# Proposals to Develop Sustainable City Center Axes Upon Case Studies: Istanbul, Erzincan, Balıkesir, Bursa, Adıyaman


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***Abstract:*** *UN Habitat recently released a report about sustainable urbanization naming 2020-2030 as "Decade of Action" to proceed and imply actions for sustainable developments. It is indicated that impacts of pandemics, climate change and inequality raised necessity of sustainable cities. Not only focusing on renewable energy issues, but also accessibility, cultural continuity and localization are needed to be emphasized. This study contains student projects in "Sustainability and Architecture" course in Architecture, focusing on examination of city centre axes and investigation of problems related to environmental, social and economic sustainability issues for Erzincan, Balıkesir, Bursa, Adıyaman and Istanbul. In this context, problem investigation methods: site observations, examinations of local dynamics, statistical data analysis of government and literature reviews. After evaluating the problems, to improve life quality and resiliency of cities, the proposals involve matrix-based tables and 2D&3D drawings. Consequently, this study aims to be a start of "Decade of Action" which can be adapted to different cities in future researches.*

***Keywords:*** *Sustainable urbanization, Resilience, Sustainable development, city center design, urban sustainability indicators.*

# Sürdürülebilir Şehir Merkezi Aksları Geliştirme Önerileri Alan Çalışmaları: İstanbul, Erzincan, Balıkesir, Bursa, Adıyaman

Öz: *Birleşmiş Milletler Habitat programı, kısa süre önce 2020-2030 yılları arasını sürdürülebilir şehirleşme için "harekete geçilmesi ve aksiyon alınması gereken on yıl" olarak ilan ettiği bir rapor yayınlamıştır. Bu raporda pandemi etkileri, iklim değişikliği ve eşitsizlik gibi konuların sürdürülebilir şehirlere olan gereği arttırdığı vurgulanmıştır. Sadece yenilenebilir enerji konuları değil, bunun yanında erişilebilirlik, kültürel devamlılık ve yerelleşme konularına da odaklanılmasına ihtiyaç duyulmaktadır. Bu çalışma, "Sürdürülebilirlik ve Mimarlık" dersi kapsamında şehir merkezlerinin incelenmesini, çevresel, sosyal ve ekonomik sürdürülebilirlik ile ilgili problemlerin araştırılmasını ve problemi ortaya koymayı amaçlayan öğrenci projelerinden yola çıkmaktadır. Bu bağlamda, araştırma yöntemi olarak saha gözlemleri, yerel dinamiklerin incelenmesi, istatistiki verilerin analizi ve literatür araştırmaları yapılmıştır. Problemlerin değerlendirilmesinden sonra; şehirlerin yaşam kalitesini arttırmayı amaçlayan, şehir akslarına farklı koşullara karşı dayanım ve esneklik getiren öneriler geliştirilmiştir. Bu öneriler matris tabanlı tablolardan ve hem iki hem de üç boyutlu görsel temsillerden oluşmaktadır. Sonuç olarak, bu çalışma "harekete geçilmesi ve aksiyon alınması gereken on yıl" için bir başlangıç noktası olmayı amaçlayarak gelecek çalışmalarda başka benzer özellikteki şehirlere uyarlanabilecek rehber öneriler sunmaktadır.*

***Anahtar Kelimeler:*** *Sürdürülebilir şehirleşme, Rezilyans, Sürdürülebilir gelişme, Şehir merkezi tasarımı, Kentsel sürdürülebilirlik göstergeleri.*

## 1. INTRODUCTION

United Nations (UN) Habitat has prepared a report to succeed in sustainable urbanization development with an aim of providing a better world for future generations. The report is a kind of manifesto calling the years between 2020-2030 as "Decade of Action" to achieve concrete objectives in sustainability in environmental, social and economic perspectives. This report consists of analysis, tools and methods to maintain the life cycle independently and provide the needs adequately in the cycle. The report is not only introducing the global approaches but also includes the unquantifiable value that gives cities their unique character; and also explores the role of innovation and technology, local governments, targeted investments and the effective implementation of the New Urban Agenda in fostering the value of sustainable urbanization [1]. Moreover, socio-economic problems like migration, poverty, housing, unemployment are examined in detail and an integrated schema of sustainable city planning is organized. Furthermore, the year 2020 symbolizes a turning point for the whole world which should be considered as a last warning towards humankind due to their treatment of the Earth. The coronavirus pandemic -as it is the worst public health crisis since the Spanish Flu in 1918- is witnessed in the whole world and economic turndowns have appeared in different countries which increase inequality, poverty and unemployment. For more than twenty years, destructive impacts of environmental problems -which are the results of uncontrolled human activities, excessive urbanization / rapid urban growth and excessive industrialization- are harshly seen and felt in daily life such as climate change, endangered species, pandemics. In consideration of these important issues; the development of sustainable cities is becoming urgent and indispensable; as the majority of the world's population lives in urban areas. According to United Nations (UN), 55% of the world's population lives in urban areas and it is forecasted to reach 60% by 2030 and 68% by 2050 [2]. The percentage of the urban population in Turkey is reported as 76% in 2020; and is expected to increase more in upcoming years [3]. While urbanization is often positively correlated with socioeconomic improvement, it has resulted in several environmental problems [4, 5, 6, 7]. Regarding these researches, urban sustainability planning is the necessity of maintaining livable environments for future generations.

According to Sasanpour [8]; the city is a phenomenon that has evolved in history, the result of culture and spatial effects of playing the basic roles of man in the geographical environment and having various dimensions of the environmental, historical, cultural, political, economic, social, and psychological. Hence, a comprehensive understanding of the city is possible by knowing all its dimensions and components [8].

Urban sustainability is classified into three aspects: environmental, social and economic. As Huang, Wu and Yan [9] defined urban sustainability as "an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human wellbeing through concerted ecological, economic, and social actions in response to changes within and beyond the urban landscape"[9]. In this study, the ultimate goal is to reach sustainable city center development within the balanced integration of these three prospects.

Urban sustainability is fundamentally a dynamic process of harmonizing the environment, economy, and society in an urban area through design, planning, and institutional activities [9]. In this study, urban sustainability indicators were considered to provide information about the functioning of a specific urban system, for a specific purpose of sustainability to support decision-making and management of the whole urban system. This study emphasizes the necessity of defining urban sustainability indicators in order to measure urban sustainability properly. European Environment Agency's Urban Metabolism Framework, European Union's European Green City Tool, European Foundation for the Improvement of Living and Working Conditions' Urban Sustainability Indicators, Reference Framework for Sustainable Cities (RFSC) are some existing urban sustainability indicator sets. Due to the overpopulation of indicators, there is a need to bring out the most important and relevant ones [10]. According to Huang, Wu and Yan [9], using different kinds of indicators in concert or combining single indices with indicator sets in the same assessment can also provide useful information for confirmation and comparison of results. Thus, in this study, necessary urban sustainability indicators were selected and accordingly, considered to define solutions for particular city center axis. The indicators were evaluated in three main aspects: environmental, social and economic (Table 1). In this study, as shown in Table 1, the environmental indicators were defined as green spaces, energy efficiency, mobility, air quality, waste – reuse – recycle and disaster management; social indicators were quality of public space, urban safety, heritage, awareness, accessibility and nuisance; economic indicators were tourism, local economy, life cycle management of urban properties in terms of materials, structures and systems, and idle buildings.

| URBAN SUSTAINABILITY INDICATORS | | |
|---|---|---|
| **Environmental Indicators** | **Social Indicators** | **Economic Indicators** |
| Green Spaces | Quality Public Space | Tourism |
| Energy Efficiency | Urban Safety | Local Economy |
| Mobility | Heritage | Life Cycle Management |
| Air Quality | Awareness | Idle Buildings |
| Waste / Reuse / Recycle | Accessebility | |
| Disaster Management | Nuisance | |

*Table 1. Urban Sustainability Indicators according to three sustainability aspects (Compiled by authors).*

In this study, existing city axis was targeted to improve by considering urban sustainable in terms of environmental, social and economic in order to obtain resilience cities as it was indicated in the UN's report for the near future. In Turkey, there are various kinds of cities in terms of geographical, climatic, demographic and economic aspects. In this study, the objective was defined to propose a sustainable transformation prototype for different cities. Five different cities which have own characteristics were examined in detail. For instance, Istanbul is the highest populated and densest city with numerous districts showing various features. While Erzincan has harsh climatic conditions with the lowest population. Bursa and Balıkesir are both example for large-scale cities. However, Bursa is center for industrialized areas, whereas Balıkesir is more focused on tourism. On the other hand, Adıyaman is a medium scale city that its economy based on agriculture in the southeast of Turkey.

The aim of this study is to measure and define the existing conditions of selected five different axes in terms of urban sustainability from environmental, social and economic perspectives; and to propose a model of sustainability transformation of selected axis in urban scale which should be considered as a prototype that can adapt to similar urban areas.

## 2. MATERIALS AND METHODS

This research gathered the findings of students' projects in "Sustainability and Architecture" and transformed these findings into a systematic evaluation method for sustainable developments in city center axis. The project was required students to work individually in their hometowns where they were continuing distant learning as result of coronavirus pandemic. In this study, student projects were considered as data sets; in order to develop the model, the datasets were analyzed, categorized and evaluated in detail according to indicator-based sustainability assessment. The course was conducted in Architecture Department of Beykoz University in the 2020-2021 fall semester.

Five different axes were examined from five different cities in Turkey: Istanbul, Erzincan, Balıkesir, Bursa, Adıyaman. These cities were located in different regions of Turkey; each showed unique characteristics (Figure 1). The methodology covered three steps: the first step was description of selected axes. The second step was identifying sustainability problems and the third one was developing proposals according to the urban sustainability indicators.

The first step was selection of city center axes in the city which were combination of both residential and trade areas. Secondly, to identify problems for sustainability in environmental, social and economic perspectives; site visits, observations including sketches and photography, statistical data collection from local and governmental authorities and literature reviews to understand the local dynamics such as historic, cultural background information and transformations were analyzed in detail. The analysis related to connectivity, accessibility, transportation and density were made. The problems were highlighted graphically in the maps of axes together with the photographs about existing conditions. The third step was proposal of design criteria along with sustainable axis design for each city. Additionally, two- dimensional and three-dimensional representations were prepared in order to illustrate sustainable solutions. As the final step; suggestions were made to respond each particular problem. This step was composed of matrix-tables which included problems, solutions and related urban sustainability indicator.


*Figure 1. Location of cities in Turkey (Drawn by authors).*

In this study, five different cities which are differentiated at HDI rankings of UN that considers the health, education and income for human development, 4 to 59 in Turkey. According to Forbes global livability index which compares cities with each other in terms of security, affordability, education, healthcare, its urban lifestyle and infrastructure about liveability, Istanbul is the first, Bursa, Balıkesir, Erzincan and Adıyaman respectively; as Adıyaman is the last in the selected cities with being number 70 (Table 2).

*Table 2. Statical Data for each city (Compiled by authors).*

| City | Region | Population (TUİK) | Urban Population (TUİK) | Area (km2) | HDI Ranking (2017) (UN) | Forbes (2020) |
|---|---|---|---|---|---|---|
| **Istanbul** | Marmara | 15 520 000 | 15 520 000 | 5461 | 4 | 1 |
| **Erzincan** | East Anatolia | 234 431 | 191 061 | 11903 | 36 | 46 |
| **Balıkesir** | Marmara - Aegean | 1 227 000 | 662 199 | 1454 | 29 | 15 |
| **Bursa** | Marmara | 3 056 120 | 286 159 | 1036 | 17 | 8 |
| **Adıyaman** | South East Anatolia | 632 459 | 411 098 | 1679 | 59 | 70 |

The reasons behind these rankings were tried to be evaluated and sustainability problems that were related about selected axes were questioned. In this regard, European Commission's Science for Environment Policy was examined in detail and a new evaluation criterion with urban sustainability indicators in order to survey environmental, social and economic sustainability were proposed. The methodology of defining the urban sustainability indicators was choice and interpretation of the indicators from the large set of Reference Framework for Sustainable Cities (RFSC) and European Foundation for the Improvement of Living and Working Condition's Urban Sustainability Indicator frameworks. In consideration of local problems and dynamics of the focused axis, not the whole city, the proposed evaluation criteria have been developed as an integration and localization of them. Each axes were analyzed qualitatively and evaluated according to the urban sustainability indicators (Table 1) and specific solutions were proposed and shown in Table 2-6.

## 3. RESULTS

### 3.1. Istanbul – Arnavutköy District Project

Istanbul is the most crowded metropolitan city of Turkey, which consists of 39 districts. Istanbul is a multi-centered city and, in this study, focal axis is Fatih Street which is located in Arnavutk**ö**y district. Even though its roots are from Roman Era, Arnavutk**ö**y is one of the newest districts of Istanbul as it became a district in 2008 [11]. It is a district in the northern part of its European side, located near the Black Sea, which has a total area of 506.52 km², has become the fourth largest district in Istanbul in terms of land size. By the construction of new Istanbul Airport in this district, it is growing in terms of urban structure. Now the population of Arnavutk**ö**y is 282 488. The selected axis is Fatih Street on which high density of vehicle and pedestrian traffic exist. The axis starts from BP Gas Station and ends in Arnavutk**ö**y Governmental

Hospital. The selected axis is 1 km long and includes Cumhuriyet Square, Arnavutköy Primary School, shopping areas and residential buildings. It is route for bus and minibus public transportation types.

Within the scope of this study, problems are determined. As this axis is located in Istanbul which is in the 1st degree earthquake zone. Although Arnavutköy is considerably less risky district in Istanbul, according to Istanbul Metropolitan Municipality (IBB) 284 buildings are expected to damage highly and very highly [12]. Specific sustainability problems about axis that defined in this study. The specific problems for Istanbul – Arnavutköy district, axis of Fatih Street is shown in Table 2. Problem about green spaces is lack of open green areas. There are important problems about mobility; can be listed as pedestrian circulation problems such as lack of crossover, not being able to cross the street in the school area, public transportation route interrupts the pedestrian circulation and high density of vehicle traffic. Insufficiency of parking areas result in parking on the pavement and blockages of the streets. Due to the high traffic and crowd; there is nuisance problem of noise. Another negative effect of high density of traffic is excessive amount of exhaust gas which leads to unhealthier air quality. In addition to these problems; undesired aspects of uncontrolled urbanization, buildings' facades without plasters and finishing materials are exist, there is no standardization on signboards, HVAC external units and TV satellite dishes on the facades which ends up in visual pollution. There is not enough open space in terms of quantity and quality for people to relax, socialize or do sport; as well as lack of green areas. There is an existing green area but the way that leads to this green area is unsafe in terms of security; so, it is not possible to use this are effectively as it is planned. Along the axis, various cafes and restaurants causes heavy food odour. Although there are lots of shopping areas and cafes, accessibility to them is another problematic issue. It is not possible to reach the units and walk continuously; both ramps and visually impaired paths are missing. Existing urban furniture are in poor conditions; there are not selected suitably for outdoor usage. Also, it is not safe anymore to use weared furniture for people. Along the axis, recycle boxes are missing which is the essential for environmental sustainability. In the meantime, there is necessity to raise the awareness of people about accessibility and recycle specifically.

The specific sustainable solutions for the selected axis are classified in different areas: solutions about mobility issues are increasement of pedestrianly movement based transportation, implementing a crossover for accessing school, continuous pedestrian paths providing same width along the axis, implementing a bicycle path to the existing road, new route for public bus transportation, increasement of traffic signs to prevent accidents and excessive usage of car horn, underground parking lots that ground levels are designed as open green public areas and encouraging electrical cars from macro scale by adding battery units in gas station on the axis.

*Table 3. Sustainability related problems – solution matrix for Istanbul (Compiled by authors).*

| | | | SUSTAINABILITY SOLUTIONS | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISTANBUL- ARNAVUTKOY DISTRICT: THE AXIS ON FATIH STREET | | | Increasement of pedestrian/cycle movement based transportation | Implementing crossover for approaching school | New route for public bus transportation | Continuous pedestrian paths providing same width | Implementing a bicycle path to the existing road | Encouraging electric cars from macro scale | Underground parking lots | Integration of ramps and visually impaired paths | Assigning social functions like cafés, bufes, galleries on the way | Increasement of night lighting based on solar energy | Increasement of traffic signs | Assigning sound absorber façade panels on buildings' ground level | Assigning environmental friendly external wall systems | Standardization about signboards | Mesh panel systems for HVAC external units | Reconsidering the mechanical ventilation systems for cafés' kitchens | Afforestation on the axis | Transformation of dressed areas to green public spaces | Reuse and recycle of existing urban furniture and equipment | Placement of recycle boxes for each 400m |
| SUSTAINABILITY ASPECTS | URBAN SUSTAINABILITY INDICATORS | SUSTAINABILITY PROBLEMS | | | | | | | | | | | | | | | | | | | | | |
| Environmental | Green spaces | Lack of quality open public spaces. | | | | | | | | | | | | | | | | | | X | X | | |
| | Energy efficiency | Facades without plasters and finishing materials. | | | | | | | | | | X | | X | X | | | | | | | | |
| | | Heat Island effect | | | | | | | | | | | | | X | | | | | X | | | |
| | Mobility | Pedestrian circulation problems. | X | X | X | X | X | | | | | | X | | | | | | | | | | |
| | | High density of vehicle traffic | X | | X | | | | | | | | | | | | | | | | | | |
| | | Lack / Insufficiency of parking areas | | | | | | | X | | | | | | | | | | | | | | |
| | Air Quality | Excessive amount of exhaust gas. | | | | | X | X | | | | | | | | | | | | | | | |
| | Waste / Reuse / Recycle | Insufficiency of trash boxes and lack of recycle boxes. | | | | | | | | | | | | | | | | | | | | | X |
| | | Old and wasted urban furniture | | | | | | | | | | | | | | | | | | | | X | |
| | Disaster Management | Insufficiency of earthquake and disaster assembly areas. | | | | | | | | | | | | | | | | | | | X | | |
| | Quality Public Space | Lack of quality open public spaces. | | | | | | | | | | | | | | | | | | | X | | |
| | Urban Safety | Unsafe conditions of pedestrian paths / overpass/underpass | | | | | | | | | X | X | X | | | | | | | | | | |
| Social | Heritage | NONE | | | | | | | | | | | | | | | | | | | | | |
| | Awareness | Accessibility | | | | | | | | X | | | | | | | | | | | | | |
| | | Recycling | | | | | | | | | | | | | | | | | | | | | X |
| | Accessibility | Lack of ramps | | | | | | | | X | | | | | | | | | | | | | |
| | | Lack of visually impaired paths | | | | | | | | X | | | | | | | | | | | | | |
| | Nuisance | High level of noise | | | | | | | | | | | X | X | | | | | | X | | | |
| | | Visual pollution (unplastered facades, AC units, signs..) | | | | | | | | | | | | | X | X | X | | | | | | |
| | | Food / Exhaust odour types. | | | | | | | | | | | | | | | | | X | X | | | |
| Economic | Tourism | NONE | | | | | | | | | | | | | | | | | | | | | |
| | Local Economy | Insufficiency of social services | | | | | | | | | X | | | | | | | | | | | | |
| | Life Cycle Management of Urban Properties (Materials, Structures, Systems) | Wasted urban furniture | | | | | | | | | | | | | | | | | | | | X | |
| | Idle Buildings | NONE | | | | | | | | | | | | | | | | | | | | | |

Integration of ramps and visually impaired paths are designed for the entrances of buildings, pedestrian paths and crossovers. In order to use existing green area efficiently; night lightening system based on solar energy and social functions like cafés, restaurants, and galleries on the way to the park are assigned. Also, this large green area is considered as earthquake and disaster assembly area. Afforestation on the axis, increasement of traffic signs to prevent accidents and excessive usage of car horn and assigning sound absorber façade panels to the trading functions on the ground level to solve nuisance problem due to the high level of noise from traffic, crowd and density. Standardization about advertisement signboards and mesh panel systems for HVAC external units are proposed to solve visual pollution. Reconsidering the mechanical ventilation systems to evacuate from kitchens of cafes and restaurants is suggested for the decrease food odor that comes from cafes and restaurants. In the axis, to solve problem about facades; assigning environmentally friendly façade solutions with recycled thermal insulation, recycled wooden panels and green façade solutions are suggested. Reuse and recycle of existing urban furniture are planned and if necessary, to design new high durability and environmentally friendly urban furniture. Placement of recycle boxes for each 400 m is planned.

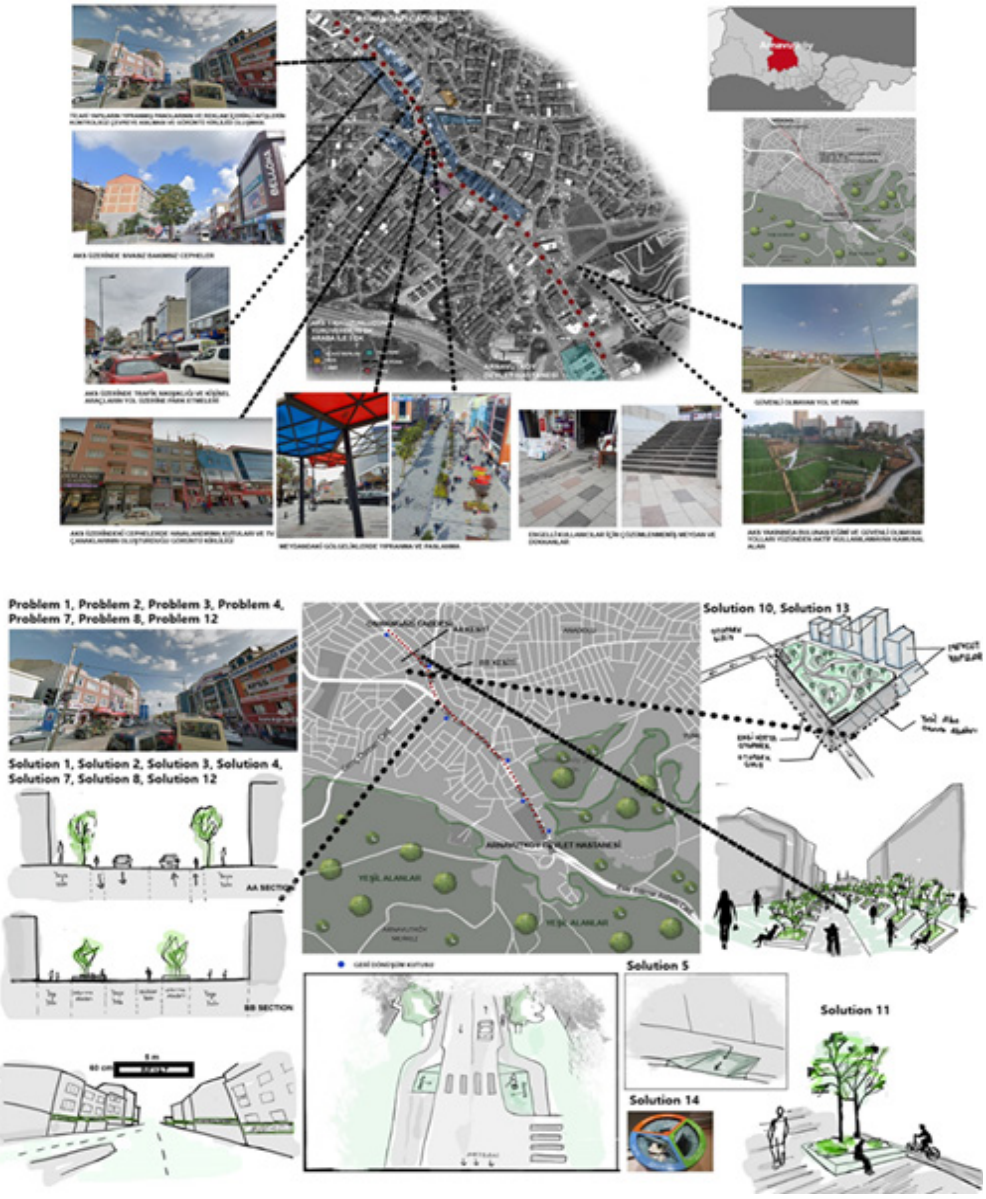


*Figure 2. Description and sustainability proposals for the axis in Istanbul, Arnavutköy by Y. Beyçimen.*

### 3.2. Erzincan

Erzincan is a city located in the Eastern part of Turkey; its descents are to the BC 387. Erzincan is a medium-sized city with a total area is 11903 km2 and the population is 234 431 [13]. Erzincan has a continental climate with freezing, snowy winters and hot and dry summers. There are some kind of renewable energy sources in use in Erzincan such as solar power plants and hydroelectric power plants.

The selected axis is composed of Halit Paşa and Fevzi Paşa Streets; the streets meet in Dörtyol Square; that is main square of Erzincan where high density of vehicle and pedestrian traffic exist. The axis starts from Erzincan Municipality Building and ends in Terzibaba Mosque. The selected axis is 2 km long and includes shopping areas and offices. It is route for bus and minibus public transportation types.

One of the main problems of Erzincan is earthquake. Throughout the history, the city suffers from various earthquakes; the strongest ones are in 1939 and 1992. Specific sustainability problems about axis are defined and shown in Table 4.

*Table 4. Sustainability related problems – solution matrix for Erzincan (Compiled by authors).*

| ERZİNCAN: THE AXIS ON HALİT PAŞA AND FEVZİ PAŞA STREETS | | | SUSTAINABILITY SOLUTIONS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUSTAINABILITY ASPECTS | URBAN SUSTAINABILITY INDICATORS | SUSTAINABILITY PROBLEMS | Increasement of pedestrianial movement based transportation. | Implementing crossovers and traffic light at some points on the axis. | Placement of new bus stops. | Continuous pedestrian paths providing same width. | Implementing a bicycle path to the existing road. | Encouraging electrical cars from macro scale. | Underground parking lots. | Integration of ramps and visually impaired paths. | Assigning social functions like cafés, bufes, galleries on the way. | Afforestation on the axis. | Transformation of idle open areas to green public spaces. | Reuse and recycle of existing urban furniture and equipment. | Reusing the existing pavement by applying top coat solutions against slipperiness or roughening the pavement material. | Placement of recycle boxes for each 400m. |
| Environmental | Green spaces | Lack of green spaces. | | | | | | | | | | X | X | | | |
| | Energy Efficiency | Heat Island affect. | | | | | | | | | | X | X | | | |
| | Mobility | Pedestrian circulation problems. | X | X | X | X | X | | | | | | | | | |
| | | High density of vehicle traffic. | X | | | | X | | | | | | | | | |
| | | Lack / insufficiency of parking areas. | | | | | | | X | | | | | | | |
| | Air Quality | Excessive amount of exhaust gas. | X | | | | X | X | | | | | | | | |
| | Waste / Reuse / Recycle | Insufficiency of trash boxes and lack of recycle boxes. | | | | | | | | | | | | | | X |
| | | Slippery Floor Finishes of Pavements. | | | | | | | | | | | | | X | |
| | Disaster Management | Insufficiency of earthquake and disaster assembly areas. | | | | | | | | | | | X | | | |
| | Quality Public Space | Lack of quality open public spaces. | | | | X | | | | | X | X | X | | | |
| | Urban Safety | Unsafe conditions of pedestrian paths /overpass/underpass. | | | | | | | | | X | | | | X | |
| | Heritage | NONE | | | | | | | | | | | | | | |
| Social | Awareness | Accessibility | | | | | | | | X | | | | | | |
| | | Recycling | | | | | | | | | | | | X | X | X |
| | Accesibility | Lack of ramps. | | | | | | | | X | | | | | | |
| | | Lack of visually impaired paths. | | | | | | | | X | | | | | | |
| | Nuisance | Exhaust odour. | | | | | | | | | | X | | | | |
| | Tourism | NONE | | | | | | | | | | | | | | |
| | Local Economy | Insufficiency of social services. | | | | | | | | | X | | | | | |
| | Life Cycle | Slippery Floor Finishes of Pavements. | | | | | | | | | | | | X | X | |
| Economic | Management of Urban Properties (Materials, Structures, Systems) | Unusage of ornamental pool. | | | | | | | | | | X | X | X | | |
| | Idle Buildings /Structures | Idle and unemployed pedestrian overpass which people usually do not prefer to use. | | | | | | | | | X | | | | | |

There are problems about mobility: existing pedestrian circulation areas are narrow; there is high density of vehicle traffic that causes excessive amount of exhaust gas leading to low air quality. Insufficiency of parking areas in the axis result in parking on the pavement and blockages of the streets. There is an idle and unemployed pedestrian overpass which people usually do not prefer to use that causes unsafety urban

environment and affects connectivity in a negative manner. There are no bicycle roads. Even though, there is bus and minibus lines passing through the axis, their stops are not defined; vehicle can easily park to bus stop without recognizing it. The pavements are made of slippery materials that causes damages for people especially in winter during rain, snow and frost. Integration of ramps and visually impaired paths are not designed that causes accessibility problems. There is no recycle bins along this axis to maintain lifecycle management. A quality open space and green areas are missing; which can be considered as also earthquake assembly areas. There is an ornament pool in the midpoint of the axis; but it is not working.

The specific sustainable solutions for the selected axis are classified in different areas: solutions about mobility issues are increasement of pedestrianly movement based transportation, implementing crossovers and traffic lights, continuous pedestrian paths providing same width along the axis, implementing a bicycle path to the existing road, placement of bus stop, increasement of traffic signs to prevent accidents, underground parking lots that ground levels are designed as open green public areas and encouraging electrical cars from macro scale by adding battery units on the axis. Integration of ramps and visually impaired paths are designed for the entrances of buildings, pedestrian paths and crossovers. In order to improve green areas, afforestation on the axis and transformation of idle open areas and car parking areas to green public spaces are designed. Also, these green areas are considered as earthquake assembly area. Transforming unemployed overpass into a small-scale green street bazaar to improve local economy are planned. Reusing the existing pavement by applying top coat solutions against slipperiness or roughening the pavement material are designed and transforming the unused ornamental pool into seating area with green is planned. Placement of recycle boxes for each 400 m is planned.


*Figure 3. Description and sustainability proposals for the axis in Erzincan by A. Adan*

### 3.3. Balıkesir

Balıkesir is located both in the Marmara and Aegean regions in the Western part of Turkey. The roots of city are from Ancient Greek; but urban settlements are from Roman Era. Historic center of Balıkesir which majority of buildings were constructed at the end of the 19th century during the Ottoman Era has a population more than 1 227 000, it is the fourth crowded city in the Marmara Region [14]. The total area of Balıkesir is 1454 km2; it has sea coasts and shores to both Marmara and Aegean Seas. The city is well-connected with other cities by highways, railway and airway. The main economic incomes are agriculture and tourism which is based on summer and spa tourism. Balıkesir has a hot-summer Mediterranean climate; winters are cool and wet with frequent frosts and summers are hot and dry. The selected axis is Anafartalar Street which is located in the historic center of the city. The axis begins from historic Zağnospasa Mosque that is constructed in the 15th century and ends in Kasaplar Mosque. Along with the axis, there are historic Ziraat Bank building, Kuvayi Milliye Museum, Library, Clock Tower, shopping areas and historic but abandoned buildings. The main complaints about the city center are air pollution, traffic, lack of parking areas, lack of social functions and insufficiency of green areas [15].

*Table 5. Sustainability related problems – solution matrix for Balıkesir (Compiled by authors).*

| | | | SUSTAINABILITY SOLUTIONS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BALIKESİR: THE AXIS ON ANAFARTALAR STREET | | | Increasement of pedestrian/all movement based transportation. | Implementing a bicycle path to the existing road. | Encouraging electrical cars from macro scale. | Underground parking lots | Integration of ramps and visually impaired paths. | Restoration, renovation and refunctioning the abandonment area | Assigning social functions like cafés, bufes, galleries on the way. | Increasement of night lighting based on solar energy. | Increasement of traffic signs | Afforestation on the axis. | Transformation of idle open areas to green public spaces. | Placement of recycle boxes for each 400m. | |
| SUSTAINABILITY ASPECTS | URBAN SUSTAINABILITY INDICATORS | SUSTAINABILITY PROBLEMS | | | | | | | | | | | | | |
| Environmental | Green spaces | Lack of quality green spaces | | | | | | | | | | X | X | | |
| | Energy efficiency | Heat Island affect | | | | | | | | | | X | X | | |
| | Mobility | High density of vehicle traffic | X | X | | | | | | | X | | | | |
| | | Lack / Insufficiency of parking areas | | | | X | | | | | | | | | |
| | Air Quality | Excessive amount of exhaust gas. | X | X | X | | | | | | | | | | |
| | Waste / Reuse / Recycle | Insufficiency of trash boxes and lack of recycle boxes. | | | | | | | | | | | | | X |
| | Disaster Management | Insufficiency of earthquake and disaster assembly areas. | | | | | | | | | | | X | | |
| | Quality Public Space | Lack of quality open public spaces. | | | | | | X | | | | | X | | |
| Social | Urban Safety | Insuffiecient night lighting | | | | | | | X | X | | | | | |
| | | Risk of collapse of negleted historic buildings | | | | | | | | | | | | | |
| | Heritage | Abandonment of historic center | | | | | | X | X | X | | X | | | |
| | Awareness | Accessibility | | | | | X | | | | | | | | |
| | | Recycling | | | | | | | | | | | | | X |
| | | Cultural Heritage | | | | | | X | | | | | | | |
| | Accessibility | Lack of ramps | | | | | X | | | | | | | | |
| | | Lack of visually impaired paths | | | | | X | | | | | | | | |
| | Nuisance | Exhaust odour | X | X | X | | | | | | | X | | | |
| Economic | Tourism | Unfunctionized and inactive of historic center | | | | | | X | X | | | | | | |
| | Local Economy | Insufficiency of social services | | | | | | | X | | | | | | |
| | Life Cycle Management of Urban Properties (Materials, Structures, Systems) | NONE | | | | | | | | | | | | | |
| | Idle Buildings | Unfunctionized and inactive of historic center | | | | | | X | X | | | | | | |


*Figure 4. Description and sustainability proposals for the axis in Balıkesir by H. N. Selamet.*

In Table 4, the specific sustainable solutions for the selected axis are classified in different areas: solutions about mobility issues are increasement of pedestrianly movement-based transportation, implementing a bicycle path to the existing road, increasement of traffic signs to prevent accidents, underground parking lots that ground levels are designed as open green public areas and encouraging electrical cars from macro scale by adding battery units on the axis. Integration of ramps and visually impaired paths are designed for the entrances of buildings, pedestrian paths and crossovers. In order to improve green areas, afforestation on the axis and transformation of idle open areas and car parking areas to green public spaces are designed. Also, these green areas are considered as earthquake assembly area. Restoration, renovation and refunctioning the abandonment historical area are designed. Transforming the axis into a culture street with small exhibition areas, bookshops, cafes and performing areas are planned. Also, night lightning system based on solar energy is assigned into the whole axis which will improve urban environmental comfort and urban safety. Placement of recycle boxes for each 400 m is planned.

### 3.4. Bursa

Bursa is a city in north western Turkey; with population more than 3 million people the fourth-most populous city in Turkey and second-most populous in the Marmara Region. The historical background of the city starts from 5200 BC and it is second capital city of Ottoman Empire, standing on the north western slopes of Mount Uludağ which is named as Mysian Olympus in classical times and nowadays it is important for winter tourism and sports [16]. It has seacoast the Marmara Sea. The city has hot, dry summers that last for three months and winters are cold and damp, also containing the most rainfall. The city is called 'green Bursa' in daily life in refer to its large green areas; even though today there is a decrease due to the excessive urbanization. Bursa is one of the industrial centers of the country as most of Turkey's automotive production takes place in Bursa. Air pollution is a chronic problem in Bursa as results of containing numerous industrial areas.

The selected axis is Altıparmak Street in historic center of Bursa. The axis starts from Veldei Palace Mosque and ends in Ahmet Vefik Paşa Theater. The axis is 1100 m long and along with it, there are historic Hans from Ottoman Empire, Gazi Orhan Bey Mosque and Ulu Mosque dated back from 14th century, the Clock Tower from 1900s, old central bank building from 1967 and new shopping mall buildings.

Bursa is also located in the 1st degree earthquake zone which makes important in designing and planning phase. The specific sustainability problems about the axis that defined in this study and shown in Table 5. There are numerous important problems about mobility: high density of vehicle traffic causes excessive amount of exhaust gas, problematic tram network as being so slow and interrupting the public transportation traffic flow, lack of bicycle road, insufficiency of traffic lights and bus stops, mislocation of bus stops, excessive crowd on open air steep 25 meters escalator which leads to Saltanat Kapısı. Also, there is an idle and unemployed underground pedestrian subway which people usually do not prefer to use. Along the axis, there is no standardization on signboards, HVAC external units and TV satellite dishes on the facades which ends up in visual pollution. There is no recycle boxes along the axis. In the meantime, accessibility conditions about visually impaired paths are missing. Another important issue about this axis is idle buildings in historic center: the Hans Area which began its economic development in the 14th century in Ottoman Empire. Finally, there are damages on existing green areas to continue urbanization.

*Table 6. Sustainability related problems – solution*

| BURSA: THE AXIS ON ALTIPARMAK STREET | | | SUSTAINABILITY SOLUTIONS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUSTAINABILITY ASPECTS | URBAN SUSTAINABILITY INDICATORS | SUSTAINABILITY PROBLEMS | Increasement of pedestrianial movement based transportation. | Implementing crossovers and traffic light at some points on the axis | Relocation of existing bus stops | Moving the existing tram network to a parallel street. | Implementing a bicycle path to the existing road. | Encouraging electrical cars from macro scale. | Integration of visually impaired paths. | To limit and control the number of people using the escalator | Restoration, renovation and refunctioning the abandonment area. | Assigning social functions like cafes, bufes, galleries for the Hans and underpass | Increasement of lighting based on solar energy in the underpass | Mesh panel systems for HVAC external units. | Afforestation on the axis. | Transformation of idle open areas to green public spaces. | Preservation of existing green areas. | Placement of recycle boxes for each 400 m. |
| Environmental | Green spaces | Damage to the existing green areas | | | | | | | | | | | | | X | X | X | |
| | Energy efficiency | Heat Island affect | | | | | | | | | | | | | X | X | X | |
| | Mobility | Pedestrian circulation problems | X | X | X | X | X | | | | | | | | | | | |
| | | High density of vehicle traffic | X | X | X | X | X | | | | | | | | | | | |
| | | Problematic tram network causing conflicts in traffic flow | | | | X | | | | | | | | | | | | |
| | | Mislocation of bus stops | | | X | | | | | | | | | | | | | |
| | Air Quality | Excessive amount of exhaust gas. | X | | | | X | X | | | | | | | | | | |
| | Waste / Reuse / Recycle | Insufficiency of trash boxes and lack of recycle boxes. | | | | | | | | | | | | | | | | X |
| | Disaster Management | Insufficiency of earthquake and disaster assembly areas. | | | | | | | | | | | | | | X | X | |
| Social | Quality Public Space | Lack of quality open public spaces. | | | | | | | | | X | | | | | X | | |
| | Urban Safety | Unsafe conditions of pedestrian paths /overpass/underpass | | X | | | | | | | | X | X | | | | | |
| | | Excessive crowd on open air steep 25 meters escalator | | | | | | | | X | | | | | | | | |
| | Heritage | Idle buildings in historic center: the Hans Area | | | | | | | | | X | X | | | | | | |
| | Awareness | Accessibility | | | | | | | X | | | | | | | | | |
| | | Recycling | | | | | | | | | | | | | | | | X |
| | | Protection of public green areas | | | | | | | | | | | | | | | X | |
| | | Cultural Heritage | | | | | | | | | X | X | | | | | | |
| | Accessibility | Lack of visually impaired paths | | | | | | | X | | | | | | | | | |
| | Nuisance | High level of noise | X | | | | X | | | | | | | | X | | X | |
| | | Visual pollution (unplastered facades, AC units, signs..) | | | | | | | | | | | | X | X | | | |
| | | Exhaust odour | X | | | | X | X | | | | | | | X | | | |
| | Tourism | Unfunctionized and inactive of historic center | | | | | | | | | X | X | | | | | | |
| | Local Economy | Insufficiency of social services | | | | | | | | | X | X | | | | | | |
| Economic | Life Cycle Management of Urban Properties (Materials, Structures, Systems) | Need of redesigning for the bus stops in terms of climate conditions | | | X | | | | | | | | | | | | X | |
| | Idle Buildings | Unfunctionized and inactive of historic center | | | | | | | | | X | X | | | | | | |

The specific sustainable solutions for the selected axis are classified in different areas: solutions about mobility issues are increasement of pedestrianly movement based transportation, implementing crossovers and traffic lights on the axis, moving the existing tram network to a parallel street, implementing a bicycle path to the existing road, relocation of bus stops, increasement of traffic signs to prevent accidents and excessive usage of car horn, underground parking lots that ground levels are designed as open green public areas and encouraging electrical cars from macro scale by adding battery units in gas station on the axis.

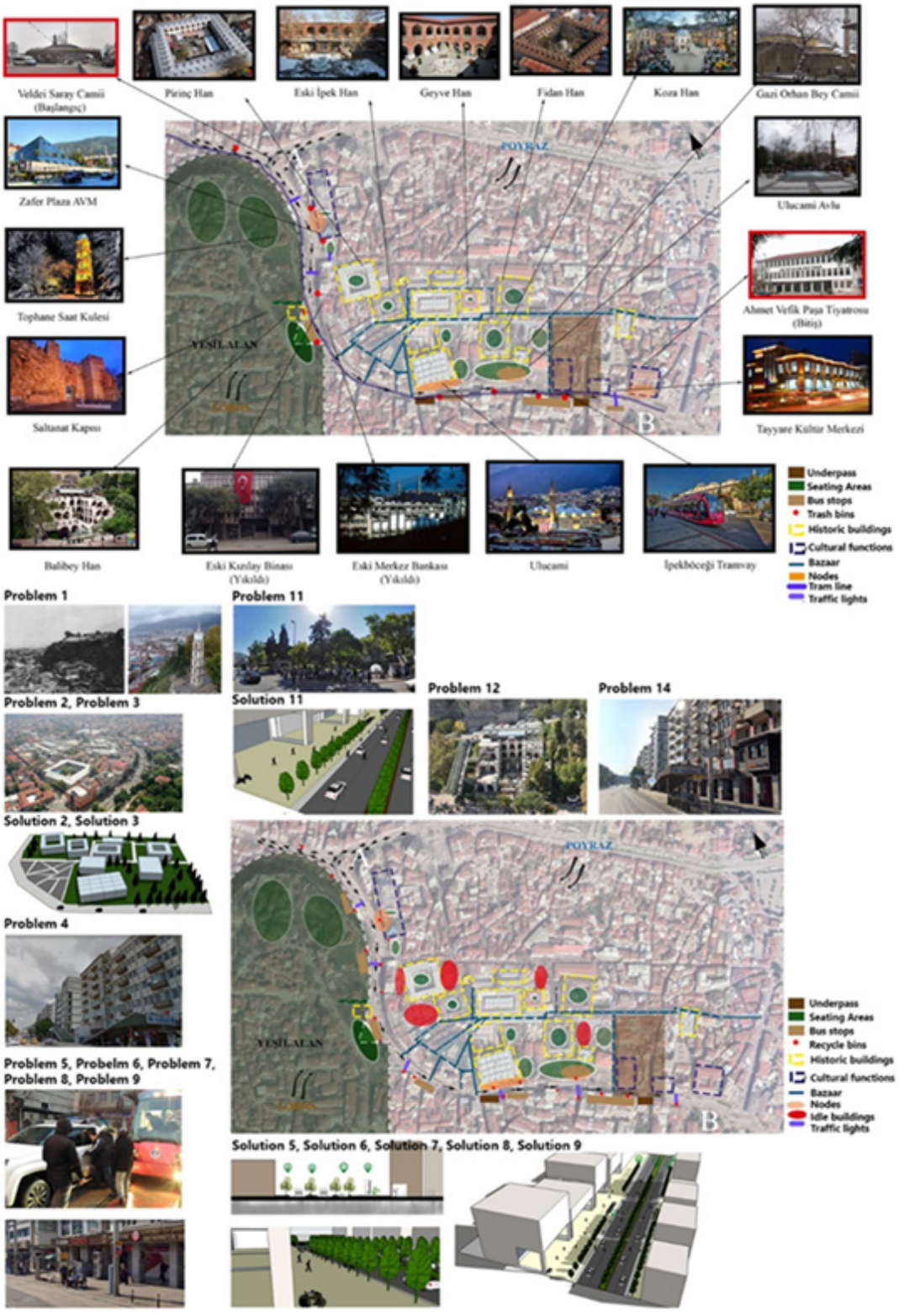


*Figure 5. Description and sustainability proposals for the axis in Bursa by M. Bakan.*

In addition, reconsideration of a new milder steep escalator system by arranging at different levels which includes landings is important for urban safety and connectivity. Integration of visually impaired paths is designed for the entrances of buildings, pedestrian paths and crossovers. In order to obtain green areas; afforestation on the axis, transformation of idle open areas and car parking areas to green public spaces and protection of existing green areas are planned. Also, this large green area is considered as earthquake and disaster assembly area. Transforming unemployed underground pass into a small-scale bazaar to improve local economy and solar panel-based lighting system to the underground pass are designed to have safer urban environment. Standardization about advertisement signboards and mesh panel systems for HVAC external units are proposed to solve visual pollution. For the continuity of cultural heritage; restoration, renovation and refunctioning the abandonment historical Hans area are planned which aims to transform Hans area into a cultural Han district with small exhibition areas, bookshops, cafes and performing areas. Placement of recycle boxes for each 400 m is planned.

### 3.5. Adıyaman

Adıyaman is a city in south eastern Turkey from 40,000 BC in bronze ages. Till Greco-Iranian Commagene kingdom was founded in 69BC [17]. The main economic activities are agriculture and tourism that is depended on Nemrut. In Adıyaman summers are very hot and very dry; winters are cool to cold with heavy precipitation. Due to its inland location and relatively high altitude, frost and snow are common. Major environmental problems are infrastructure, unplanned urbanization, insufficient landscaping, scarcity of green areas and air pollution in winter throughout the whole city [18].

*Table 7. Sustainability related problems – solution matrix for Adıyaman (Compiled by authors).*

| | | | SUSTAINABILITY SOLUTIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADIYAMAN: THE AXIS ON ATATURK BOULEVARD | | | Increasement of pedestrianial movement based transportation | Implementing a bicycle path to the existing road. | Encouraging electrical cars from macro scale | Underground parking lots | Integration of ramps and visually impaired paths. | Defining a proper function for the unfinished building | Completion of the unfinished construction work with sustainable approach and materials. | Increasement of traffic signs | Assigning sound absorber façade panels on building's ground level. | Assigning environmental friendly external wall systems | Standardization about signboards | Mesh panel systems for HVAC external units | Limitations and standardization about exterior extensions of cafes and restaurants. | Afforestation on the axis | Transformation of idle open areas to green public spaces | Placement of recycle boxes for each 400m. |
| SUSTAINABILITY ASPECTS | URBAN SUSTAINABILITY INDICATORS | SUSTAINABILITY PROBLEMS | | | | | | | | | | | | | | | | |
| Environmental | Green spaces | Lack of quality open public spaces. | | | | | | | | | | | | | | X | X | |
| | Energy efficiency | Facades without plasters and finishing materials. | | | | | | | | | X | X | | | | | | |
| | | Heat Island affect | | | | | | | | | | | | | | X | X | |
| | Mobility | Pedestrian circulation problems | X | X | | | | | | | | | | | | | | |
| | | High density of vehicle traffic | X | X | X | | | | | | | | | | | | | |
| | | Lack / Insufficiency of parking areas | | | | X | | | | | | | | | | | | |
| | Air Quality | Excessive amount of exhaust gas. | X | X | X | | | | | | | | | | | | | |
| | Waste / Reuse / Recycle | Insufficiency of trash boxes and lack of recycle boxes. | | | | | | | | | | | | | | | | X |
| | Disaster Management | Insufficiency of earthquake and disaster assembly areas. | | | | | | | | | | | | | | | X | |
| Social | Quality Public Space | Lack of quality open public spaces. | | | | | | | | | | | | | | | X | |
| | | Invasion of pedestrian paths by exterior seating extensions of cafes | | | | | | | | | | | | | X | | | |
| | Urban Safety | Unsafe conditions of pedestrian paths / overpass / underpass | | | | | | | X | X | | | | | | | | |
| | Heritage | NONE | | | | | | | | | | | | | | | | |
| | Awareness | Accessibility | | | | | X | | | | | | | | | | | |
| | | Recycling | | | | | | | | | | | | | | | | X |
| | Accessibility | Lack of ramps | | | | | X | | | | | | | | | | | |
| | | Lack of visually impaired paths | | | | | X | | | | | | | | | | | |
| | Nuisance | High level of noise | | | | | | | | X | X | | | | | X | | |
| | | Visual pollution. (unplastered facades, AC units, signs...) | | | | | | | | | | X | X | X | X | | | |
| | | Exhaust odour | X | X | X | | | | | | | | | | | X | | |
| | Tourism | NONE | | | | | | | | | | | | | | | | |
| | Local Economy | Insufficiency of social services | | | | | | X | | | | | | | | | X | |
| Economic | Life Cycle Management of Urban Properties (Materials, Structures, Systems) | NONE | | | | | | | | | | | | | | | | |
| | Idle Buildings | Unfinished construction works and buildings | | | | | | X | X | | | | | | | | | |


*Figure 6. Description and sustainability proposals for the axis in Adıyaman by Ş. Bozkurt.*

The selected axis is located on Atatürk Boulevard in the center of Adıyaman. The axis starts from Clock Tower and ends in Atatürk Street Intersection. The selected axis is 440 m long and includes banks, shopping areas and offices. It is a route for bus and minibus public transportation types.

As Adıyaman is located in the 1st-degree earthquake zone; the lack of earthquake assembly areas is one of the main problems on the axis. The specific sustainability problems about the axis defined in this study and are shown in Table 6. There are problems in mobility: high density of vehicle traffic, an excessive amount of exhaust gas results in decreasing air quality, insufficiency of parking areas, lack of bicycle roads and accessibility problems about missing ramps and visually impaired paths. Due to the high density of traffic, there is a nuisance of a high level of noise. Along the axis, there is no standardization on signboards, HVAC external units and TV satellite dishes on the facades which ends up in visual pollution. There are not enough open green areas. The main functions along the axis are based on trading and there are so many cafes and restaurants. There is an invasion of pedestrian paths by exterior seating extensions of cafes and restaurants. There are no recycle boxes to maintain lifecycle management. In the meantime, there is an idle building that has unfinished construction works causes urban safety problems as well as visual pollution.

The specific sustainable solutions for the selected axis are classified in different areas: solutions about mobility issues are increment of pedestrian movement-based transportation, implementing a bicycle path to the existing road, increment of traffic signs to prevent accidents, underground parking lots that ground levels are designed as open green public areas and encouraging electrical cars from macro-scale by adding battery units on the axis. Integration of ramps and visually impaired paths are designed for the entrances of buildings, pedestrian paths and crossovers. In order to improve green areas, afforestation on the axis and transformation of idle open areas and car parking areas to green public spaces are designed. Also, these green areas are considered as an earthquake assembly areas. Completion of the unfinished construction work with sustainable approach and materials and defining a proper function for the economy and social life of Adıyaman are planned. Also, a night lightening system based on solar energy is assigned to the whole axis which will improve urban environmental comfort and urban safety. Limitations and standardization about exterior extensions of cafes and restaurants are planned. Standardization about signboards and mesh panel systems for HVAC external units are proposed for the facades of buildings on the axis. Placement of recycling boxes for every 400 m is planned.

## 4. DISCUSSION

In this study, five different cities which are differentiated at HDI rankings and Forbes livability index were evaluated. Then, sustainability problems that were related to selected axes were defined. In this regard, European Commission's Science for Environment Policy was examined in detail and a new evaluation criterion with urban sustainability indicators in order to investigate environmental, social and economic sustainability were proposed.

In order to improve the sustainability of the axis, major urban sustainability indicators were defined with consideration of frequency and quantity of problems related to the indicator. The major eight indicators were mobility, urban safety, the existence of idle buildings, quality of open spaces, nuisance, recycling, green spaces and accessibility.

The urban metabolism framework has been created as a spider diagram in Figure 7. It shows the existing situation with a simple representation technique and a tool to understand and classify main problems easily as well as facilitating the linkage between the environment and economy [19, 20]. Spider diagram compares urban dynamics to organize data in a logical way as well as being a visual tool. This spider diagram framework shows the comparisons of existing sustainability urban situations of the axes on major eight sustainability indicators that are selected in this study. The levels of problems from 0 to 3 are classified according to quantity and quality of sub-problems from Table 3, Table 4, Table 5, Table 6, Table 7. Therefore, the spider diagram has been formed as in Figure 7.

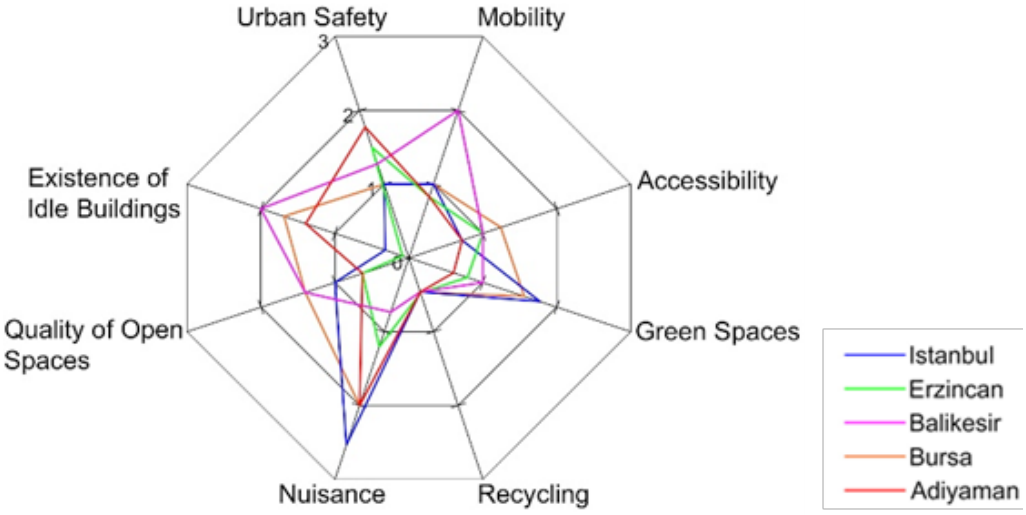


*Figure 7. The Urban Metabolism Framework. The Urban Metabolism Framework was tested on five representative cities: İstanbul, Erzincan, Balıkesir, Bursa and Adıyaman (Drawn by authors).*

As it is obvious in Figure 7, there is an urgent necessity to solve recycling and accessibility problems rapidly as their levels are the lowest in all five axes. Also, these problems can be solved relatively easily by the involvement of local authorities. In addition, public awareness has to increase; as the most important thing is not placing recycle boxes; but providing public to use them efficiently. Enlarging the green spaces are not only improves environmental conditions but also acts as disaster assembly areas.

Particularly for the whole five axes, existing earthquake assembly areas are not sufficient. According to Japan International Cooperation Agency (JICA), the gross minimum area of the assembly areas for the population living in that region is determined as 2 m2/person for the 1st-degree earthquake zones [21]. For the whole axes, this calculation should be done and aimed to be obtained this safe level. Moreover, nowadays as a result of the coronavirus pandemic; the necessity of quality of open public spaces is increased. While proposing sustainable urban models for axes, current coronavirus requirements should be taken into consideration.

## 5. CONCLUSION

As highlighted in the UN's report, today the Earth and all the livings are encountering immense challenges to sustainable development. Climate change, disasters, pandemics are real; there is no other option to think and imply sustainable solutions starting from the very micro scale. In this study, it is emphasized that thinking on a macro-scale while designing in micro is crucial. With an aim of having sustainable cities by 2030; five different city center axes were studied in this study as a starting point. Sustainable transformations on axes should be considered as parts of the whole world.

The objectives of this study are to measure and define the existing conditions of selected five different axes from Turkey in terms of urban sustainability from environmental, social and economic perspectives; and to sustainability transformation model on an urban scale. These five axes are examined according to urban sustainability indicators and solutions are generated via 2D&3D presentations and tables.

One of the main key findings of this study is; all five axes have limited sustainability features in terms of urban areas. Although, there is an insight about accessibility, there are misapplications and improper solutions in all city axes. Besides, there is a huge need for green areas as green areas are the main public recreation areas and disaster assembly areas. In addition, vehicle parking areas are problematic issues that are directly related to over-urbanization and the heat-island effect. Moreover, there are some obstacles in walkability as discontinuity of pedestrian axes exists.

Implications of the study can be listed as:

-Think in macro, design in micro

-Increase in sustainability awareness of public

-Protection of existing green areas and extension green areas

-Necessity of rearranging transportation system, considering the urban sustainability indicators

-Implication of sustainability plans as soon as possible by local authorities and government agencies

-Covering sustainability subjects in architecture education in various courses.

For further studies, this model should be considered as a prototype that can adapt to similar urban areas; not only for city centers but also all around the city. For future studies, this study should be considered as a guideline about sustainable transformations about axes in the urban context, and aimed to be a resource for government and local authorities. In addition, local authorities could use the urban sustainability indicators to obtain the problems and solutions rapidly.

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