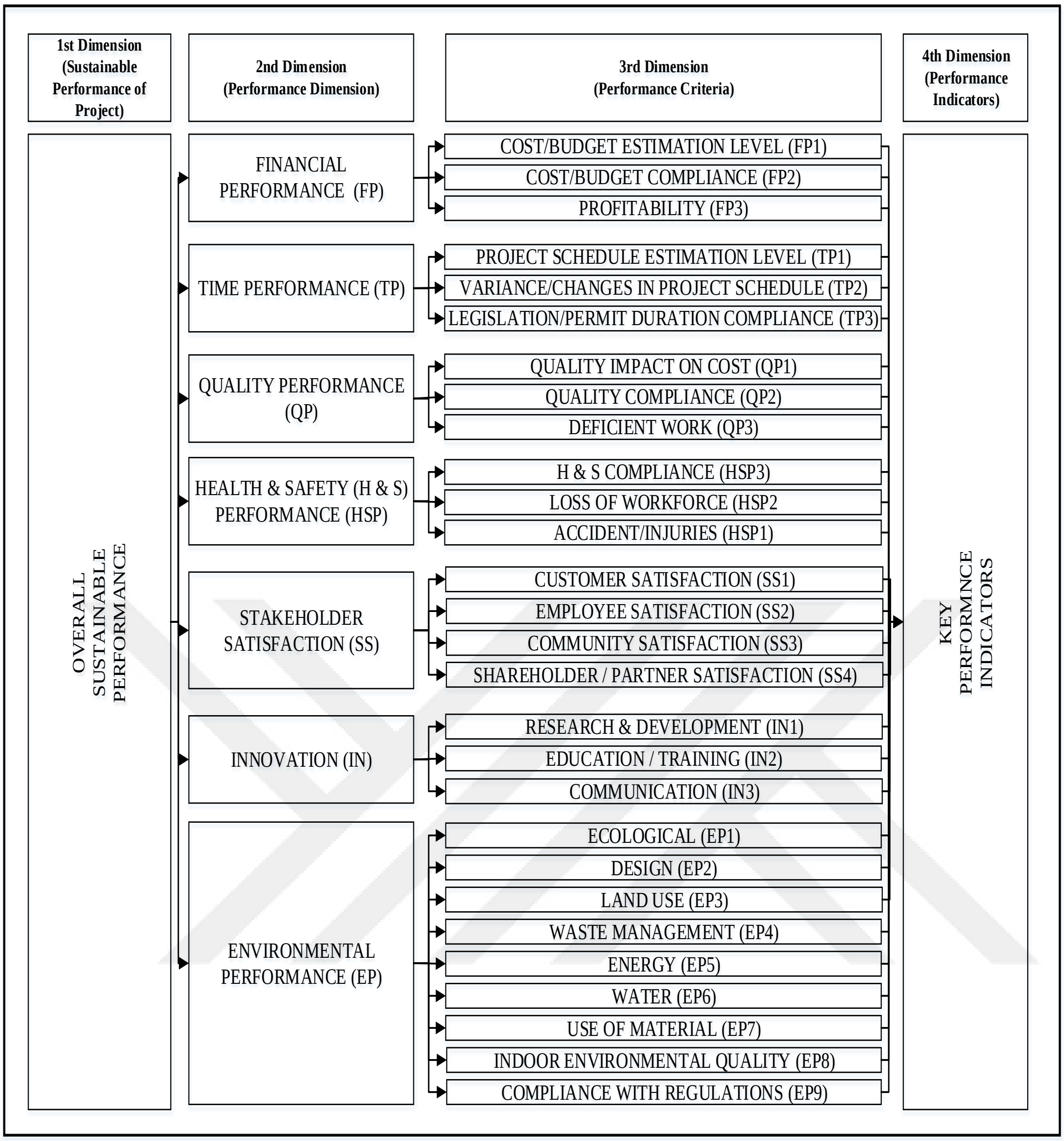

Figure 6.1 : AHP Model Structure.

In comparisons between items at a particular hierarchical level, an item in row i is not always compared to an item in column j. In the corresponding terminology, aij is an indication of how much (or less) element i is more important than j. In AHP, preferences are assumed to have reciprocity (Cabała, 2010). For example, if i-th is x times more important than j-th (aij = x), then it is automatically assumed that j-th is as important as 1 / x as i-th (aji = 1 / x). An appropriate assessment scale should be introduced to enable the participants of the AHP study to accurately measure all parts of the characteristics of the elements to be analyzed. In this study, the AHP scale is presented from 1 to 9. A detailed interpretation of the assessment scale is given in Table 6.15.

Table 6.15 : Evaluation Scale Used In Pairwise Comparisons.

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong Importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Interval Values

To reconcile the evaluations of the experts for each pairwise comparison, it has been chosen to reach consensus via geometric mean. Geometric mean as the method of combining more than one pair-wise judgments, is most commonly used in the literature into a mathematical expression. In this way, pair-wise comparison matrices reflecting the group decision were obtained for the next step in the operations in the AHP algorithm. Different feedback from the expert panel indicates the views of a group. To consolidate the assessments of the experts for each pairwise comparison, the most common geometric mean method was used to combine pair-wise judgments. Thus, pair-wise comparison matrices reflecting the group decision were generated for the next step in the AHP algorithm process. Saaty (2005) proposed the consolidation of the opinions of different participants by using the weighted geometric mean method to obtain a single opinion from these different views. The X dataset, X = (x1, x2,…, xn), n represents the feedback of the participant, and the W dataset, W = (w1, w2,…, wn), represents the consolidated assessment to express the importance weights of these participants. The weighted geometric mean of the evaluations was calculated as indicated in (6.4) (Saaty, 2005):

$$\bar{x} = \left(\prod_{i=1}^{n} x_i^{w_i} \right)^{1/\sum_{i=1}^{n} w_i} \tag{6.4}$$

In Table 6.16, the group decsion matrix of financial performance is given as a example. dimensons and criteria od the mode. The comparison matrices of each participant, group decision matrices generated for each dimension and finally the matrix comparing the dimensions of the project performance are given in the Appendix D.

Table 6.16 : Group Decision Matrix of Financial Performance (FP).

Group Decision Matrix			
	FP1	FP2	FP3
FP1	1	0,5751052288	0,8976833109
FP2	1,738812221	1	1,512067145
FP3	1,113978602	0,6613462923	1
SUM	3,852790823	2,236451521	3,409750456

A total of 224 comparison matrices are shown in Table 6.17, which includes the evaluation of 32 experts, 7 of which are the comparison matrix for performance criteria and 1 for the performance dimensions.

Table 6.17 : Raw benchmarking matrices showing comparative judgment of experts.

Comparison Matrices	Number of Matrices
Financial Performance (FP)	32
Time Performance (TP)	32
Quality Performance (QP)	32
Health & Safety Performance (HSP)	32
Innovation (IN)	32
Environmental Performance (EP)	32
Overall Sustainable Performance (TP)	32
SUM	224

Step3. Finding Priority and Eigen Vector: as previously mentioned, the normalized group decision matrix (Aw), the relative importance (priority) vector (Wi), the weighted total vector (D) were obtained. Each element of this vector (D) is used for measuring the consistency of the Eigenvector E.

After the “pairwise comparisons matrix” is developed; (each environmental performance criterion) has priority vectors indicating the severity of the criteria. Linear algebra techniques are used to construct priority vectors. There are different methods developed for the generation of priority vectors for ease of implementation with the methodology of AHP (Lipovetsky, 2009). The two most common prioritization procedures of AHP are the eigenvector method (EM) and the line geometric mean method. Both methods achieve the same relative importance vector values (Escobar et al., 2004). In this study, the eigenvector method was used.

Finding the eigenvector:

In the group decision matrix, each column element is summed, and each element is divided into this sum to obtain a normalized group decision matrix (Aw). In this matrix, the sum of the columns is equal to 1.

In the normalized group decision matrix (Aw), the arithmetic mean of the elements in each row is obtained to the relative importance (priority) vector (Wi). The sum of the elements in this vector is equal to 1. The elements in the group decision matrix are multiplied by the relative priority vector to give the priority vector or weighted total vector (D). Each element of this vector (D) is used for measuring the consistency of the eigenvector (E) by dividing the corresponding element in the relative importance vector (Wi).

In Table 6.18, normalized group decision matrix (Aw) and relative importance (priority) vector (Wi) of financial performance is given as an example. The Normalized Group Decision Matrix (Aw) And The Relative İmportance (Priority) Vector (Wi) of Financial Performance.

Table 6.18 : Normalized Group Decision Matrix and Relative Importance (Priority) Vector (Wi).

	Normalized Matrix (Aw)			Relative Importance (Priority) Vector (Wi)
	FP1	FP2	FP3	
FP1	0,2595521132	0,2571507691	0,2632695039	0,2599907954
FP2	0,4513123864	0,4471368999	0,4434539021	0,4473010628
FP3	0,2891355003	0,2957123309	0,293276594	0,2927081418
SUM	1	1	1	1

Also, in Table 6.19, weighted total vector (D), eigenvector (E) is given.

Table 6.19 : The Priority Vector or Weighted Total Vector (D) And The Eigenvector (E) of Financial Performance.

Priority Vector or Weighted Total Vector (D)	EIGEN VEKTOR (E)
0,7799951893	3,000087707
1,341970599	3,000150706
0,8781532241	3,000098388
LAMDA MAX	3,000112267

Step 4. Checking consistency: at the last stage, it is necessary to calculate the consistency ratio for each comparison matrix to determine whether the decision-maker behaves consistently when comparing the factors (Dağdeviren et al., 2004). The consistency of the pair-wise comparisons matrices developed in the evaluations was checked while collecting the data on the AHP. In this way, it was evaluated whether the process of comparison of criteria is consistent. By checking whether the consistency is acceptable, decision-makers were asked to reconsider their pair-wise comparisons.

To check the consistency: Firstly maximum eigenvalue λmax is obtained from the eigenvector E matching the maximum value (see Table 6.19). After determination of the λmax, the consistency index (CI) has been conducted as follows: CI=λmax−n/n−1, where *n* is the matrix size. Next calculation is done to evaluate consistency ratio to benchmark that the matrix /the judgment whether is consistent or not. For this purpose, consistency index is divided to random index (RI) in order to obtain consistency ratio (CR). The acceptable CR value is 10%, in other words, 0.10. In Table 6.20, selected random index for examined matrix size is given.

Table 6.20 : Random Index (RI) for Varying Martix Size.

Size of Matrix (N)	Random Average (Random Index) (RI)
1	0
2	0
3	0,58
4	0,9
5	1,12
6	1,24
7	1,32
8	1,41
9	1,45
10	1,49
11	1,51
12	1,48

In Table 6. 21, consistency index (CI), random index (RI), and consistency ratio (CR) of financial performance is given.

Table 6.21 : The Consistency Index (CI), Random Index (RI), and Consistency Ratio (CR) of Financial Performance.

Consistency Index (CI)	Random Index (RI)
0,00005613342154	0,58
Consistency Ratio (CR=CI/RI)	<0,10 (<%10)
0,00009678176127	OK

In this study, the initial pair-wise comparison and group decision matrix, results of solved AHP matrices, calculations about consistency ratio and weighted values were all done in Microsoft Excel platform. In addition, AHP is not used to choose between multiple choices or decisions, but as a part of the methodology to determine the importance weights of a group of factors. However, in the scope of the thesis, in the adaptation of the method, different from the classical applications. It is not primarily for the evaluation of alternatives and selection of the best alternative that meets the criteria but rather is used to determine the relative importance weights of the model components.

The consistency ratio of all pair-wise comparison matrices is less than 0.1 and therefore the feedback of decision makers is consistent. Consistency of all matrices developed as group decision was calculated with MS Office Excel. Consistency calculations for the 2nd level performance dimensions were made according to AHP algorithm. But, as an example total calculations of the AHP process and checking the consistancy for financial performance can be seen at Table 6.22. Finally, the total consistany ratio off all pair-wise comparison matrices is shown at Table 6.23.

Table 6.22 : Field Study A-Consistency ratios of performance measurement model.

Comparison Matrices	Matrix Size	Consistency Ratio
Financial Performance (FP)	3x3	0,00010
Time Performance (TP)	3x3	0,00137
Quality Performance (QP)	3x3	0,01531
Health & Safety Performance (HSP)	3x3	0,00620
Shareholder Satisfaction (SS)	4x4	0,02348
Innovation (IN)	3x3	0,00977
Environmental Performance (EP)	9x9	0,01026
Overall Sustainable Performance (TP)	7x7	0,01943

Table 6.23 : Total calculations of the AHP Process and checking the consistancy for Financial Performance.

STEP1	Group Decision Matrix			STEP 2	Normalized Matrix (Aw)			Relative Importance (Priority) Vector (Wi)	STEP 3	Priority Vector or Weighted Total Vector (D)	Eigen Vector (E)	STEP4				
	1,00	0,58	0,90		0,26	0,26	0,26	0,26		0,78	3,00					
	1,74	1,00	1,51		0,45	0,45	0,44	0,45		1,34	3,00					
	1,11	0,66	1,00		0,29	0,30	0,29	0,29		0,88	3,00		Consistency Index (CI)	Random Index (RI)	Consistency Ratio (CR=CI/RI)	<0,10 (<%10)
SUM	3,85	2,24	3,41	SUM	1,00	1,00	1,00	1,00		LAMDA MAX	3,00		0,00	0,58	0,00	OK

6.1.4.2 Sustainable performance measurement model for urban regeneration projects

According to the results of the Field Study-A, the importance weghts of key performance indicators were obtained and then normalized with arithmetic mean. After that this normalized weights of KPI was multiply with the importance weights of the 3rd level performance criteria and 2nd level performance dimensions. These calculations were made to obtain the importance of KPIs in determining project performance. The importance weights of 135 key performance indicators in the whole model are given in Table 6.25. In this table colum A represents the importance weights of perfromance dimensions in determining project performance (obtained with AHP). Column B represents the importance weights of perfromance criteria in determining project performance (obtained with AHP). Column C represents the normalized importance weights of perfromance criteria in determining project performance (obtained with summation of Column E). Column D represents the normalized importance weights of key performance indicators (by normalizing the significance levels obtained with 7-scale). Finally, Coumn E represents the the importance weights of KPIs in determining project performance (obtained with multiplication of Column A&B&D).

- Health and Safety Performance dimension (HSP) was the most important and decisive dimension in measuring project performance with a weight of 0.2307. Health and Safety was followed by Financial Performance (FP) with a weight of 0.2005 and Environmental Performance with a weight of 0.1882 (EP). The fourth place is Quality Perfromance (QP) with a weight of 0.1458. The weight of these four dimensions in total project performance was 0.7654 (76,54%).
- The importance weight for Time Performance dimension (TP) was 0,1023, for Shareholder Satisfaction dimension (SS) was 0.077, and for Innovation dimension (IN) was 0.0545. The weight of these four dimensions in total project performance was 0.2346 (23,46%).
- Considering the importance weights of performance criteria, HSP-Accident / Injuries (0,1273) and FP2-Cost/Budget Compliance (0,0897) were determined as the most important performance criteria. Two of the five most important performance criteria are belongs to Health and Safety Performance dimension,

while the other two are among the Financial Performance dimension. QP2-Qualty Compliance was the other performance criterion (0.0529) that is placed top five criteria. Other performance criteria are shown in Table 6.24 in order of importance.

Table 6.24 : Importance weights of Level 3 Performance Criteria obtained with AHP.

Importance Weights	**3rd Dimension (Performance Criteria)**	**RANK**
0,127317001	**ACCIDENT/INJURIES (HSP1)**	1
0,089713353	**COST/BUDGET COMPLIANCE (FP2)**	2
0,071009612	**H & S COMPLIANCE (HSP3)**	3
0,05870728	**PROFITABILITY (FP3)**	4
0,052966687	**QUALITY COMPLIANCE (QP2)**	5
0,052145296	**COST/BUDGET ESTIMATION LEVEL (FP1)**	6
0,051353265	**QUALITY IMPACT ON COST (QP1)**	7
0,042554266	**ENERGY (EP5)**	8
0,041544552	**DEFICIENT WORK (QP3)**	9
0,041355326	**VARIANCE/CHANGES IN PROJECT SCHEDULE (TP2)**	10
0,038369078	**COMMUNITY SATISFACTION (SS3)**	11
0,035457574	**PROJECT SCHEDULE ESTIMATION LEVEL (TP1)**	12
0,034517687	**WATER (EP6)**	13
0,032443508	**LOSS OF WORKFORCE (HSP2)**	14
0,02549815	**LEGISLATION/PERMIT DURATION COMPLIANCE (TP3)**	15
0,022166169	**ECOLOGICAL (EP1)**	16
0,022091743	**RESEARCH & DEVELOPMENT (IN1)**	17
0,021333567	**LAND USE (EP3)**	18
0,020428045	**WASTE MANAGEMENT (EP4)**	19
0,017848912	**CUSTOMER SATISFACTION (SS1)**	20
0,016491372	**COMMUNICATION (IN3)**	21
0,015903962	**EDUCATION / TRAINING (IN2)**	22
0,015718551	**INDOOR ENVIRONMENTAL QUALITY (EP8)**	23
0,01205926	**USE OF MATERIAL (EP7)**	24
0,011092354	**EMPLOYEE SATISFACTION (SS2)**	25
0,010450828	**SHAREHOLDER / PARTNER SATISFACTION (SS4)**	26
0,010249614	**DESIGN (EP2)**	27
0,00849416	**COMPLIANCE WITH REGULATIONS (EP9)**	28

Table 6.25 : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,2005659293	**FINANCIAL PERFORMANCE**	0,2599907954	0,0521452955	COST/BUDGET ESTIMATION LEVEL (FP1)	0,1540669856	0,008033868494	Estimation level of design cost
					0,1894736842	0,009880161253	Estimation level of construction cost
					0,1540669856	0,008033868494	Estimation level of cost caused by work orders/variation orders
					0,1961722488	0,01022945988	Estimation level of total project cost
					0,1531100478	0,00798396869	Estimation level of claim/conflict number and cost
					0,1531100478	0,00798396869	Estimation level of reworks' cost
		0,4473010628	0,08971335336	COST/BUDGET COMPLIANCE (FP2)	0,227014756	0,02036625502	Change in total project budget/cost
					0,1816118048	0,01629300402	Change in design cost
					0,2213393871	0,01985709864	Change in construction cost
					0,1861520999	0,01670032912	Change in cost caused by work orders/variation orders
					0,1838819523	0,01649666657	Amount of conflict/claim cost
		0,2927081418	0,05870728048	PROFITABILITY (FP3)	0,3389830508	0,01990077304	Project profit margin
					0,3406779661	0,02000027691	Return on investment (ROI)
					0,3203389831	0,01880623053	Return on equity (ROE)

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,1023110497	**TIME PERFORMANCE**	0,346566421	0,03545757433	PROJECT SCHEDULE ESTIMATION LEVEL (TP1)	0,2756232687	0,009772932537	Estimation level of total project schedule
					0,228531856	0,008103185269	Estimation level of design schedule
					0,2603878116	0,009232720186	Estimation level of construction schedule
					0,2354570637	0,008348736338	Estimation level of delays caused by work orders/variation orders
		0,4042117214	0,04135532552	VARIANCE/CHANGES IN PROJECT SCHEDULE (TP2)	0,2721088435	0,0112531498	Changes in total project schedule
					0,2421768707	0,01001530332	Number of revisions in design schedule
					0,2517006803	0,01040916357	Number of revisions in construction schedule
					0,2340136054	0,00967770883	Total delays caused by work orders/variation orders
		0,2492218576	0,02549814986	LEGISLATION/PERMIT DURATION COMPLIANCE (TP3)	0,3307692308	0,008434003415	Duration of the pre-construction documentation preparation
					0,3365384615	0,008581108126	Duration of formal approval process
					0,3326923077	0,008483038318	Duration of post-construction formal process
0,1458645031	**QUALITY PERFORMANCE**	0,3520614237	0,05135326463	QUALITY IMPACT ON COST (QP1)	0,5254237288	0,02698222379	Cost overrun due by low quality
					0,4745762712	0,02437104084	Saving from improvement of quality
		0,3631225252	0,05296668672	QUALITY COMPLIANCE (QP2)	0,3551401869	0,01881059902	Compliance with standards
					0,3196261682	0,01692953912	Number of complaint/conflicts related with quality
					0,3252336449	0,01722654858	Level/success of project monitoring system
		0,2848160511	0,04154455177	DEFICIENT WORK (QP3)	0,4932975871	0,02049382715	Number of deficient works
					0,5067024129	0,02105072462	Cost of completion the deficient work

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,2307701211	**HEALTH & SAFETY (H & S) PERFORMANCE**	0,5517048745	0,1273170007	ACCIDENT/INJURIES (HSP1)	0,359430605	0,04576162659	Number of fatal/severe accidents
					0,3327402135	0,042363486	Number of injuries
					0,3078291815	0,03919188812	Number of occupational diseases
		0,1405879929	0,03244350815	LOSS OF WORKFORCE (HSP2)	0,5147058824	0,01669886449	Number of days with absenteeism due to accidents/injuries
					0,4852941176	0,01574464366	Number of days with absenteeism due to occupational disease
		0,3077071326	0,07100961225	H & S COMPLIANCE (HSP3)	0,1501597444	0,01066278523	Compliance with H & S Standards
					0,1405750799	0,009982181913	Number of complaints related with H & S
					0,1405750799	0,009982181913	Presence of H & S organization
					0,1437699681	0,01020904968	Number of corrective measures for risks
					0,1365814696	0,0096985972	Number of H & S training
					0,1453674121	0,01032248357	Number of appropriate signage for safety and wayfinding
					0,142971246	0,01015233274	Total paid compensation

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,07776117199	**STAKEHOLDER SATISFACTION**	0,2295350125	0,01784891159	CUSTOMER SATISFACTION (SS1)	0,2387843705	0,004262041117	Number of awards (Design, Construction, H &S, Quality, etc.)
					0,2575976845	0,004597838296	Number of customer's complaints
					0,2518089725	0,004494516087	Number and cost of disputes/conflicts/court
					0,2518089725	0,004494516087	Duration of dispute resolution
		0,1426464383	0,01109235423	EMPLOYEE SATISFACTION (SS2)	0,2594752187	0,002878191038	Number of employees' complaints
					0,2682215743	0,002975208714	Level of salary with respect to industry
					0,2448979592	0,002716494913	Level of social integration at work
					0,2274052478	0,002522459562	Level/Number of recreational opportunities
		0,4934220672	0,03836907823	COMMUNITY SATISFACTION (SS3)	0,07054296708	0,002706668623	Level of consultation activities with the local community
					0,07652843095	0,002936325354	Level of increase in life quality and urban prosperity
					0,07139803335	0,002739476727	Level of access to social services
					0,07353569902	0,002821496988	Level of identification of community needs, goals, plans and issues
					0,07567336469	0,00290351725	Level of generating new jobs or increasing the existing business, entertainment and cultural capacity for the public
					0,06755023514	0,002591840257	Level of improvement the community productivity
					0,06926036768	0,002657456466	Level of contribution to local employment, training, and education, with emphasis on the neediest and/or disadvantaged groups
					0,07567336469	0,00290351725	Level/number of activities to prevent pollution/complaint of construction activities
					0,07225309962	0,002772284832	Level of reduction of traffic disruption during construction and operation
					0,07225309962	0,002772284832	Level of net positive impact on public safety and security

6.1.5 Opinions and suggestions of participants (Field Study A-Part V)

In the last part of Field Study A, the participants were asked their opinions and suggestions. Among the responses received, following statements are recorded as positive evaluations:

1) “A sustainable performance measurement model that takes into account the characteristics of urban transformation projects will serve many successful projects.”,

2) “Each dimension, criteria and key performance indicators in the model covers almost every aspect that needs to be considered in an urban transformation project.”,

3) “The model make increase on social awareness and meets the need for sustainable performance model both in sector and academy.”,

4) “There is a need for a general performance measurement model which is composed of internationally validated standards and regulations and that the developed model meets this need to a large extent.”.

Negative evaluations are that the questionnaire is very long because it is prepared to evaluate many subjects from different angles. Therefore, the evaluations were long and sometimes difficult. This limit of Field Study A has been exceeded by providing detailed information about the model components through face-to-face interviews with the participants. As a matter of fact, the model was completed withcompleted data from 32 people.

General Evaluation

With the Field Study-A;

(1) determination of current practices about performance measurement and benchmarking for urban regeneration projects,

(2) the weights of level 4 key performance indicators of the model,

(3) the relative importance weights of the performance dimensions (level 2) and performance criteria (level 3) of the sustainable performance measurement model were determined.

Thus, the model is ready for validation and testing.

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,07776117199	**STAKEHOLDER SATISFACTION**	0,4934220672	0,03836907823	COMMUNITY SATISFACTION (SS3)	0,06840530141	0,002624648361	Level of identification/enhancement/restoring historic and cultural resources
					0,06968790081	0,002673860518	Number /level of satisfaction of added public spaces (e.g., parks, plazas, recreational facilities, or accessible space in wildlife refuges)
					0,06712270201	0,002575436204	Number of applied policies
					0,07011543395	0,00269026457	Number of jobs proposed
		0,1343964819	0,01045082795	SHAREHOLDER / PARTNER SATISFACTION (SS4)	0,4918478261	0,005140217006	Satisfaction level of project shareholders
					0,5081521739	0,00531061094	The ratio of company net profit to project net profit
0,05448707831	**INNOVATION**	0,4054492215	0,02209174349	RESEARCH & DEVELOPMENT (IN1)	0,3447619048	0,007616391564	Number of new technologies applied
					0,3371428571	0,007448073518	Number of new technologies/practices developed in the project
					0,3180952381	0,007027278404	Level of solutions to problem, barriers, limitations
		0,2918850272	0,01590396234	EDUCATION / TRAINING (IN2)	0,199057715	0,003165806402	Total training hour
					0,1978798587	0,00314707382	Number of on-site trainings
					0,1861012956	0,002959747997	Number of off-site training
					0,2049469965	0,003259469313	Change in productivity after trainings
					0,2120141343	0,003371864807	Change in defect number after trainings
		0,3026657512	0,01649137249	COMMUNICATION (IN3)	0,2795216741	0,004609696047	Stakeholder communication level
					0,2122571001	0,003500410902	Number of surveys attended
					0,2496263079	0,004116680427	Level of information exchange and feedback mechanism
					0,2585949178	0,004264585113	Number and duration of response to feedback

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,1882401464	**ENVIRONMENTAL PERFORMANCE**	0,1177547387	0,02216616925	ECOLOGICAL (EP1)	0,3344768439	0,007414070333	Level of protection or restoration of habitat
					0,3413379074	0,007566153827	Total carbon emissions
					0,3241852487	0,007185945092	Ecological footprint
		0,05444967066	0,01024961398	DESIGN (EP2)	0,3302411874	0,00338484469	Level of esthetic design
					0,3302411874	0,00338484469	Level of landscape design
					0,3395176252	0,003479924597	Level of integrated design policies
		0,1133316529	0,02133356693	LAND USE (EP3)	0,08829926055	0,001883738185	Level of effective site selection
					0,08438451501	0,001800222699	Preservation level of high value landscapes and its features
					0,08960417573	0,00191157668	Level of access to public transportation and public facilities
					0,08568943019	0,001828061194	Alternative transportation opportunities
					0,07872988256	0,001679589219	Level of compact development
					0,08003479774	0,001707427714	Provision of open spaces
					0,08090474119	0,001725986711	Level of regularization of population density/urban development
					0,07742496738	0,001651750724	Number of housing stock
					0,08003479774	0,001707427714	Level of increase in existing reconstruction rights
					0,08003479774	0,001707427714	Number of storm water management measures
					0,08742931709	0,001865179188	Land pollution reduction
					0,08742931709	0,001865179188	Level of accessibility

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	**2nd Dimension (Performance Dimension)**	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	**3rd Dimension (Performance Criteria)**	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	**4th Dimension (Performance Indicators)**
0,1882401464	**ENVIRONMENTAL PERFORMANCE**	0,1085211935	0,02042804536	WASTE MANAGEMENT (EP4)	0,1747572816	0,003569949674	Design for minimum waste
					0,1641659312	0,003353589088	Provision of construction waste management plan
					0,1668137688	0,003407679234	Ratio of recycled/reused waste
					0,1615180936	0,003299498941	Identification and reuse of unwanted by-products/discarded materials
					0,1676963813	0,003425709283	Storage and collection of recyclables
					0,1650485437	0,003371619137	Ratio of recycled or salvaged material
		0,2260637111	0,04255426608	ENERGY (EP5)	0,1325782811	0,005641771452	Building energy performance certificate level (EPC)
					0,1279147235	0,00544331718	Provision of building energy model
					0,1312458361	0,005585070232	Building energy efficiency level (Performance or prescripted)
					0,1225849434	0,005216512298	Utilization level of renewable energy
					0,1165889407	0,004961356805	Level of measurement and verification system applied
					0,1199200533	0,005103109856	Application level of building commissioning
					0,1225849434	0,005216512298	Provision of green power
					0,1265822785	0,005386615959	Reduction level the net embodied energy
		0,1833704835	0,03451768667	WATER (EP6)	0,2557544757	0,008828052856	Level of reduction of water pollution (Negative impact on water)
					0,2621483376	0,009048754177	Total water use reduction
					0,2480818414	0,00856321127	Provision of water efficient landscaping
					0,2340153453	0,008077668363	Number of innovative wastewater technologies applied

Table 6.25 (continued) : The importance weights of the sustainable performance measurement model for urban transformation projects with AHP.

Column A: Importance Weights of Performance Dimensions	2nd Dimension (Performance Dimension)	Column B: Importance Weights of Performance Criteria	Column C: Normalized Importance Weights of Performance Criteria	3rd Dimension (Performance Criteria)	Column D: KPI_Normalized	Column E: Importance Weights of Performance Indicators	4th Dimension (Performance Indicators)
0,1882401464	**ENVIRONMENTAL PERFORMANCE**	0,0578654869	0,0120592603	USE OF MATERIAL (EP7)	0,2076502732	0,00226185297	Quantity of environmentally preferable materials used
					0,2010928962	0,002190426034	Regional material usage level
					0,2010928962	0,002190426034	Material reuse level
					0,2010928962	0,002190426034	Level of building life cycle impact reduction
					0,1890710383	0,002059476652	Number of materials with EPDs
		0,09351899926	0,01571855075	INDOOR ENVIRONMENTAL QUALITY (EP8)	0,1071049841	0,001166652577	Indoor air quality level
					0,09703075292	0,001708132296	Application of indoor air quality strategies
					0,0980911983	0,001726800409	Low-emmisioning materials used
					0,09756097561	0,001717466353	Provision of construction IAQ plan
					0,1012725345	0,001782804746	Compliance level with daylight design requirement
					0,09650053022	0,00169879824	Compliance level with lighting design standard
					0,1033934252	0,001820140971	The chemical and pollutant source control level
					0,09384941676	0,001652127959	Building acoustic standards/requirements compliance level
					0,098621421	0,001736134465	Noise pollution reduction level
					0,1065747614	0,001876145309	Air pollution prevention level
		0,04512406348	0,008494160317	COMPLIANCE WITH REGULATIONS (EP9)	0,2527322404	0,002146748167	Level of compliance with property rights
					0,2445355191	0,002077123903	Number of reported environmental issues/disputes
					0,25	0,002123540079	Level of compliance with legal requirements
					0,2527322404	0,002146748167	Number of actions to improve sustainable performance

6.2 Field Study B - Statistical Procedure and Analysis

Field Study-B was conducted to investigate the validity and suitability of the model. In addition, this study was used to obtain statistically significant quantitative evidence.

Descriptive statistics, frequency analysis and hypothesis tests were used for a single population average. In other words, Student's t-distribution parametric test was used in statistical analysis. In the evaluation of normality of data, Kolmogrov-Smirnov test with SPSS 15 software was used, and Cronbach's Alpha method statistical analysis procedures were used where reliability levels were examined.

Responses from the sample within the scope of Field Study-B Appendix E.1. The tables related to the statistical analyzes performed in the Field Study-B are given in the subsections. Ms Office Excel program outputs are given in Appendix E.2 for the analysis of the 6th question and in Appendix E.3 for the analysis of the question 7.

6.2.1 Analysis and findings of the participants (Field Study B-Part I)

The sample for Field Study-B is composed of 35 participants who participated in the Field Study A and who did not participate in the Field Study A. The data of 21 managers who answered the questionnaire were analyzed and the findings are shown in following Tables. In this thesis, Field Study B took 1 month to complete. Since there were no missing data in the questionnaires in the study, no analyzes were conducted due to missing data. Field Study-B response rate calculated as 60,00% (21/35).

Field Study-B response rate is 18.1%. The answers of the participants to questions 1, 2, 3, 4,5 are given in Appendix E.1 and answers to questions 6 and 7 are given in Appendix E.2 and Appendix E.3.

In this section, the findings obtained by means of descriptive statistics related to the respondents who participated in urban transformation projects / construction industry and answered the questionnaire are given. The working time of the respondent in the sector and urban regeneration projects was questioned as this would increase the significance and reliability of the evaluations regarding the project performance. The findings of the participants' years of experience in the sector and in the urban regeneration projects are summarized in Tables 6.26, 6.27 and 6.28.

Table 6.26 : Findings on the expertise of the participants.

Profession	N	%	Valid	Cumulative
Architect	8	38,10	38,10	38,10
Civil Engineer	7	33,33	33,33	71,43
Mechanical Engineer	3	14,29	14,29	85,71
Landscape Architect	1	4,76	4,76	90,48
Geomatic Engineer	1	4,76	4,76	95,24
HVAC Technician	1	4,76	4,76	100,00
Total	21	100,00	100,00	

The distribution of participants in terms of expertise is as follows: 8 (38,10%) are architects; 7 (33,33%) are civil engineers; 3 (14,29%) are mechanical engineers; 3 (14,29%) are from other fields of expertise (1 landscape architect, 1 geomatics engineer, 1 technician and 1 urban and rregional planner). When the findings are examined, it is seen that the participants have a high proportion of architects and civil engineering backgrounds. The findings also show that the participants were selected to cover almost all disciplines in the perspective of urban transformation (See Table 6.26).

Table 6.27 : Findings of participants' experience in the construction sector.

Experience in the construction sector	N	%	Valid	Cumulative
<5 years	7	33,33	33,33	33,33
5-10 years	6	28,57	28,57	61,90
10-15 years	1	4,76	4,76	66,67
15-20 years	3	14,29	14,29	80,95
20-25 years	2	9,52	9,52	90,48
>25 years	2	9,52	9,52	100,00
Total	21	100,00	100,00	

Among the participants who answered the questionnaire, 7 of them (33,33%) have under 5 years experience; 6 of them (28,57%) have experience between 5-10 years; one of them (4,76%) 10-15 years experience; 3 of them (14,29%) have experience between 15-20 years; 2 of them (9,52%) are experiened between about 20-25 years and similarly 2 of them (9,52%) have been working in the construction sector for more than 25 years (See Table 6.27).

Table 6.28 : Findings of participants' experience in the urban regeneration projects.

Experience in the urban regeneration projects	N	%	Valid	Cumulative
<5 years	14	66,67	66,67	66,67
5-10 years	3	14,29	14,29	80,95
10-15 years	3	14,29	14,29	95,24
15-20 years	1	4,76	4,76	100,00
20-25 years	0	0,00	0,00	100,00
>25 years	0	0,00	0,00	100,00
Total	21	100,00	100,00	

The experts who answered the questionnaire had the following experiences in urban transformation projects: 14 of them (66,67%) have under 5 years experience; 3 of them (14,29%) have experience between 5-10 years; similarly 3 of them (14,29%) 10-15 years experience; one of them (4,76%) have experience between 15-20 years; and none of them are experiened between about 20-25 yaers and more than 25 years (see Table 6.27).

The experience of the experts who answered the questionnaire in urban regeneration projects is 5 years in average and 10 years in construction sector. When the validation of the sustainable project performance measurement model for urban regeneration projects is considered, the experiences and knowledge of the participants are supportive.

6.2.2 The validity of the sustainable performance measurement model (Field Study B-Part II)

Descriptive statistics calculated for the sixth question of Field Study-B are given in Table 6.29. In question 6, experts were asked to evaluate the performance dimensions and performance criteria that constitute the performance measurement model and their importance in measuring project performance.

From this value, the arithmetic mean and standard deviation were used to calculate the confidence interval according to the t-distribution. In this section, the coefficient of variation as a measure of proportional variability is also calculated. The coefficient of variance which shows the relationship between standard deviation and aritmetic means, is obtained by dividing the standard deviation of any series by the arithmetic mean and multiplying by 100.

It can be said that the series with small coefficients of variation are less variable than the others. This means that the series are distributed more homogeneously around the arithmetic mean. When the coefficient of variation is greater than 30%, the degree of predicting the integrity of the data is poor (Kan, 2006). Most of the coefficients obtained in Table 6.29 is lower than 30%. This is evidence that the data is good at predicting the truth.

In question 7, experts were asked to evaluate the model developed for the purpose of measuring sustainable project performance according to the scale given below, ranging from 1-5 according to usability, practicality and applicability criteria.

Student-t test (single sample t test) was used for Field Study B-6th and 7th questions. The normality assessment for Field Study-B-6th and 7th questions was performed by Kolmogrov-Smirnov test. The normality test was searched as a prerequisite since the data obtained according to t-distribution were wanted to be analyzed.

In the tests, it was stated that the data came from a normally distributed population by the H0 hypothesis, while the distribution of the population was not normal by the H1 hypothesis, and tested by the Kolmogrov-Smirnov (KS) test z value and its significance level (asymp. Sig.) $p<0.05$ (Field, 2000).

Table 6.29 : Descriptive statistics of Field Study-B/6th question.

No	Field Study B-Question 6	Arithmetic Mean	Standard Deviation	Coefficient of Variance	Min	Max	Mod	Median
1	**FINANCIAL PERFORMANCE (FP)**	5,905	0,831	0,141	4	7	6	6
1.1	Cost/Budget Estimation Level	5,143	1,153	0,224	3	7	5	5
1.2	Cost/Budget Compliance	5,429	0,978	0,180	4	7	5	5
1.3	Profitability	5,762	1,044	0,181	3	7	6	6
2	**TIME PERFROMANCE (TP)**	5,714	1,007	0,176	4	7	6	6
2.1	Project Schedule Estimation Level	5,524	1,030	0,187	4	7	6	6
2.2	Variance/Changes in Project Schedule	5,238	1,091	0,208	3	7	5	5
2.3	Legislation/Permit Duration Compliance	5,381	1,244	0,231	3	7	6	6

Table 6.29 (continued) : Descriptive statistics of Field Study-B/6th question.

No	Field Study B-Question 6	Arithmetic Mean	Standard Deviation	Coefficient of Variance	Min	Max	Mod	Median
3	**QUALITY PERFORMANCE (QP)**	5,381	1,024	0,190	3	7	6	6
3.1	Quality Impact on Cost	5,286	1,056	0,200	4	7	5	5
3.2	Quality Compliance	5,095	1,091	0,214	3	7	6	5
3.3	Deficient Work	5,476	1,123	0,205	3	7	6	6
4	**HEALTH & SAFETY (H & S) PERFORMANCE (HSP)**	5,810	1,327	0,228	3	7	7	6
4.1	Accident/Injuries	6,095	1,091	0,179	3	7	7	6
4.2	Loss of Workforce	5,190	1,537	0,296	2	7	5	5
4.3	H & S Compliance	5,476	1,470	0,268	2	7	7	6
5	**STAKEHOLDER SATISFACTION (SS)**	5,571	1,121	0,201	3	7	5	6
5.1	Customer Satisfaction	5,429	1,165	0,215	4	7	4	5
5.2	Employee Satisfaction	5,238	1,446	0,276	2	7	5	5
5.3	Community Satisfaction	5,381	1,431	0,266	3	7	7	5
5.4	Shareholder / Partner Satisfaction	5,762	1,091	0,189	3	7	6	6
6	**INNOVATION (IN)**	4,524	1,601	0,354	1	7	4	4
6.1	Research & Development	4,905	1,179	0,240	2	7	4	5
6.2	Education/Training	4,762	1,546	0,325	2	7	5	5
6.3	Communication	4,619	1,396	0,302	2	7	4	4
7	**ENVIRONMENTAL PERFORMANCE (EP)**	5,714	1,419	0,248	2	7	7	6
7.1	Ecological	5,524	1,289	0,233	3	7	7	6
7.2	Design	5,095	1,895	0,372	1	7	7	6
7.3	Land Use	5,381	1,284	0,239	3	7	5	5
7.4	Waste Management	5,571	1,399	0,251	2	7	6	6
7.5	Energy	6,143	1,195	0,195	3	7	7	7
7.6	Water	6,190	1,030	0,166	3	7	7	6
7.7	Use of Material	5,381	1,322	0,246	3	7	5	5
7.8	Indoor Environment Quality	5,810	1,078	0,186	4	7	7	6
7.9	Compliance with Regulations	5,333	1,197	0,224	2	7	6	5

Table 6.30 : Normal distribution test of performance dimensions (according to individual evaluations) (Field Study-B, question 6).

Performance Dimensions	N	Kolmogorov-Smirnov (Z)	asymp. Sig. (p)
FP-FINANCIAL PERFORMANCE	21	0.99	0.33
TP-TIME PERFORMANCE	21	0.86	0.40
QP-QUALITY PERFORMANCE	21	0.61	0.70
HSP-HEALTH & SAFETY (H & S) PERFORMANCE	21	0.57	0.73
SS-STAKEHOLDER SATISFACTION	21	0.78	0.46
IN-INNOVATION	21	0.64	0.68
EP-ENVIRONMENTAL PERFORMANCE	21	0.96	0.37

Although the data obtained were largely normal, the normality test were done once again by the sum of the evaluations made for the performance criteria (See Table 6.30). All dimensions of the performance measurement model have normal distribution according to Kolmogrov-Smirnov (KS) test z value based on the total scores of performance criteria. ($p > 0.05$). These procedures were performed to provide the assumption of normality for the t test to be applied in the next steps.

Table 6.31 : Normal distribution test of performance dimensions (according to performance criteria total) (Field Study- B, question 6).

Performance Dimensions	N	Kolmogorov-Smirnov (Z)	asymp. Sig. (p)
FP-FINANCIAL PERFORMANCE	21	0.83	0.42
TP-TIME PERFORMANCE	21	0.75	0.48
QP-QUALITY PERFORMANCE	21	0.37	0.88
HSP-HEALTH & SAFETY (H & S) PERFORMANCE	21	0.47	0.79
SS-STAKEHOLDER SATISFACTION	21	0.59	0.72
IN-INNOVATION	21	0.90	0.38
EP-ENVIRONMENTAL PERFORMANCE	21	0.51	0.77

Kolmogrov-Smirnov (KS) test and normality test results are shown in Table 6.32 Performance dimensions present normal distribution according to KS test z value and related significance level (asymp.Sig.) $p > 0,05$.

Table 6.32 : Normal distribution test of performance criteria (Field Study-B, Question 6).

Performance Criteria	N	Kolmogorov-Smirnov (Z)	asymp. Sig. (p)
FP1-Cost/Budget Estimation Level	21	0.71	0.55
FP2-Cost/Budget Compliance	21	0.65	0.68
FP3-Profitability	21	0.53	0.75
TP1-Project Schedule Estimation Level	21	0.87	0.41
TP2-Variance/Changes in Project Schedule	21	0.59	0.72
TP3-Legislation/Permit Duration Compliance	21	0.99	0.38
QP1-Quality Impact on Cost	21	0.51	0.77
QP2-Quality Compliance	21	0.95	0.37
QP3-Deficient Work	21	0.36	0.88
HSP1-Accident/Injuries	21	0.65	0.68
HSP2-Loss of Workforce	21	0.44	0.8
HSP3-H & S Compliance	21	0.76	0.46
SS1-Customer Satisfaction	21	0.54	0.75
SS2-Employee Satisfaction	21	0.88	0.39
SS3-Community Satisfaction	21	0.53	0.75
SS4-Shareholder / Partner Satisfaction	21	0.66	0.68
IN1-Research & Development	21	0.39	0.86
IN2-Education/Training	21	0.88	0.39
IN3-Communication	21	0.97	0.36
EP1- Ecological	21	0.99	0.38
EP2-Design	21	0.51	0.77
EP3-Land Use	21	0.95	0.37
EP4-Waste Management	21	0.36	0.88
EP5-Energy	21	0.61	0.7
EP6-Water	21	0.74	0.47
EP7-Use of Material	21	0.93	0.38
EP8-Indoor Environment Quality	21	0.58	0.72
EP9-Compliance with Regulations	21	0.41	0.82

The t-distribution test was selected as the test procedure for testing the hypotheses. The hypotheses were developed to evaluate performance dimensions, performance criteria and the the key performance indicators.

Student’s T distribution also allows to work with small samples.T-test is an analysis method developed to test the hypothesis whether the mean value of a group differs from the predetermined value in terms of a studied variable (Tekçe, 2010).

In this study, one-sample t-test was used since it was a single sample. The sample size is ($n < 30$) and it is assumed that the data largely conforms to normal distribution conditions. In the test with one sample t-distribution test, the hypotheses based on the data in question 6 were generated as follows.

H0: The arithmetic means obtained from the sample for performance dimensions and performance criteria are equal to the population mean.

$$H_0: X = \mu = 4$$

H1: The arithmetic means obtained from the sample for performance dimensions and performance criteria are different from the population mean.

$$H_1: X \neq \mu \neq 4$$

The significance level of all performance dimensions constituting the model was found to be equal or above the value of 4 = Important (95% confidence at 5% significance level ($p < 0.05$)). In the assessment by experts following evaluation system was used: 1 = Not important (2 and 3 intermediate values) 4 = Important (5 and 6 intermediate values) 7 = Most important.

This result indicates that all performance dimensions are equal or above the value of 4 = Important for project performance. Also that qualitative support was provided for the validity of the model.

The results of the one sample t test for whether the performance dimensions are equal or above the importance level of 4= importance are given in Table 6.33. In addition, the results of the one sample t test for whether the performance criteria are equal or above the importance level of 4= importance are given in Table 6.34.

Table 6.33 : One-Sample T Test for performance criteria (Field Study-B, Question 6).

Performance Criteria	N	Arithmetic Mean	t-stat	asymp. Sig. (p)
FP1-Cost/Budget Estimation Level	21	5.143	5,93	0.000
FP2-Cost/Budget Compliance	21	5.429	8.13	0.000
FP3-Profitability	21	5.762	9.30	0.000
TP1-Project Schedule Estimation Level	21	5.524	5.18	0.000
TP2-Variance/Changes in Project Schedule	21	5.238	17.35	0.000
TP3-Legislation/Permit Duration Compliance	21	5.381	13.11	0.000
QP1-Quality Impact on Cost	21	5.286	6.09	0.000
QP2-Quality Compliance	21	5.095	8.37	0.000
QP3-Deficient Work	21	5.476	6.15	0.000
HSP1-Accident/Injuries	21	6.095	6.58	0.000
HSP2-Loss of Workforce	21	5.190	21.7	0.000
HSP3-H & S Compliance	21	5.476	6.11	0.000
SS1-Customer Satisfaction	21	5.429	6.13	0.000
SS2-Employee Satisfaction	21	5.235	17.2	0.000
SS3-Community Satisfaction	21	5.37	6.10	0.000
SS4-Shareholder / Partner Satisfaction	21	5.760	6.5	0.000
IN1-Research & Development	21	4.905	7.85	0.000
IN2-Education/Training	21	4.762	5.67	0.000
IN3-Communication	21	4.619	5.56	0.000
EP1- Ecological	21	5.53	6.18	0.000
EP2-Design	21	5.095	5.90	0.000
EP3-Land Use	21	5.382	6.11	0.000
EP4-Waste Management	21	5.571	6.26	0.000
EP5-Energy	21	6.143	5.62	0.000
EP6-Water	21	6.190	9.65	0.000
EP7-Use of Material	21	5.381	12.11	0.000
EP8-Indoor Environment Quality	21	5.810	17.37	0.000
EP9-Compliance with Regulations	21	5.333	7.08	0.000

Table 6.34 : One-Sample T Test for performance dimensions (Field Study-B, Question 6).

Performance Dimensions (according to individual evaluations)	N	Arithmetic Mean	T-Statistic	asymp. Sig. (p)
FP-FINANCIAL PERFORMANCE	21	5,905	7.8	0.00
TP-TIME PERFORMANCE	21	5,714	8.5	0.00
QP-QUALITY PERFORMANCE	21	5,381	6.75	0.00
HSP-HEALTH & SAFETY (H & S) PERFORMANCE	21	5,810	11.41	0.00
SS-STAKEHOLDER SATISFACTION	21	5,571	10.54	0.00
IN-INNOVATION	21	4,524	6.2	0.00
EP-ENVIRONMENTAL PERFORMANCE	21	5,714	7.5	0.00

In the seventh question, since the 5-point Likert scale was used in the hypothesis tests. “3 = moderately useful / moderately practical / moderately applicable” assessment was used as the threshold value for the model's usability, practicality and applicability criteria.

The hypotheses for Question 7 are as follows:

H0: For the evaluation criteria of the sustainable performance measurement model, The arithmetic means obtained from the sample are equal to the population mean.

$$H_0 : X = \mu = 3$$

H1: For the evaluation criteria of the sustainable performance measurement model, The arithmetic means obtained from the sample are different from the population mean.

$$H_1 : X \neq \mu \neq 3$$

Descriptive statistics calculated for question 7 are given in Table 6.35. None of the coefficients obtained in Table 6.35 is greater than 30%.

Table 6.35 : Descriptive Statistics of Field Study-B/7. Question.

Field Study B-Question 7	Arithmetic Mean	Standard Deviation	Coefficient of Variance	Min	Max	Mod	Median
Usability	4,667	0,577	0,124	3	5	5	5
Practicability	4,190	0,750	0,179	3	5	4	4
Applicability	4,381	0,498	0,114	4	5	4	4

Table 6.36 : Normal distribution test of validation criteria (according to individual evaluations) (Field Study-B, question 7).

Field Study B-Question 7	**N**	**Kolmogorov-Smirnov (Z)**	**asymp. Sig. (p)**
Usability	21	0.74	0.54
Practicability	21	0.52	0.78
Applicability	21	0.58	0.75

According to Kolmogorov-Smirnov test z value, all validation criteria can be claimed to present normal distribution. ($p > 0.05$).

Table 6.37 : One-Sample T Test For Validation Criteria (Field Study-B, Question 7).

Validation Criteria	**N**	**Arithmetic Mean**	**T-Test**	**asymp. Sig. (p)**
Usability	21	4,667	8.65	0.00
Practicability	21	4,190	9.12	0.00
Applicability	21	4,381	7.60	0.00

The significance level of all performance dimensions constituting the model was found to be equal or above the value of 3 = moderately useful / moderately practical / moderately applicable (95% confidence at 5% significance level ($p < 0.05$)). In the assessment by experts following evaluation system was used: 1: Not useful / Not practical / Not applicable 2: Less useful / Less practical / Less applicable 3: moderately useful / moderately practical / moderately applicable 4: Useful / practical / applicable 5: Very useful / very practical / Applicability is very high.

As a result, the model was evaluated by experts as useful, practical and applicable in measuring sustainable performance for urban regeneration projects.

Table 6.38 : Reliability Test For Performance Measurement Model Validaion Criteria.

Validation Criteria	**Cronbach's Alpha**	**N of Items**
Total	0.788	3

Cronbach's Alpha test for performance measurement model and total evaluation for validation criteria is shown in Table 6.38. The overall reliability value for all evaluation criteria indicated by Cronbach's Alpha coefficient is 0.788 which represents a moderately reliable result. ($0.60 \leq 0.788 < 0.80$)

6.2.3 Comments and suggestions for the sustainable performance measurement model (Field Study B-Part III)

Unfortunately, only one comment and suggestion has been obtained for Field Study B. The comment is stated as follows: “Very unfortunately, urban regeneration projects and processes are not applied in Turkey, especially in Istanbul. From the period of urban regeneration projects have been started, many unnamed, unknown, inexperienced contractors have been popped-up, most of them have been lost during time. I believe, before the structuring of a performance measurement model, a strong, rigid and political-free law shall be constructed first.”.

6.3 Field Study C - Statistical Procedure and Analysis

Field Study-C was conducted to test the sustainable performance measurement model for the developed urban regeneration projects. The performance of 3 urban regeneration projects was measured using the developed sustainable performance measurement model and the success of the model in measuring performance was evaluated.

All responses received in Field Study C are given in Appendix F.1 and F.2. The the coefficient of varince was calculated: the percentage value of standard deviation / the arithmetic mean (Özdamar, 1999). In the analyzes in this section, the coefficient of variation was calculated to test the model. When the coefficient of variation is> 30, the results obtained from the data are so reliable (Kan, 2006).

6.3.1 Properties of the sample group

In order to test the model, 3 urban regeneration projects were used to measure performance using model components. Data was collected through a questionnaire.

The experts who submitted the questionnaire were 5 people and 3 of them work within the same company. These 3 expert evaluated the their urban regeneration project together and they they obtained their results unanimously. The questionarie form of Firld Study C is given at Appendix F.1.

Table 6.39 : Findings on the expertise of the participants.

Profession	N	%	Valid	Cumulative
Architect	1	20,00	20,00	20,00
Civil Engineer	3	60,00	60,00	80,00
Computer Engineer	1	20,00	20,00	100,00
Total	5	100,00	100,00	

The distribution of participants in terms of expertise is as follows: 1 (20,00%) is an architect; 3 (60,00%) are civil engineers; and one (20,00%) of them is computer engineer. 2 of the civil engineers and architect are from the same company and project. (See Table 6.39).

Table 6.40 : Findings of participants' experience in the construction sector.

Experience in the construction sector	N	%	Valid	Cumulative
<5 years	1	20,00	20,00	20,00
5-10 years	1	20,00	20,00	40,00
10-15 years	1	20,00	20,00	60,00
15-20 years	0	0,00	0,00	60,00
20-25 years	2	40,00	40,00	100,00
>25 years	0	0,00	0,00	100,00
Total	5	100,00	100,00	

Among the participants who answered the questionnaire, one of them (20,00%) have under 5 years experience; one of them (20,00%) have experience between 5-10 years; one of them (20,00%) 10-15 years experience; 2 of them (40,00%) are experiened between about 20-25 years (See Table 6.40).

Table 6.41 : Findings of participants' experience in the urban regeneration projects.

Experience in the urban regeneration projects	N	%	Valid	Cumulative
<5 years	2	40,00	40,00	40,00
5-10 years	0	0,00	0,00	40,00
10-15 years	1	20,00	20,00	60,00
15-20 years	2	40,00	40,00	100,00
20-25 years	0	0,00	0,00	100,00
>25 years	0	0,00	0,00	100,00
Total	5	100,00	100,00	

The experts who answered the questionnaire had the following experiences in urban regeneration projects: 2 of them (40,00%) have under 5 years experience; one of them (20,00%) have experience between 10-15 years experience; two of them (40,00%) have experience between 15-20 years (see Table 6.41).

The first project is an urban regeneration project located in Fenerbahçe / Kadıköy (İstanbul). The duration of the project is 18 months. The total cost of this project, which has 30 employees, is 6.5 million TL. Second project is located at Babaeski (Kırklareli) and it is expected to last 12 months. The total cost of this project is 1 million TL. there are 20 employees in this project. Third and last project The last project is more comprehensive and is located in Küçükbakkalköy-Ataşehir (Istanbul). The project duration is 36 months and 70 employees taking apart. The cost of the project is approximately 10 million TL. As can be seen, project durations, costs, number of employees and locations have been tried to be selected relatively differently and evaluated.

6.3.2 Testing the sustainable performance measurement model

Using the performance measurement model, two of the three projects (Project 1 and Project 2) were based on Level 3 performance criteria (28); one of them (Project 3) was based on Level 4 key performance indicators (135) scores were evaluated.

Making the evaluations based on KPIs are largely time consuming, because of that only one project was evaluated according to KPIs. From the experts, the receivings were obtained by 5 point Likert scale.

In addition, a total performance of the project were asked to determine. The performance scores of the projects are multiplied by the importance scores of different levels for obtaining the total project performance score. The total performance score and the calculated performance scores then banchmarked for determining the success of the model. MS Office Excel Program was used for data analysis.

3 urban regeneration projects tested by the sustainable performance measurement model. The calculated weighted performance scores which is based on Level 3 performance criteria are given in this section for follow-up and guidance.

As shown in Table 6.42 average project performance (1: Very Poor 2: Poor 3: Average 4: Good 5: Excellent) was measured as the corresponding 3,72 value. Also, standard deviation and coefficient of cariance are given in Table 6.42.

Table 6.42 : The weighted performance scores for the 3rd level performance criteria of 3 urban regeneration projects.

	3rd Dimension (Performance Criteria)	Project #1- Criteria Performance Score	Project #2- Criteria Performance Score	Project #3- Criteria Performance Score	Arithmetic Mean	Standard Deviation	Coefficient of Variance
1	COST/BUDGET ESTIMATION LEVEL (FP1)	0,209	0,209	0,209	0,209	0,000	0,000
2	COST/BUDGET COMPLIANCE (FP2)	0,359	0,449	0,449	0,419	0,052	0,124
3	PROFITABILITY (FP3)	0,117	0,235	0,176	0,176	0,059	0,333
4	PROJECT SCHEDULE ESTIMATION LEVEL (TP1)	0,177	0,177	0,177	0,177	0,000	0,000
5	VARIANCE/CHANGES IN PROJECT SCHEDULE (TP2)	0,207	0,207	0,083	0,165	0,072	0,433
6	LEGISLATION/PERMIT DURATION COMPLIANCE (TP3)	0,127	0,127	0,025	0,093	0,059	0,630
7	QUALITY IMPACT ON COST (QP1)	0,205	0,205	0,154	0,188	0,030	0,157
8	QUALITY COMPLIANCE (QP2)	0,212	0,265	0,159	0,212	0,053	0,250
9	DEFICIENT WORK (QP3)	0,125	0,166	0,125	0,138	0,024	0,173
10	ACCIDENT/INJURIES (HSP1)	0,127	0,637	0,255	0,340	0,265	0,781
11	LOSS OF WORKFORCE (HSP2)	0,032	0,162	0,032	0,076	0,075	0,990
12	H & S COMPLIANCE (HSP3)	0,284	0,355	0,213	0,284	0,071	0,250
13	CUSTOMER SATISFACTION (SS1)	0,089	0,089	0,071	0,083	0,010	0,124
14	EMPLOYEE SATISFACTION (SS2)	0,055	0,055	0,033	0,048	0,013	0,266
15	COMMUNITY SATISFACTION (SS3)	0,192	0,192	0,115	0,166	0,044	0,266
16	SHAREHOLDER / PARTNER SATISFACTION (SS4)	0,042	0,052	0,042	0,045	0,006	0,133
17	RESEARCH & DEVELOPMENT (IN1)	0,066	0,110	0,044	0,074	0,034	0,458
18	EDUCATION / TRAINING (IN2)	0,048	0,080	0,016	0,048	0,032	0,667
19	COMMUNICATION (IN3)	0,049	0,066	0,016	0,044	0,025	0,573
20	ECOLOGICAL (EP1)	0,066	0,111	0,044	0,074	0,034	0,458
21	DESIGN (EP2)	0,041	0,051	0,020	0,038	0,016	0,417
22	LAND USE (EP3)	0,064	0,107	0,107	0,092	0,025	0,266
23	WASTE MANAGEMENT (EP4)	0,082	0,082	0,061	0,075	0,012	0,157
24	ENERGY (EP5)	0,128	0,213	0,170	0,170	0,043	0,250
25	WATER (EP6)	0,138	0,173	0,069	0,127	0,053	0,417
26	USE OF MATERIAL (EP7)	0,036	0,048	0,048	0,044	0,007	0,157
27	INDOOR ENVIRONMENTAL QUALITY (EP8)	0,063	0,079	0,079	0,073	0,009	0,124
28	COMPLIANCE WITH REGULATIONS (EP9)	0,034	0,042	0,042	0,040	0,005	0,124
		3,376	**4,744**	**3,036**	**3,719**		

Table 6.43 shows the weighted performance scores for the second level project performance dimensions of urban regeneration projects.

Table 6.43 : The weighted performance scores for the 2nd level performance criteria of 3 urban regeneration projects.

	2nd Dimension (Performance Dimension)	**Project #1- Criteria Performance Score**	**Project #2- Criteria Performance Score**	**Project #3- Criteria Performance Score**	**Arithmetic Mean**	**Standard Deviation**	**Coefficient of Variance**
1	FINANCIAL PERFORMANCE	0,68	0,89	0,83	0,80	0,11	0,13
2	TIME PERFORMANCE	0,51	0,51	0,29	0,44	0,13	0,30
3	QUALITY PERFORMANCE	0,54	0,64	0,44	0,54	0,10	0,18
4	HEALTH & SAFETY (H & S) PERFORMANCE	0,44	1,15	0,50	0,70	0,39	0,56
5	STAKEHOLDER SATISFACTION	0,38	0,39	0,26	0,34	0,07	0,21
6	INNOVATION	0,16	0,26	0,08	0,17	0,09	0,54
7	ENVIRONMENTAL PERFORMANCE	0,66	0,91	0,64	0,73	0,15	0,20
	OVERALL SUSTAINABLE PERFORMANCE	**3,38**	**4,74**	**3,04**	**3,72**		

The performances of the projects were measured with the scores of the experts involved in urban regeneration projects using the model components. The difference between measured performance and actual performance in the test of the model was calculated as follows:

$$\%Error=(Measured\ Performance/Actual\ Performance)*100 \tag{2.2}$$

The actual performance is again the general evaluation of the experts for the projects and obtained with Field Study C Questionary.

The accuracy of the model in measuring the project performance is satisfactory when the results of the calculation are evaluated using the measured and actual performance scores. The average error rate was calculated as 19% (see Table 6.44).

Table 6.44 : Measured performance and actual performance of projects margins determined by comparison.

	Project #1	Project #2	Project #3	Arithmetic Mean
The Suggested Performance Score	3,38	4,74	3,04	3,72
The Real Performance Score	4,00	5,00	4,00	4,33
Error	-0,18	-0,05	-0,32	-0,19
%Error Absolute Value	0,18	0,05	32 %	**0,19**

As can be seen in the evaluation of projects in Istanbul (Project 1 and 3), the actual performance is lower than Project 2 and performance deviations are 18% and 32%. On the other hand, when evaluating the project outside Istanbul, the margin of error is calculated as only 5%.

This may have been due to the subjective assessment of performance scores or the fact that some performance dimensions and criteria were more effective than others in determining overall performance. In addition, 3 experts worked together to evaluate the second project. This shows that the model may be affected by individual evaluations.

As a result, the validity of the sustainable performance measurement model is provided in this section and tested.

7. CONCLUSION AND FUTURE WORK

Under this section of the thesis, the results obtained from the study are evaluated in three parts. the first part (7.1) includes output and explanations about the current practices related to the performance measurement obtained from the Field Study-A. The second part (7.2) includes the validation, testing and assessment of model components and weightings. Finally, Part 3 (7.3) includes general evaluation of the proposed model and its applications.

7.1 General Evaluations for Current Status of Performance Measurement in Urban Regeneration Projects

Participants of Field Study A represent a large spectrum of different disciplines working in urban regeneration projects. Some of the findings gathered using information from the participants in Field Study A on current status of performance measurement systems in urban regeneration projects are as follows.

65% of the participant experts mentioned not having experienced any performance measurement in their current and previous projects. Additionally, among participants who were involved in projects using performance measurement models, 63 % used in 1 to 5 urban regeneration projects, 9 % used between 5-10 urban regeneration projects and 18 % in more than 10 urban regeneration projects.

These results demonstrate a low-level utilisation of performance measurement systems in the overall construction sector, which also indicate the need for a thorough, practical performance measurement model proposed for the purpose of this thesis.

Most important motivating factors for adopting performance measurement systems were respectively: expected benefits of performance measurement, recommendations by consultants, client needs and expectations and requirements by international project partners. Other factors for adopting a performance measurement system voluntarily, such as becoming one of the best companies in national and international scale and initiative of employees are ranked below. These results strongly suggest that

Performance management in construction projects is usually performed when It is mandatory and/or it is required by a third-party. This is another indication of a need for enhancing measurement practices in overall management system.

Most common applications (50%) used for processing performance data are conventional accounting and office software such as MS Excel, Logo etc. Almost 28% of the participants stated that they used a specific software for performance measurement in their projects, which could be interpreted as a sign for advancement in the adoption of IT tools in Construction.

Another important output was the use of Green building rating systems such as LEED, BREEAM and EDGE as a performance measurement tool by one of the experts. This is an innovative approach for the utilization of Green Building performance rating systems in an alternative way.

Additionally, adoption of current green building performance rating systems as a part of overall project performance measurement system could be a further research area.

Effectiveness of performance measurement systems experienced at company level was also asked in the survey. Responses define the application of these systems at company level as either effective or very effective. Hence, this positive approach by the experts to the use of performance measurement at company level can be seen as a for a sign of further benefits in project level applications. A large ratio of respondents (%62,5) defined site data as the primary source of input for performance measurement in their former experience. Project Reviews and Site Data were also determined as the type of data which should have the priority for performance measurement. It was followed by cost reporting system and customer surveys, respectively. Common use and preference of site data by the participating experts confirm the site-oriented approach in construction sector.

Most of the experts participating the survey responded that they intend to utilize performance measurement systems in their future projects, If corresponding costs are low compared to benefits. Therefore, cost being an important dimension in project performance measurement model (Tekçe, 2010), is also an important criterion for using the performance measurement model. In addition to that, finally, survey results confirm the need for an internationally developed sustainable performance measurement model for urban regeneration projects. Proposed study shall be used as a framework for further international research on this subject.

7.2 Evaluations on Sustainable Performance Measurement Model for Urban Regeneration Projects

Urban regeneration projects are considered as important drivers of construction industry, due to their wide scope, larger budget and social, economic and ecological effects on urban life.

However, there is no consensus on approaches and models for assessing performance of urban regeneration projects. For the purpose of this study, criteria and indicators for the sustainable performance measurement were developed by following a certain methodology, and a sustainable performance measurement model was proposed. This thesis can be considered as the first study which defines the performance indicators specific to urban regeneration projects for a comprehensive measurement of sustainable performance. Within the scope of the thesis, a model was developed, validated by experts and verified in 3 different urban regeneration projects.

As adopted in former studies (Tekçe, 2010), proposed model was developed by using an Analytical Hierarchy Process methodology to determine weights of the model indicators. The process was supported by Field Surveys and statistical analysis of empirical findings.

Target user group for the model include experts from urban regeneration projects. However, the proposed model could be used by all stakeholders of urban regeneration projects, including public officials. Following a thorough literature study and feedback from subject-matter-experts, many factors for measuring sustainable performance was incorporated into the proposed model. These elements of the model develop a synthesis of urban regeneration, project management and sustainability. The model was then validated by experts through a second field survey, according to its practicality, usability, and feasibility. Finally, the proposed model with specified criteria was tested in 3 Real- Life urban regeneration projects.

Expert group responses in AHP model was assessed via Consistency Index (C.I.) which implies the consistency of judgement. C.I. for the study was within acceptable limits and indicates that the expert judgments were reasonable and sound.

Original value-added parts of the proposed model include; primary focus on performance indicators instead of factors affecting performance, complementary approach on previous performance measurement models, specifying model weights using AHP approach including a validation process and final verification of the developed model in real life projects. Also, it should be noted that proposed model in this study is primarily specific to urban regeneration projects. 32 participants with expertise in different disciplines of construction and urban regeneration were involved in the model development phase. Validation of the proposed model was executed by contributions from 21 different experts. Finally, 5 experts from 3 different Urban Regeneration was involved in the model verification process by providing feedback.

Table 6.24 outlines the determined weightings of the model components. These values which were obtained using AHP methodology indicate that, Health & Safety (H & S) Performance Dimension (0,23), Financial Performance Dimension (0,20), Environmental Performance Dimension (0,18) are the most important parameters for measuring the performance of urban regeneration projects. Less important model components are Quality Performance Dimension (0,14); Time Performance Dimension (0,10); Stakeholder Satisfaction Dimension (0,08) and Innovation Dimension (0,05), respectively.

It should be emphasized that in this study, Health and Safety Performance was ranked as the most important parameter for measuring success of urban regeneration projects, which usually carry a high level of Health and Safety risk. Also focus on Environmental Dimension in the upcoming survey results clearly indicate that sustainability issues should be a main topic when defining success in construction projects.

The results of this study reveal that there is a need for more sophisticated solutions for performance management in urban regeneration projects with more focus on Health & Safety and Sustainability.

According to the survey, first 10 among a total of 28 Third Level Criteria in Model Hierarchy was ranked according to their weightings (Table 6.24):

1. Accident/Injuries (HSP1),
2. Cost/Budget Compliance (FP2),
3. H & S Compliance (HSP3),

4. Profitability (FP3),
5. Quality Compliance (QP2),
6. Cost/Budget Estimation Level (FP1),
7. Quality Impact on Cost (QP1),
8. Energy (EP5),
9. Deficient Work (QP3),
10. Variance/Changes In Project Schedule (TP2).

Although H&S criteria are on higher levels, there are more finance related criteria in the list. Results of another study on measuring performance of Turkish contractors's show that Health and Safety and Environmental Performance are important determinants of success (Tekçe, 2010). Although, (Tekçe 2010) study aims to define determinants of company performance, It also defines a high level of correlation between performance indicators of the company and its projects, which also supports the findings of this thesis.

Last 10 Third-Level Criteria in the model Hierarchy with lower weightings are listed as:

1. Waste Management (EP4),
2. Customer Satisfaction (SS1),
3. Communication (IN3),
4. Education / Training (IN2),
5. Indoor Environmental Quality (EP8),
6. Use of Materials (EP7),
7. Employee Satisfaction (SS2),
8. Shareholder / Partner Satisfaction (SS4),
9. Design (EP2),
10. Compliance with Regulations (EP9).

Although Compliance with Regulations criteria is very curicial for urban regeneration projects, its weighting is lowest for measuring project performance. This may be due to being a mandatory measure for all urban regeneration projects and usually achieved by most of them.

Table 6.45 : Importance weights of Level 3 Performance Criteria obtained with AHP.

Importance Weights	**3rd Dimension (Performance Criteria)**	**RANK**
0,127317001	**ACCIDENT/INJURIES (HSP1)**	1
0,089713353	**COST/BUDGET COMPLIANCE (FP2)**	2
0,071009612	**H & S COMPLIANCE (HSP3)**	3
0,05870728	**PROFITABILITY (FP3)**	4
0,052966687	**QUALITY COMPLIANCE (QP2)**	5
0,052145296	**COST/BUDGET ESTIMATION LEVEL (FP1)**	6
0,051353265	**QUALITY IMPACT ON COST (QP1)**	7
0,042554266	**ENERGY (EP5)**	8
0,041544552	**DEFICIENT WORK (QP3)**	9
0,041355326	**VARIANCE/CHANGES IN PROJECT SCHEDULE (TP2)**	10
0,038329078	**COMMUNITY SATISFACTION (SS3)**	11
0,035457574	**PROJECT SCHEDULE ESTIMATION LEVEL (TP1)**	12
0,034517687	**WATER (EP6)**	13
0,032443508	**LOSS OF WORKFORCE (HSP2)**	14
0,02549815	**LEGISLATION/PERMIT DURATION COMPLIANCE (TP3)**	15
0,022166169	**ECOLOGICAL (EP1)**	16
0,022091743	**RESEARCH & DEVELOPMENT (IN1)**	17
0,021333567	**LAND USE (EP3)**	18
0,020428045	**WASTE MANAGEMENT (EP4)**	19
0,017848912	**CUSTOMER SATISFACTION (SS1)**	20
0,016491372	**COMMUNICATION (IN3)**	21
0,015903962	**EDUCATION / TRAINING (IN2)**	22
0,015718551	**INDOOR ENVIRONMENTAL QUALITY (EP8)**	23
0,01205926	**USE OF MATERIAL (EP7)**	24
0,011092354	**EMPLOYEE SATISFACTION (SS2)**	25
0,010450828	**SHAREHOLDER / PARTNER SATISFACTION (SS4)**	26
0,010249614	**DESIGN (EP2)**	27
0,00849416	**COMPLIANCE WITH REGULATIONS (EP9)**	28

7.3 Verification of The Proposed Sustainable Performance Measurement Model for Urban Regeneration Projects

Model proposed in this thesis was validated by experts in Field Study B. After validation of the model, 5 experts from 3 different urban regeneration project were asked to apply the model in these projects for the verification process.

This study mainly focuses on determining the criteria and key performance indicators for measuring sustainable project performance in urban regeneration projects. Factors affecting performance is not within the scope of this thesis and should be subject to further discussion.

Proposed criteria and key performance indicators determined within the context of this study can be further adapted to the needs of decision makers in the future. In the literature review, it has been found that most of the past research include only certain key performance indicators for performance measurement which do not cover all success measures of today's construction sector. Issues in sustainable development are usually missing from the proposed models. Most of the studies do not focus on specific areas such as sustainable performance in urban regeneration. Also lack of verification in real life projects for proposed criteria and models in the literature is another important topic to address. A thorough and structured approach has been taken to address these issues in the thesis. Eventually, the methodological tool for decision makers to measure sustainable performance in urban regeneration projects has been developed. In addition to that measuring performance using a pre-determined set of criteria and key indicators enables benchmark analysis.

Assessment methodology and tools for the application of proposed performance measurement model is provided in Appendix K.

Proposed model can be adapted to existing systems to measure performance in projects or can be used a guideline to further develop custom models. Feedback from decision-makers with respect to enhance performance can be used for further adaptation of the proposed model.

Most of the proposed KPI’s determined as the output of this study are quantitative, which could be a good indication of the tendency of technical staff to rely on measurable results for project performance. The model developed in this study can be used as a baseline for future research and may be improved in the context of alternative project types, stakeholders and/or organizations.

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APPENDICES

APPENDIX A: Field Study A Questionnaire *(in CD-ROM)*

APPENDIX B: Field Study B Questionnaire. *(in CD-ROM)*

APPENDIX C: Field Study C Questionnaire. *(in CD-ROM)*

APPENDIX D.1: Participants' Answers of Field Study A-(Part I). *(in CD-ROM)*

APPENDIX D.2: Participants' Answers of Field Study A-(Part II). *(in CD-ROM)*

APPENDIX D.3: Participants' Answers of Field Study A-(Part III). *(in CD-ROM)*

APPENDIX D.4: Participants' Answers of Field Study A-(Part IV). *(in CD-ROM)*

APPENDIX D.5: Participants' Answers of Field Study A-(Part V). *(in CD-ROM)*

APPENDIX E.1: Participants' Answers of Field Study B-(Part I). *(in CD-ROM)*

APPENDIX E.2.1: Participants' Answers of Field Study B-(Part II-Q6). *(in CD-ROM)*

APPENDIX E.2.2: Participants' Answers of Field Study B-(Part II-Q7). *(in CD-ROM)*

APPENDIX E.3: Participants' Answers of Field Study B-(Part III). *(in CD-ROM)*

APPENDIX F.1: Participants' Answers of Field Study C-(Part I). *(in CD-ROM)*

APPENDIX F.2: Participants' Answers of Field Study C-(Part II). *(in CD-ROM)*

APPENDIX G.1: Field Study-A (Part III) Statistical Analysis and Ranking of Key Performance İndicators. *(in CD-ROM)*

APPENDIX H: Field Study-A Calculation of the Relative Importance Weights of the Model Components and the Consistency Rates of the Comparison Matrices. *(in CD-ROM)*

APPENDIX I: Field Study-B Investigation of the Validity of the Sustainable Performance Measurement Model. *(in CD-ROM)*

APPENDIX J: Field Study-D Testing the Sustainable Performance Measurement Model. *(in CD-ROM)*

APPENDIX K: Sustainable Performance Measurement Model for Urban Transformation Projects (Key performance indicators evaluation methods and tools).
(in CD-ROM)

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- BREEAM International Assessor
- RESNET Home Energy Rating System (HERS) Rater
- Certified Real Estate Appraiser
- Derivative Instruments License (SPK)
- Corporate Governance Rating License (SPK)
- Credit Rating License (SPK)
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