EVALUATING THE IMPACTS OF GEOTHERMAL ENERGY PLANTS ON QUALITY OF LIFE: CASE OF ALASEHIR (MANISA)

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ABSTRACT

EVALUATING THE IMPACTS OF GEOTHERMAL ENERGY PLANTS ON QUALITY OF LIFE: CASE OF ALASEHIR (MANISA)

Quality of life has been handled with different approaches by many disciplines from past to present, and it has started to be used frequently in the international agenda in order to meet the needs of the increasing world population and to find solutions to problems such as climate change. Due to the multidimensional and complex nature of the concept, there is no consensus on the definition and measurement method. Quality of life definitions, and indicators varies in the context of scale, approach, and method. The study concentrates on the perceived quality of life of people close proximity to geothermal power plants in the case of Alaşehir.

First, the indicators used in neighbourhood, rural and environmental quality of life studies were examined and grouped under the parameters of built environment, accessibility, vulnerability, degradation, health, contamination, and resilience. Then, the historical background, usage, geothermal systems, environmental impacts and social acceptance of geothermal energy and geothermal energy studies in Turkey were evaluated. As a result of this evaluation, the participation parameter was added to the research. In line with socio-spatial analysis, the areas under the influence of geothermal power plants were determined and semi-structured interviews were conducted with the parameters. As a result of the analyses and interviews, it has been determined that the impact of geothermal energy on the quality of life in Alaşehir district is perceived through agricultural production. Contamination, vulnerability, and participation parameters come to the fore, and show that geothermal power plants negatively affect the perceived quality of life.

Keywords*:* *Perceived Quality of Life, Geothermal Energy, GIS.*

ÖZET

JEOTERMAL ENERJİ SANTRALLERİNİN YAŞAM KALİTESİ ÜZERİNE ETKİLERİNİN DEĞERLENDİRİLMESİ: ALAŞEHİR (MANİSA) ÖRNEĞİ

Yaşam kalitesi kavramı, geçmişten günümüze birçok disiplin tarafından farklı yaklaşımlarla ele alınmış olup günümüzde artan dünya nüfusunun ihtiyaçlarının karşılanması ve iklim değişikliği gibi problemlere çözüm üretebilmek amacıyla uluslararası gündemde sıklıkla kullanılmaya başlanmıştır. Kavramın çok boyutlu ve karmaşık yapısı sebebiyle fikir birliği sağlanmış bir tanımı ve ölçüm yöntemi bulunmamaktadır. Yaşam kalitesi tanımları ve indikatörleri ölçek, yaklaşım, ve yöntem bağlamında değişiklik göstermektedir. Çalışma, Alaşehir örneğinde jeotermal santrallere yakın insanların algılanan yaşam kalitesine odaklanmaktadır.

Çalışmada ilk olarak mahalle, kır ve çevresel yaşam kalitesi araştırmalarında kullanılan indikatörler incelenerek yapılı çevre, erişilebilirlik, kırılganlık, degradasyon, sağlık, kontaminasyon, ve dirençlilik parametreleri altında gruplandırılmıştır. Daha sonra jeotermal enerjinin tarihsel arka planı, kullanım alanları, jeotermal sistemler, çevresel etkileri ve sosyal kabulü ile Türkiye’deki jeotermal enerji çalışmaları değerlendirilmiştir. Bu değerlendirme sonucunda katılım parametresi yaşam kalitesi araştırmasına eklenmiştir. Sosyo-mekansal analizler doğrultusunda jeotermal enerji santrallerin etki alanları tespit edilmiş ve bu alanlarda literatür araştırması sonucu belirlenen parametreleri içeren yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Analizler ve görüşmeler neticesinde Alaşehir ilçesinde jeotermal enerjinin yaşam kalitesi üzerindeki etkisinin tarımsal üretim üzerinden algılandığı, kontaminasyon, kırılganlık ve katılım parametrelerinin ön plana çıktığı, ve jeotermal enerji santrallerinin algılanan yaşam kalitesini olumsuz etkilediği tespit edilmiştir.

Anahtar Kelimeler: *Algılanan Yaşam Kalitesi, Jeotermal Enerji, Coğrafi Bilgi Sistemleri.*

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LIST OF ABBREVIATIONS

CH_4: Methane

C/N: Carbon to Nitrogen

CO_2: Carbon Dioxide

CORINE: Coordination of Information on the Environment

DSI: General Directorate of State Hydraulic Works

EEC: European Environment Agency

GIS: Geographic Information Systems

H_2O: Hydrogen Oxide

H_2S: Hydrogen Sulphide

IEA: International Energy Agency

MW: Megawatt

NDVI: Normalized Difference Vegetation Index

NH_3: Ammonia

PM10: Particulate Matter 10

QoL: Quality of Life

TSI: Turkish Statistic Institute

USA: United States of America

USD: United States Dollar

WHO-QOL: World Health Organization Quality of Life

WHOQOL-BREF: World Health Organization Quality of Life- Brief

CHAPTER 1

INTRODUCTION

1.1. Background of the Study

Since the quality of life is related to every aspect of human life, it has been addressed by many disciplines such as philosophy, psychology, sociology, economics, political sciences, and planning from past to present. The multidimensional and complex nature of the concept causes the lack of a definition and conceptual framework accepted by all disciplines. Dealing with the quality of life has always been an issue in the literature. Aristotle declared that a good life is a virtuous life. This approach forms the basis for studies linking quality of life to happiness. The social indicators movement, which emerged in the 1960s in response to the fact that quality of life was treated only in terms of economic indicators, contributed to the systematization of studies on quality of life.

Marans, and Rodgers (1975), Campbell (1976), Shafer et. al. (2000), and Pacione (2003) have contributed to the conceptual framework of quality of life through the models they have developed. There are two basic measurement methods used in quality of life studies: objective and subjective. While the objective approach uses secondary data to measure whether established standards of living are met, the subjective approach uses methods such as surveys and interviews to measure how individuals perceive the environment in which they live.

Measuring quality of life only with objective or subjective indicators has been criticized by many researchers. McCrea (2007) states that measuring the quality of life by using objective and subjective indicators together is a research gap in the literature. Marans (2003) states that geographic information systems are an appropriate tool to assess objective and subjective dimensions together in different scales.

Quality of life dimensions and indicators vary by scale, such as national, regional, urban, rural, and neighborhood. Neighborhood quality of life studies use indicators of the environmental and social characteristics of neighborhoods, people's perceptions of and satisfaction with these characteristics, and accessibility to public services and amenities. Rural quality of life studies are usually measured using agricultural and health-related indicators.

To meet the needs of the world's growing population and find solutions to problems such as climate change, terms such as sustainability, quality of life and environmental quality are increasingly used in the international agenda. The 2030 Agenda for Sustainable Development was adopted by United Nations member states in 2015 and set 17 Sustainable Development Goals. The Sustainable Development Goals focus on ending poverty, reducing inequality, controlling climate change, protecting natural resources, and promoting clean energy. In this context, studies on the quality of life in the environment have increased in recent years. Van Camp. et. al. (2003) mention that environmental quality of life is a *container concept* because terms such as environmental quality, sustainability, quality of life, quality of place can be used interchangeably.

The Paris Agreement, which is the first internationally binding agreement regarding environmental problems, was accepted by 196 countries in 2016. The main focus of the agreement is to limit global warming and reduce greenhouse gas emissions. The International Energy Agency (2021) mentions that the climate change challenge is an energy challenge, and the Paris Agreement is a milestone in the fight against climate change. The use of renewable energy sources in coping with climate change is becoming widespread, according to the IEA's Global Energy Review, global demand for renewable energy increased by 3% in 2021.

Geothermal energy, which is one of the renewable energy sources, is an advantageous source because it is proportionally distributed around the world and is less affected by climatic conditions than other renewable energy sources. The temperatures of geothermal energy fields vary depending on their location in the world. Depending on the temperatures of the geothermal energy sources, the areas of use and geothermal systems also differ.

Studies on geothermal energy focus on issues such as life cycle assessments, efficiency, and environmental impact. In recent years, studies on the social acceptance of geothermal energy have also increased. For geothermal energy to spread and develop, the impact of geothermal energy use on quality of life should be addressed with a holistic approach.

1.2. Aim of the Thesis

For the widespread use of renewable energy, which is important for sustainable development, it is important to consider the impacts of renewable energy resource use on the quality of life with a systematic approach. In this study, dimensions, and assessment tools of objective, and perceived quality of life are examined that can reveal the impacts of a special domain as geothermal energy on perceived quality of life. The possible impacts of geothermal energy on the perceived quality of life is examined through the case of Alaşehir, where many geothermal power plants are located.

1.3. Methodology

This study seeks to answer how geothermal energy, affects the perceived quality of life in Alaşehir district. The sub-questions are as follows:

- What are the dimensions, indicators, and tools for measuring domain specific quality of life ?
- How can an objective and a perceived assessment of quality of life be integrated in order to face complex environmental and community challenges ?
- What types of quality of life dimensions can explain the perceived assessments of geothermal-related quality of life?

This study, which seeks answers to the questions stated, includes a qualitative approach. The study consists of three main stages: reviewing and categorizing the indicators, methods, and approaches of neighborhood, rural and environmental quality of life studies, evaluating the geothermal energy challenges for environment and society and the case study analysis.

The case study consists of two main parts: the socio-spatial analysis and the perceived quality of life analysis. Statistical and spatial data were used in the socio-spatial analysis part. For the analysis of perceived quality of life, primary data obtained through semi-structured interviews. The subjective part were organized with the snowball sampling method covering interviewees close proximity to geothermal power plant sites.

1.4. Structure of the Thesis

This study consists of five chapters. The first chapter contains the background and purpose of the research and the method used in the study. In the second chapter, the definition of the concept of quality of life, measurement methods, indicators, and methods used in the neighborhood, rural and environmental quality of life studies are included. The third chapter of the study consists of the historical background of geothermal energy, area of use, geothermal energy systems, environmental impacts, and social acceptance of geothermal power plants and geothermal energy studies in Turkey. Chapter 4 starts with the case study methodology and continues with general information about Alaşehir and socio-spatial analyses. At the end of chapter 4, perceived quality of life is evaluated. The last chapter is the conclusion.

CHAPTER 2

QUALITY OF LIFE

2.1. Quality of Life: Definitions and Conceptions

Since the quality of life is a complex and multidimensional concept, there is no clear definition. It is treated with different approaches by different disciplines such as philosophy, psychology, sociology, economics, political science, and planning. The concept of quality of life has always been in the field of philosophy (Veenhoven, 2007) and has started to be addressed with approaches that focus on individual satisfaction (Sarı and Kındap, 2018). Based on Aristotle's idea that a good life is a virtuous life, quality of life has been evaluated as synonymous with "happiness" (McCrea, et. al. 2011). This approach forms the basis for studies that focus on measuring the quality of life through happiness.

With the emergence of the social indicators movement in the 1960s as a reaction to the measurement of quality of life by purely economic indicators, the concept of quality of life began to enter the sphere of interest of the social sciences. It became an academic discipline with the scientific journal Social Indicators Research, which was started to be published in 1974 (Maclean and Salama, 2019). With the establishment of the International Society for Quality-of-Life Studies in 1995, the concept was institutionalized and began to be treated more systematically (Veenhoven, 2007). The development of information and communication technologies and the facilitation of data collection and processing methods also contributed to the systematization of the concept.

With the prominence of the sustainability approach in recent years, urban and environmental quality of life issues have attracted the attention of researchers in the planning literature and developing remote sensing technologies allow for a more comprehensive approach of the studies.

The scope and measurement methods of the quality of life have always varied and have generated controversy in the literature. Definitions of quality of life in the literature depend on factors such as scale (individual, community, rural, national), approach (individual well-being and satisfaction, health-related quality of life, place-based quality of life, etc.), and research method (subjective, objective, or both).

Campbell et. al. (1976), define the quality of life as “satisfaction” because of its adaptability to a study design that sought a series of measures from separate domains of life rather than a single global measure. When they are saying “single global measure” they are referring to the concept of happiness. As shown in Figure 2.1, overall life satisfaction depends on the evaluation of a particular domain related to the objective environment and the way it is perceived by a person. Campbell's (1976) model is one of the first examples of studies on satisfaction and subjective well-being and is one of the most cited studies in the literature. The model is an adapted version of the approach of Marans and Rogers (1975), which explains the quality of urban life in terms of satisfaction with housing, neighborhood, and city for all aspects of life (from Salihoğlu, 2016).

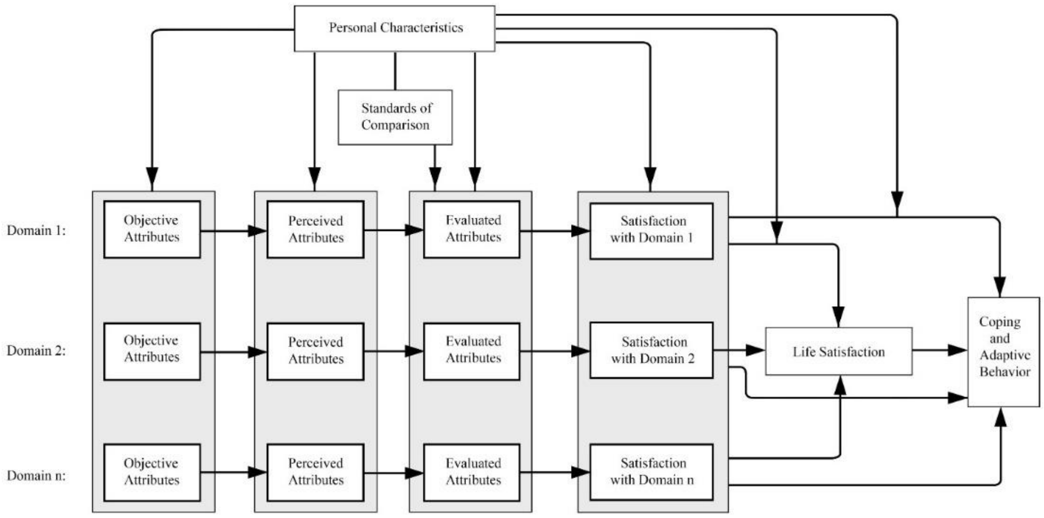

Figure 2.1. Relationships among domain satisfaction levels and the general life satisfaction (Source: Campbell et. al., 1976)

Similarly, Felce and Perry, (1995) defined quality of life as “an overall general well-being that comprises objective descriptors and subjective evaluations of physical, material, social, and emotional wellbeing along with the extent of individual development and purposeful activity, all weighted by a personal set of values".

WHO-QOL Group (1993) described QoL as "an individual's perception of their position in life within the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns."

Veenhoven (2007) and, Rejeski and Mihalko (2001) defined quality of life as an "umbrella term" to emphasize that the concept of quality of life is a socio-psychological construct (from Salihoğlu, 2016).

Pacione (2003) evaluated the approach that general life satisfaction is the sum of satisfaction in different domains of life as the simplest quality of life model and developed a five-dimensional model consisting of domains (level of generality/specificity), scale-level (geographical scale from national to local), time frame, indicator type (objective/subjective), and social groups (by class, age, etc.) (Figure 2.2). This model is an important guide in determining the indicators while evaluating the quality of life in the context of a specialized subject (Velibeyoğlu, 2014).

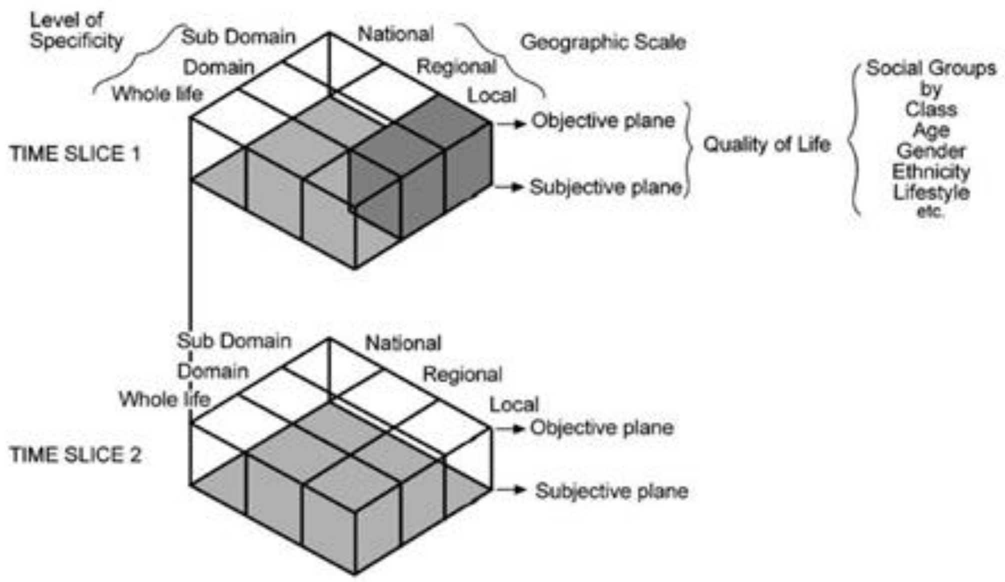

Figure 2.2. A five-dimensional structure for quality of life research
(Source: Pacione, 2003)

Shafer et. al. (2000), in their study examining the impact of greenway facilities on quality of life through user perceptions, stated that economic, social, and environmental aspects should be considered together for a sustainable community and developed a model showing that quality of life is created through the interaction between community, environmental and economic qualities (Figure 2.3). This model is based on the human ecosystem approach. While domain specificity is central to the model, the relationship between time, personal experience, objective and subjective indicators, and different scales has not been fully defined (Maclean and Salama, 2019).

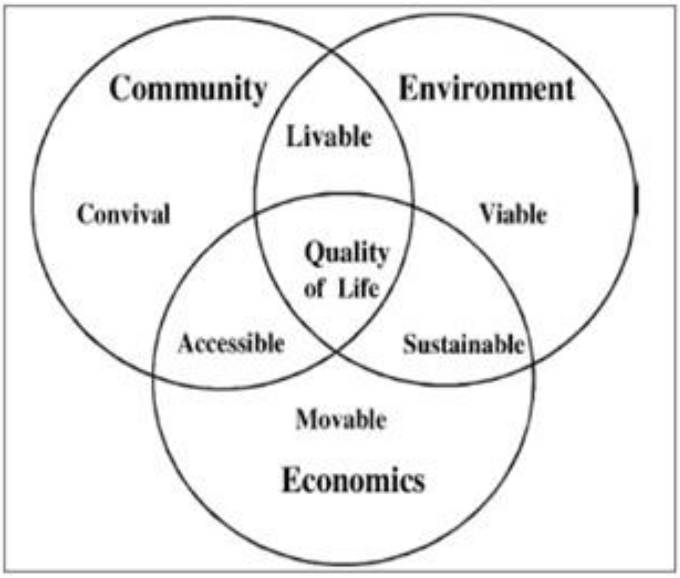

Figure 2.3. Quality of life in a human ecological perspective

(Source: Shafer et. al., 2000)

Biagi et. al. (2018) defined quality of life as an important element of competition between cities, regions, and countries and stated that the concept of quality of life depends on internal (status, gender, age, education, culture, and ethnicity of the population) and external (the quality and quantity of public services, built and natural environment, cultural amenities, and intangible factors such as human relations and social and human capital) factors.

Campbell (1976), Veenhoven (2007), Pacione (2003), Marans and Rogers (1975), and Shafer et. al. (2000) have contributed to building the conceptual framework by defining quality of life. Due to the multidimensional and complex nature of the concept, many researchers have attempted to assess the quality of life using measurement methods rather than providing clear definitions. Three main models (Campbell et. al. (1976), Pacione (2003), and Shafer et. al. (2000)) that influence the quality of life studies address quality of life with a domain-specific approach.

Maclean and Salama (2019), compared the quality of life models through context, outcomes, and core dimensions (Table 2.1). All three studies attempted to define life domains and life domains/scales. However, the dimensions of time, context, and culture were defined only in Pacione's (2003) model.

Table 2.1. Comparison of three quality of life models

(Source: Mclean and Salama, 2019)

	Marans & Rodgers, 1975	**Shafer et al., 2000**	**Pacione, 2003**
Introduction	Meta-theory model that joins a broad theoretical framework. Useful for conceptualising a variety of findings on satisfaction with urban living	Conceptual model based on the humans ecosystems perspective	Five dimensional structures of QOUL research. Tackles urban environmental quality and human well-being from a social geographical perspective
Context in which the model was designed and tested	Michigan, USA	Texas, USA	Scotland
Expected and intended outcomes	Inform planning and policy decisions	For policy use	Positively affecting and evaluating policies and increasing public participation
Core Dimensions			
Living Domains	Addressed Implicitly	Addressed Explicitly	Addressed Implicitly
Life domains/Scale	Addressed Explicitly	Addressed Implicitly	Addressed Explicitly
Context and Culture	Not Addressed	Not Addressed	Addressed Implicitly
Objective and Subjective Indicators	Addressed Explicitly	Not Addressed	Addressed Explicitly
Personal Experience	Addressed Explicitly	Not Addressed	Addressed Implicitly
Time	Not Addressed	Not Addressed	Addressed Explicitly

2.2. Measuring Quality of Life

The lack of an interdisciplinary comprehensive definition and conceptual framework for the concept of quality of life has led researchers to identify indicators. Stimson and Marans (2011) explain that indicators should be determined and observed to see how and to what extent these indicators change over the process to understand the quality of life in a particular setting such as the city. As a result of these efforts to identify indicators, quality of life has begun to become more systematic in the planning literature. There are two main methods of measurement used in quality of life studies: subjective and objective.

2.2.1. Objective Measurement of Quality of Life

Objective measurement of quality of life calculated using statistical data such as population, age, education level, income level, unemployment. Stimson and Marans (2011) mention that there are two basic approaches to the objective measurement of quality of life as *social indicators* and *weight*. Stimson and Marans (2011) evaluated the social indicators approach as the simplest among the measurement methods of quality of life. As in the social indicators approach, secondary data is used in the weight approach. Unlike the first approach, the determined indicators get weights. In both approaches, it tested whether standards set for different dimensions of quality of life were met.

Today, objective measurement methods are used for indexes and rankings (Mercer's Quality of Living Ranking, Human Development Index, Active Aging Index, etc.) for different dimensions of quality of life on global, national, and city-wide comparisons. Measuring the quality of life with purely objective methods is criticized by many researchers because although the objective indicators are above the determined standards, people may have a low level of quality of life due to their problems such as psychological problems, personal health problems, relationships with relatives.

2.2.2. Subjective Measurement of Quality of Life

Campbell's (1976) study is important for beginning to include individuals' perceptions as well as objective conditions in studies of quality of life. In the subjective measurement method, people's perceptions and satisfaction are measured using primary data, generally obtained through surveys and face-to-face interviews. Although the development of information and communication technologies and the ability to conduct surveys on websites are important for the collection of primary data, this is not always a useful tool depending on the focus group of the study. Field research is particularly necessary for studies focusing on disadvantaged groups without Internet access. There are very few studies of subjective quality of life at the national, international, or metropolitan level, as it is a time-consuming and labor-intensive method to collect data through field studies. The studies that do exist are large-scale studies funded by public agencies or international organizations. Studies that deal with quality of life in a particular area are usually on the scale of a city, a neighborhood, or a rural settlement.

Subjective measurement methods based on individual assessments are often criticized in the literature because the personal characteristics of individuals can easily influence their perceptions. McCrea et. al. (2011) state that a process of adaptation can occur when people's expectations and the characteristics of the environment in which they live become interwoven over time. In this adjustment, the person whose expectations have decreased may say that they are satisfied even if the living environment has poor conditions.

2.2.3. Linking the Objective and Subjective Measurement of Quality of Life

Measuring quality of life exclusively by objective or subjective methods is often criticized in the literature for the reasons mentioned in the previous sections. Zapf (1984), in his study of well-being and quality of life, mentions four situations involving objective living conditions and subjective evaluations of individuals. The "dissatisfaction dilemma" is the situation in which an individual characterizes his/her own living conditions as very bad, while objective indicators show the opposite. "Satisfaction paradox" is the situation in which people evaluate their living conditions positively, although according to objective evaluations they live in poor conditions (from von Wirth, 2015).

Figure 2.4. A research gap in the urban quality of life literature

(Source: McCrea, 2007)

Noting that there is a research gap in linking subjective and objective approaches in quality of life studies (see Figure 2.4), McCrea (2007) examined the links between objective and subjective dimensions of the urban environment using Geographic Information Systems (GIS) in the case of Southeast Queensland, Australia. Similarly, Marans (2003) examined objective conditions and people's subjective and behavioral responses to those conditions in the case of Detroit Metropolitan Ares using a merged dataset (see Figure 2.5). This dataset contains both subjective and objective data that was also merged using the GIS tool. GIS is an important tool for developing a holistic approach to quality of life studies. The use of GIS is often preferred by researchers in studies where the quality of life is addressed along with subjective and objective indicators on different scales.

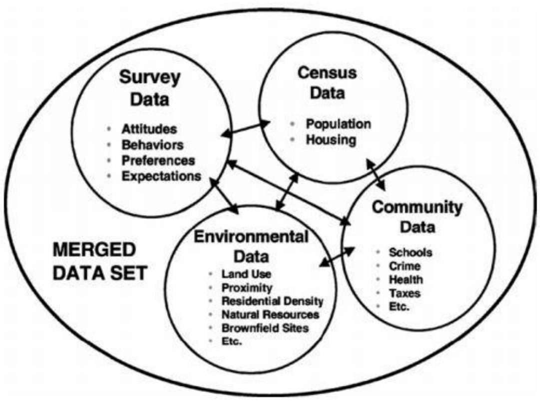

Figure 2.5. Merged data set

(Source: Marans, 2003)

For the purposes of this study, the explanation and grouping the indicators will be investigated in neighborhood, rural, and environmental quality of life studies literature consecutively.

2.3. Neighborhood Quality of Life

The addition of the spatial dimension to quality of life has created an academic field of study to measure quality of life at different scales such as urban, neighborhood, and rural. In studies conducted at the neighborhood level, the environmental characteristics of the neighborhood, people's perceptions of and satisfaction with these characteristics, the social and technical amenities surrounding the residence, and the accessibility of these areas inform how the neighborhood quality of life dimension is treated by researchers.

Table 2.2. Indicators used in neighborhood quality of life studies

Main Indicators	Sub-Indicators	Empirical Studies
Built Environment	Built-up density, urban texture, slope, traffic, quality of housing, natural environment, air and noise quality, architectural characteristics, land use and land cover, public green spaces, parking spaces, quality of roads, sidewalks, cleanliness, greenness, recreational/leisure facilities.	Kazemzadeh-Zow et. al., 2018; Zhang et. al., 2020; Delmelle and Thill, 2014; Oktay and Marans, 2010; Parra et. al. 2010, Rogers et. al., 2011; Apparicio et. al., 2008; Jun 2006; Fisher and Li, 2004; Lo and Faber, 1997; Russ-Eft, 1979.
Accessibility	Educational, health care, governmental, religious, security, recreational, sports, transportation, infrastructural, cultural, and commercial services	Abd El Karim and Awawdeh, 2020; Omazic and Borcic, 2019; Kazemzadeh-Zow et. al. 2018; Zhang et. al., 2020; Ebrahimzadeh et. al., 2016; Gandelman et. al., 2012; Oktay and Marans, 2010; Appracio et. al., 2008; McCrea et. al., 2006.

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Vulnerability	Literacy, employment rate, income, divorce rate, social anomaly, sex ratio, public guardianship, age, number of children in the home, home ownership/renter status, neighbourhood tenure, health status, pop. /Housing density, housing value, marriage status,	Kazemzadeh-Zow et. al., 2018; Talmage et. al., 2018; Zhang et. al., 2020; Delmelle and Thill, 2014; Erin et. al., 2012; Parra et. al., 2010; Rogers et. al., 2011; Apparicio et. al., 2008; Li and Weng, 2007; Rinner, 2007; McCrea et. al., 2006; Jun 2006; Fisher and Li, 2004; Jensen et. al., 2004; Lo and Faber, 1997.
Degradation	Air quality, traffic, noise, garbage collection, maintenance of cleanliness, greenness, soil moisture and contamination, vegetation health, land surface temperature, water pollution, impervious surface, vegetation index (NDVI)	Omazic and Borcic, 2019; Kazemzadeh-Zow et. al., 2018; Ebrahimzadeh et. al., 2016; Discoli et. al., 2014; Li and Weng, 2007; Jun 2006; Lo and Faber, 1997; Russ-Eft, 1979.

To understand how the quality of life is managed at the neighborhood level, the indicators used in the studies are categorized as built environment, accessibility, vulnerability, and degradation (see Table 2.2). The built environment, which is the first of the main dimensions, is studied in the measurement of quality of life under the title of physical indicator (Kazemzadeh et. al, 2018; Delmelle and Thill, 2014; Oktay and Marans, 2010; Apparicio et. al, 2008; Rogers et. al, 2011; Russ-Eft, 1979) and environmental indicator (Omazic and Borcic, 2019; Zhang et. al, 2020; Parra et. al, 2010; Jun, 2006; Lo and Faber, 1997). Built-up density, traffic, urban texture, slope, accessibility, housing quality, infrastructure, public transportation, land use, road structures are used as physical indicators, while public green spaces, air and noise quality, traffic, land use and land cover, quality of roads, natural environment, architectural features, parking spaces, etc. are considered as environmental indicators.

Accessibility is one of the most commonly used indicators to measure quality of life at the neighborhood level. Accessibility has been addressed using objective (Abd El Karim and Awadeh, 2020; Kazemzadeh-Zow et. al, 2018; Appracio et. al, 2008), subjective (Zhang et. al, 2020; Ebrahimzadeh et. al, 2016; Gandelman et. al, 2012; Oktay and Marans, 2010) and both objective and subjective (Omazic and Borcic, 2019; McCrea et. al, 2006) approaches. Abd El Karim and Awawdeh (2020) measured quality of life in Buraidah city using accessibility to education, health, government, religion, security, recreation, and sports services. Similarly, Kazemzadeh-Zow et al. (2018) measured quality of life using environmental, physical (infrastructural), and socio-economic indicators, where accessibility was considered as access to urban services under the title of physical (infrastructural) indicators. Appracio et. al. (2008) examined the quality of the urban environment around public housing in Montreal using social, physical, and accessibility indicators for services and facilities. In these studies, quality of life was measured using GIS with an objective approach. Accessibility is a commonly used indicator in studies where quality of life is measured with GIS by using objective indicators.

Zhang et. al. (2020) studied accessibility under the title of environmental factors and listed accessibility as facilities/services, public transportation, public spaces, health and safety facilities, physical activity, and recreational facilities. Ebrehimzadeh (2016) examined accessibility as urban services and transportation networks. Gandelman et. al. (2012) evaluated infrastructure elements such as electricity, running water, sewage, drainage, garbage disposal as public goods and discussed accessibility through these variables. In their quality of life research, Biagi et. al. (2018), measured accessibility to amenities, services, and disamenities, and evaluated environmental factors such as air quality, cleanliness, and noise as disamenity.

Vulnerability indicators are used at the neighborhood, rural, urban, national, and international levels for quality of life. At the neighborhood level, vulnerability is measured under socio-economic (Kazemzadeh-Zow et. al, 2018; Li and Weng, 2007; Jun 2006; Jensen et. al, 2004; Lo and Faber, 1997), demographic (Talmage et. al., 2018; Rogers et. al., 2011), descriptive (Zhang et. al., 2020), social (Delmelle and Thill, 2014; Apparicio et. al., 2008) and socio-demographic (Erin et. al., 2012; Parra et. al., 2010) dimensions. Parra et. al. (2010) assessed the elderly as a vulnerable group in their study of health-related quality of life in Bogota. Fisher and Li (2004) evaluated the quality of life at the neighborhood level using walkability and similarly identified the elderly as the focus group of the study. Vulnerable groups can be determined before work begins, as well as emerge as a result of analysis during the work process.

The last main indicator, degradation, is addressed in neighborhood quality of life studies under the title of an environmental indicator. The use of satellite imagery as an information source in studies that specialize in degradation and quality of life, and the analysis of this imagery via GIS is a method that has attracted the attention of researchers in recent years.

As the scale ranges from the city to the residential environment, it can be seen that due to the difficulty of obtaining objective data that allows comparison, research on the quality of urban life has begun to focus on the quality of experience in the residential environment and is mostly designed to measure household perceptions and satisfaction (Salihoğlu, and Türkoğlu, 2019).

2.4. Rural Quality of Life

Rural quality of life is also one of the topics frequently discussed in the literature. Rural quality of life studies mostly focuses on agriculture and health-related quality of life. Bernard (2018) defines the lack of a qualified workforce and the lack of accessibility to various opportunities and public services as the main problems of rural settlements. Küçükoğul and Türkoğlu (2021) pointed out that many components affecting daily life as well as economic activities have a positive or negative impact in rural settlements as well as in urban areas and that it is important to determine spatial, sociological, cultural, economic, and other parameters to determine the quality of life in rural areas.

Table 2.3. Indicators used in rural quality of life studies

Main Indicators	**Sub-Indicators**	**Empirical Studies**
Health	Health services, healthcare expenditures, number of hospital beds per 1000 people, physical health, bodily pain, mental health, medical aids, memory and concentration, self-esteem, rural life expectancy, rural mortality, rural infant mortality, the number of rural mother's deaths, current smoker and drinker, depression level, hypertension, chronic kidney disease, stroke.	Qu et. al., 2019; Nguyen et. al., 2020; Liang and Xu, 2020; Yodmai et. al., 2018; Karimi and Astane, 2021; Fang et. al., 2020; Liu et. al., 2008; Chen et. al., 2017; Esmaeili et. al., 2019; Soroushmehr et. al., 2018; Bukenya et. al., 2003)

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Accessibility	Educational, health and social care, commercial, sports, cultural and artistic, financial and credit services, police stations, public transportation, gas stations, healthy drinking water, landfill sites, internet.	Alavizadeh et. al., 2018; Karimi and Astane, 2021; Fang et. al., 2020; Qu et. al., 2019; Esmaeili et. al., 2019)
Vulnerability	Job, income, expenditures, education, ethnicity, age, gender, marital status, number of family members living in the same household, public safety, social interaction, number of working family members, social solidarity, life expectancy, health, community participation, savings, number of rural with electricity, gas piping, telephone, kitchen, bathroom, internet and sanitary water, agricultural entrepreneurial income, agricultural productivity, agricultural trade, religion.	Balasescu and Dovleac, 2016; Bukenya et. al., 2003; Bernard, 2018; Seangpraw et. al., 2019; Alavizadeh et. al, 2018; Soroushmehr et. al., 2018; Karimi and Astane, 2021; Liang and Xu, 2020; Nguyen et. al., 2020; Esmaeili et. al., 2019)
Contamination	Using sanitary methods for garbage disposal, soil erosion, destruction, rate of centralized treatment of rural domestic garbage and sewage, forest coverage, noise pollution, desire to migrate, discharge of groundwater resources, the amount of pesticide use and chemical fertilizer, generate energy from renewable resources, amount of nitrate emissions in the agricultural sector, amount of CO2 emissions, annual precipitation, farmland bird index, soil organic matter in arable land, habitation level.	Karimi and Astane, 2021; Fang et. al., 2020; Esmaeili et. al., 2019; Soroushmehr et. al., 2018; Balasescu and Dovleac, 2016; Liu et. al., 2008; Kachniewska, 2015)

As a result of the literature review, the indicators used in rural quality of life studies are categorised into four main dimensions: Health, Accessibility, Vulnerability, and Contamination (see Table 2.3). Health-related quality of life studies focus on the impact of environmental and social factors on health (Velibeyoğlu, 2014). Health indicators of rural quality of life focus on both mental and physical health (Liang and Xu, 2020; Qu et. al, 2019; Chen et. al, 2017; Liu et. al, 2008). Nguyen et. al. (2020) divided health indicators into physical health and mental health in their study on the quality of life of farmers in Vietnam. In some studies, WHOQOL-BREF is used when considering the subjective dimension of health-related rural quality of life (Nguyen et. al., 2020; Qu et. al., 2019; Chen et. al., 2017).

Accessibility is considered in some studies as accessibility to education, health, public spaces, and facilities, while in other studies it is considered as accessibility to infrastructure services such as healthy drinking water and internet services. Soroushmehr et al (2018) examined the quality of rural life on three basic parameters as economic, social, and environmental, and considered the number of houses benefiting from infrastructure services such as electricity, gas pipelines, telephone, internet, and sanitation as a social indicator. In rural quality of life studies, the number of households with access to basic infrastructure services is also considered as an indicator of vulnerability along with demographic indicators.

Rural development and rural life quality are related to agricultural activities. For this reason, pollutants that can directly affect agricultural production are included as indicators in rural life quality studies. Soroushmehr et al. (2018) evaluated the pollutants in the context of agricultural production and used the amount of pesticide, chemical fertilizer, nitrate emissions, and CO_2 emissions variables. Underground and surface water quality, garbage, and waste treatment are also used in studies as important variables for rural life quality. Esmaeili et al. (2019) stated that the analysis of quality of life should be considered together with external factors such as living in the countryside, getting married, the desire to have a child, the desire to move to the city, job, and life satisfaction, and included the desire to migrate variable in the environmental quality parameter. Analysing the effect of pollutants on the decision to move from the countryside brings a different perspective to rural quality of life research.

2.5. Environmental Quality of Life

In environmental quality of life studies, the environment is considered by many researchers as the built environment. Rogerson (1995) says that the environmental quality of life consists of external conditions (material life arena) and internal factors (personal life arena) (see Figure 2.6). According to this model, the material life arena consists of goods, services, and social, physical, and economic environment, and the personal life arena consists of personal characteristics such as age, gender, and social class, experiences, and subjective assessments of quality.

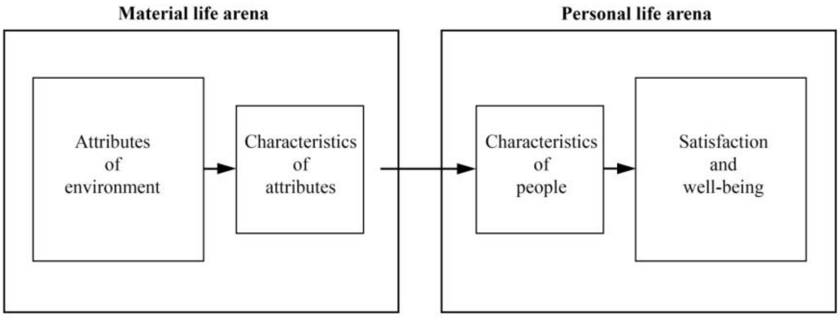

Figure 2.6. Conceptualization of environmental quality of life

(Source: Rogerson, 1995)

Van Kamp et. al. (2003) said that the concepts such as environmental quality, sustainability, living quality, quality of place, residential perception are used interchangeably, and he called the concept of environmental quality of life a "container concept" because different theories have different relationships with environmental quality. The characteristics of quality of life were discussed in five groups: Type of indicator, domains, geographical scale, time, and context (Figure 2.7). Depending on the academic discipline and the context of the research, the choice of quality of life dimensions differs (from Salihoğlu, 2016).

Figure 2.7. Domains of human livability and environmental quality of life

(Source: Van Kamp et. al., 2003)

Although environmental quality of life is considered as built environment by many authors in the literature, nowadays, with the increase in studies involving sustainability approaches, environment has begun to be considered as sustainable living environments and natural environment. Marans (2015) states that in order to combat the negativities brought by the increasing world population, the issue of the culture of sustainability should be addressed as a part of the quality-of-life studies. For this purpose, he defined objective environmental indicators and sustainability cultural indicators that can be used in life quality measurements.

Table 2.4. Indicators used in environmental quality of life studies

Main Indicators	**Sub-Indicators**	**Empirical Studies**
Resilience	River flooding risk, landslide susceptibility, coastal surge risk, natural resources, public awareness of hazardous materials, alternative fuelled cars share, schools and community programs about sustainable agriculture, % of households and businesses participating in recycling programs, per capita water consumption, recycled water use, number of manufacturers using recycled material as a raw material, number of schools with environmental education, dumbs, flood areas, resilience scale, recycling, resource productivity, energy productivity, share of renewables in final energy, sewage sludge protection and disposal, erosion.	Joseph et. al., 2014; Marans, 2003; Marans, 2015; Esparza et. al., 2012; Ilevbare and Idemudia, 2018; Garcia et. al., 2017; Stremikiene, 2014, Rahman et.al., 2014.
Degradation	Greenness, land use, brown field sites, species removed from natural areas, temperature, precipitation, vegetation index, land cover, impervious surface, land surface temperature, built-up index, wetness index, soil erosion	Marans, 2003; Joseph et. al., 2014; Marans, 2015; Ahmadiani and Ferreira, 2019; Banzhaf et. al., 2014; Ogneva-Himmelberger et. al., 2013; Faisal and Shaker, 2017; Rahman et. al., 2014.

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Vulnerability	Education, crime, health, taxes, employment, people with respiratory problems, age, gender, low income class, fuel poverty, ethnicity, number of children and elderly people, marital status, religion, income, housing value, poverty, rent, pop. density, housing density, per room occupancy, birth-rate, young people percentage, safety, security, purchasing power,	Marans, 2003; Venghaus and Hoffmann, 2016; Marans, 2015; Rehdanz and Maddison, 2008; Santamouris and Kolokotsa, 2015; Ahmadiani and Ferreira, 2019; Banzhaf et. al., 2014; Gobbens and Assen, 2018; Ilevbare and Idemudia, 2018; Ogneva-Himmelberger et. al. 2013; Orru et. al., 2016; Garcia et. al., 2017; Rahman et. al., 2014; Fleury-Bahi et. al., 2013; Esparza et. al., 2012, Faisal and Shaker, 2017.
Contamination	Air, noise, water body and coastal pollution, contaminated sites within city, household garbage, wastewater and rainwater disposal, sound pollution, PM10 value, biochemical oxygen demand in rivers, CO2 emissions, C/N ratio, clay content, soil depth, soil ph.	Joseph et. al. 2014; Marans, 2015; Rehdanz and Maddison, 2008; Fleury-Bahi et. al., 2013; Esparza et. al., 2012; Orru et. al., 2016; Stremikiene, 2014; Rahman et. al., 2014; Venghaus and Hoffmann, 2016; Banzhaf et. al., 2014, Gobbens and Assen, 2018, Ogneva-Himmelberger et. al., 2013.

Indicators used in environmental quality of life studies are examined under the headings of resilience, degradation, vulnerability, and contamination (Table 2.4). The indicators of resilience domain consist of natural disaster risks (Joseph et. al., 2014; Marans, 2015; Rahman et. al., 2014), and sustainability/recycling (Marans, 2015; Streimikiene, 2014) sub-indicators. Under the degradation dimension, there are indicators of spatial deterioration such as greenness, vegetation index, land cover, and indicators that contain climatic elements such as temperature and precipitation. Marans (2015) has defined species removed from natural areas and diversity of birds in parks as indicators of biodiversity. This approach is important in that it leads to the use of different dimensions of degradation, such as biodiversity, in research.

For the vulnerability dimension, socioeconomic, demographic, social indicators are used as in the rural and neighborhood quality of life studies. Air, water, noise, soil pollution and waste disposal sub-indicators are used in the contamination dimension.

2.6. Summary

This chapter includes the definitions of the quality of life, its models, measurement methods, and the types of indicators used in rural, neighborhood, and environmental quality of life research. Quality of life has been on the agenda of philosophy since Ancient Greece, and in the 1960s, it entered the field of study of social sciences. The fact that the concept has a multidimensional, complex, and dynamic structure causes the lack of a comprehensive definition and approach that is accepted by all disciplines. For this reason, there are many definitions of quality of life and approaches. The lack of a clear conceptual framework of the concept of quality of life causes quality of life studies to be shaped through measurement methods.

For the purposes of this study, subjective and objective research approaches are examined. While primary data obtained by survey and interviews is used in the subjective research, secondary data used in the objective approach. While the subjective method based on the respondents' assessments is criticized because people's evaluations cannot be independent of their personal characteristics and therefore cannot always reach the right results, the objective method is criticized because it evaluates the living environments without individual evaluations. Objective and subjective indicators should be evaluated together in order to obtain comprehensive results in quality of life studies.

Subjective and objective indicators used in rural, neighborhood and environmental quality of life studies are grouped in order to determine which dimensions of quality of life stand out at different scales (Figure 2.8). Vulnerability parameter includes age, sex, gender, marital status, education, employment etc. which are common in neighbourhood, rural and environmental quality of life studies.

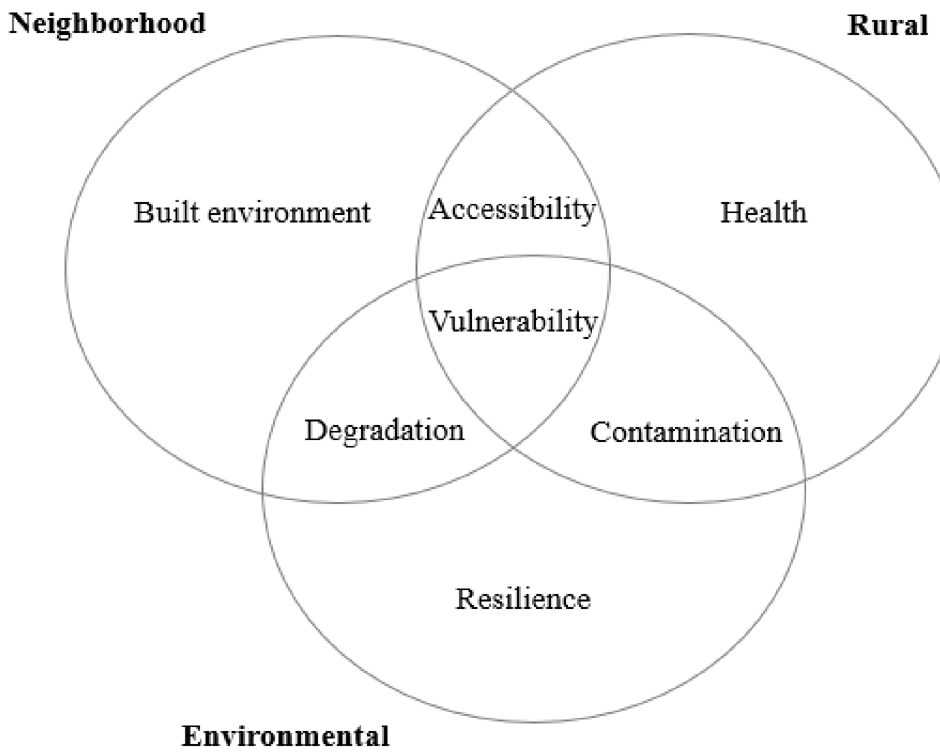


Figure 2.8. Dimensions of neighborhood, rural, and environmental quality of life

The accessibility parameter includes sub-indicators that measure accessibility to services such as education, health, sports, recreation, and public transportation in neighbourhood and rural quality of life studies. While accessibility analyzes at neighbourhood scale generally measure access to urban services, rural life quality studies also include accessibility measurement of infrastructure systems such as internet and sanitary. While built environment indicators are the most used indicators at the neighbourhood scale, health indicators are used more in rural life quality studies compared to other scales.

Indicators such as greenness, vegetation index, land use, land cover, and land temperature used in environmental quality of life studies are also used in neighbourhood quality of life studies. This similarity is gathered under the degradation dimension. Indicators such as garbage disposal, waste treatment, agricultural chemicals were grouped as contamination dimension since they were used in both rural and environmental quality of life studies. Degradation and contamination parameters contain common sub-indicators. In environmental quality of life studies, degradation includes various sub-indicators such as spatial degradation, climate change, biodiversity, and sustainability, in neighbourhood scale studies, pollution indicators are also included under the title of degradation. In environmental quality of life studies, pollution indicators were grouped under the contamination parameter.

The indicators to be used in this research were determined together with the examination and grouping of the indicators used in neighbourhood, rural and environmental quality of life studies. In the next part of the study, the topic of geothermal energy will be examined.

CHAPTER 3

GEOTHERMAL ENERGY

3.1. Historical Background

With the growing population, the concept of sustainability has gained prominence on the international agenda. Due to the reasons such as meeting energy needs and combating pollution and climate change. In this context, the Paris Agreement was adopted by 196 countries on November 4, 2016, which includes basic goals such as limiting global warming and reducing greenhouse gas emissions. The agreement is a milestone as it is the first legally binding international agreement to combat climate change. The International Energy Agency (IEA) (2021) asserts that the climate change challenge is primarily an energy challenge and that policymakers are turning to renewable energy sources to reduce the risks associated with climate change. According to the IEA's Global Energy Review, global demand for renewable energy increased by 3% in 2021.

Geothermal energy, which is one of the renewable energy sources, basically refers to the portion of thermal energy that is below the surface and is used to produce energy by bringing it to the surface (Manzella, 2019). Geothermal energy contains more dissolved minerals, salts, and gases compared to groundwater and surface water (Arslan et. al., 2001). The proportional distribution of geothermal energy resources in the world and the fact that it is a type of energy less affected by climatic conditions has the advantage of being preferred as a renewable energy source.

The geothermal system consists of the heat source in the depths of the earth's crust, the heat-bearing fluid, the reservoir rock that contains the fluid, and the cap rock that prevents heat loss. The magma activities that reach the shallow depths in the crust and the Earth's surface from the broken zones created by tectonism in the center of the Earth constitute the heat source of the geothermal system. The water heated at depth collects in the reservoir rock, which is porous and permeable. Some of this water rises along fault lines and reaches the earth's surface to form geothermal resources. The geothermal fluid in the reservoir rock, which cannot reach the earth because it is surrounded by impermeable cover rock, is brought to the earth by drilling (Arslan et. al., 2001).

High temperature belts in the world are located at plate boundaries, in regions where volcanic activities and earthquakes are common (Kervankıran, 2012). As it can be seen from Map 3.1, important belts and countries in terms of geothermal energy are as follows;

- Andean volcanic belt; It covers Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile, and Argentina. Due to the presence of active volcanism, there are high-temperature geothermal resources.
- Alpine-Himalayan belt; It includes Italy, Yugoslavia, Greece, Turkey, Iran, Pakistan, India, Tibet, Myanmar, and Thailand. It is one of the largest geothermal belts in the world.
- East African Rint system; It covers Zambia, Malawi, Tanzania, Uganda, Kenya, Ethiopia, and Djibouti. It is an active system.
- Carrebean Islands
- Central American volcanic arc; It contains Guatemala, El Salvador, Nicaragua, Costa Rico, and Panama (Ilgar, 2005).

Map 3.1. Geothermal belts

(Source: Url 1)

For centuries, geothermal energy has been used for heating, therapeutic purposes, bathing, cooking, producing salts (Stober and Bucher, 2013). In the Roman and Ottoman Empires, there were public hot water pools in the cities. These pools are cultural and public spaces as well as places where personal hygiene is provided. In addition, many civilizations evaluated thermal water as curative.

Figure 3.1. First machine to generate geothermal to electricity

(Source: Stober and Bucher, 2013)

While thermal water was first used for residential heating in the 14th century in Chaude Aigues, France (Barbier, 2002), its use for energy production did not begin until the second half of the 19th century. In 1827, the first low-pressure steam boiler with geothermal energy was built in the Lardello region of northern Italy, and in 1904, the first electric power was generated using a steam engine (Figure 3.1). In 1909, the first home heating system was installed in Reykjavik, Iceland (Barbier, 2002). In 1913, the first power plant with a geothermal energy supply was opened in Lardeolla. In the 1920s, geothermal energy began to be used extensively in Reykjavik for heating homes and greenhouses (Stober and Bucher, 2013). In the 1950s, the use of geothermal energy became widespread, and New Zealand began to evaluate geothermal resources for commercial use. In the 1960s, electricity from geothermal sources began to be generated in the United States, and heat pumps became widespread. Today, geothermal power plants exist in many countries (Map 3.2). According to the IEA Geothermal Report

(2020), there has been an annual capacity increase of 500 MW in the last 5 years, and the source of these increases is usually emerging countries.

Map 3.2. Existing geothermal power plants

(Source: Url 2)

3.2. Usage of Geothermal Energy

Geothermal energy fields are divided into three basic groups according to their temperature, and their area of usage change according to temperature values (Figure 3.2):

1- Areas with a temperature between 20 °C and 70 °C are considered as low-temperature zones. Geothermal energy is used in fish farms in areas with a temperature of 20 °C. As the temperature increases, geothermal energy is used for swimming pools, fermentations, distillation facilities, soil heating activities, mushroom cultivation, Turkish baths, greenhouses, barn, and poultry heating and cooling purposes, respectively.

2- Areas with a temperature between 70 °C and 150 °C are medium-temperature areas. In these areas, activities such as cooling, ground, and greenhouse heating, drying of fish, organic matter, and cement, obtaining hot water by distillation, sugar, and salt industry, canning, drying of farm products, and aluminium production are carried out.

3- Areas with a temperature of 150 ^{o}C and above are high-temperature areas. In these fields, geothermal energy is used in timber and fish drying, drying of diatomites, heavy water and hydrogen sulfide production, and electricity generation (Külekçi, 2009; Arslan et. al. 2001, Barbier, 2002).

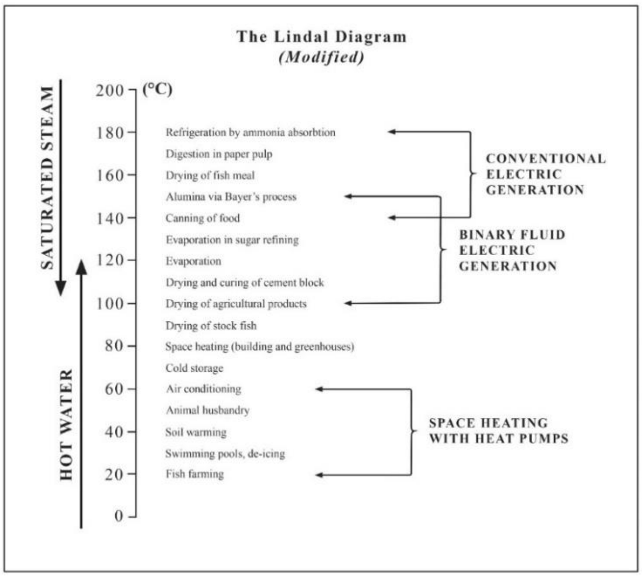


Figure 3.2. The Lindal diagram on typical fluid temperatures for direct applications of geothermal resources (Source: Barbier, 2002)

Geothermal energy uses are divided into two as electricity production and direct use. Areas below 150 ^{o}C are suitable for direct use, while areas above them are suitable for electricity generation. Barbier (2002) claims that a hot water distribution network must be established for direct use. Electricity is produced in geothermal power plants. Many countries benefit from geothermal energy as a direct use or electricity production (Map 3.3).

Map 3.3. Global geothermal use in 2015

(Source: Url 3)

3.3. Geothermal Systems

Geothermal energy systems are divided into two groups: shallow/near-surface and deep systems, depending on the depth of the geothermal reservoirs (Figure 3.3). Near-surface systems are generally used for heating and cooling, while deep geothermal systems are used for power generation. In doublet hydrothermal systems, thermal energy can be used simultaneously for electricity generation and for various activities such as heating, cooling, and greenhouse cultivation.

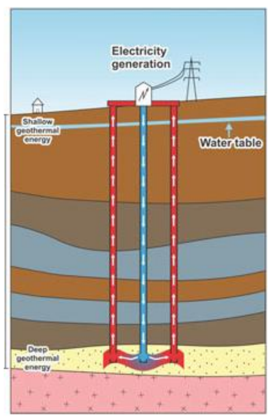


Figure 3.3. Difference between shallow and deep geothermal energy systems

(Source: Malo et. al., 2019)

3.3.1. Heating and Cooling Systems

Geothermal energy is used for heating and cooling purposes in homes, greenhouses, and agriculture. Heating homes accounts for a large portion of energy consumption, especially in cold countries. Shallow geothermal systems are generally used for heating and cooling.

Welding depth in near-surface geothermal systems varies from 150 to 400 meters. Ground heat collectors, borehole heat exchangers, boreholes into groundwater, and geothermal energy piles are used in these systems (Stober and Bucher, 2013). The thermal fluid can circulate directly in the heating system after being extracted from the ground, or it can be added to the system after its temperature has been adjusted through the heat exchanger. After this process, the thermal fluid is re-injected into the ground in double or triple systems (Figure 3.4) (Manzella, 2019).

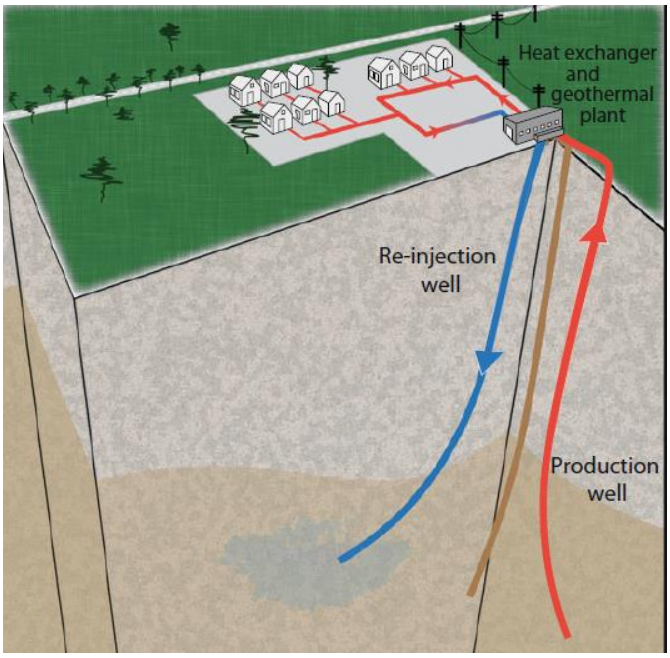


Figure 3.4. Geothermal system for heating purposes

(Source: Manzella, 2019)

Near-surface geothermal systems consist of vertical and horizontal systems. In a vertical system, ground heat collectors utilize solar radiation heat, so a large area is needed (Figure 3.5). This system is widely used in Sweden and America in family homes with the required space. In recent years, systems in which ground heat collectors are placed on the floor of the house (Figure 3.5) have also been used (Stober and Bucher, 2013).

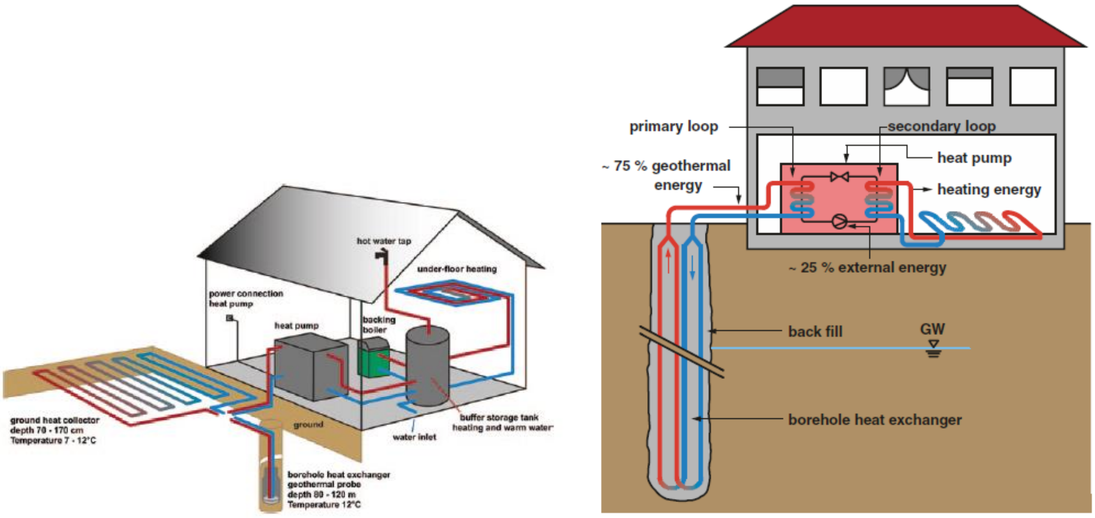


Figure 3.5. Horizontal (on the left) and vertical (on the right) near-surface geothermal systems (Source: Stober and Bucher, 2013)

3.3.2. Electricity Production Systems

Deep geothermal systems are used because a thermal fluid with high temperatures is needed to generate electricity. Deep geothermal systems can use thermal fluids in areas where the thermal source is located at a depth of 400 meters or more (Stober and Bucher, 2013). In power plants, electricity is generated by generators driven by turbines. Steam is used to drive the turbines.

Three main technologies, dry steam, flash steam, and binary cycle, are used in geothermal power plants (Figure 3.6). Dry steam technology is used in areas where geothermal fluids evaporate completely in the reservoir or evaporate before reaching the surface due to well pressure. In these areas, the temperature of the fluid is above 250 ^{o}C. After the vapor passes through the tribune, it is sent to the condenser and from there it is cooled in the wet cooler and pumped into the ground through injection pipes. In this method, part of the vapor is lost in the atmosphere and the rest is condensed and re-injected.

In the flash steam method, which is used in areas with a heat source of 180 ºC or more, the liquid that vaporizes under pressure is separated in the separator, and the steam is then sent to the turbine. While all the liquid remaining in the separator is re-injected, the steam used in the turbines is passed to the condenser as in the dry steam method and after cooling in the wet cooler, it is pumped to the ground. In this method, the loss of liquid is less than in a dry steam system. Most of the liquid can be re-injected.

Binary cycle technologies are used for electricity generation in areas with thermal liquids at 110 ºC and below. In this system, steam is produced in the heat exchange tank by exchanging temperature between a thermal liquid and another liquid with a low boiling point. Since the evaporated liquid in this system is a liquid with a low boiling point, the thermal fluid can be completely reinjected. This method is getting more and more popular. In power plants where the steam coming out of the tribune has a suitable temperature for other uses, it is tried to increase energy efficiency by combining binary cycle with dry or flash steam technology (Manzella, 2019).

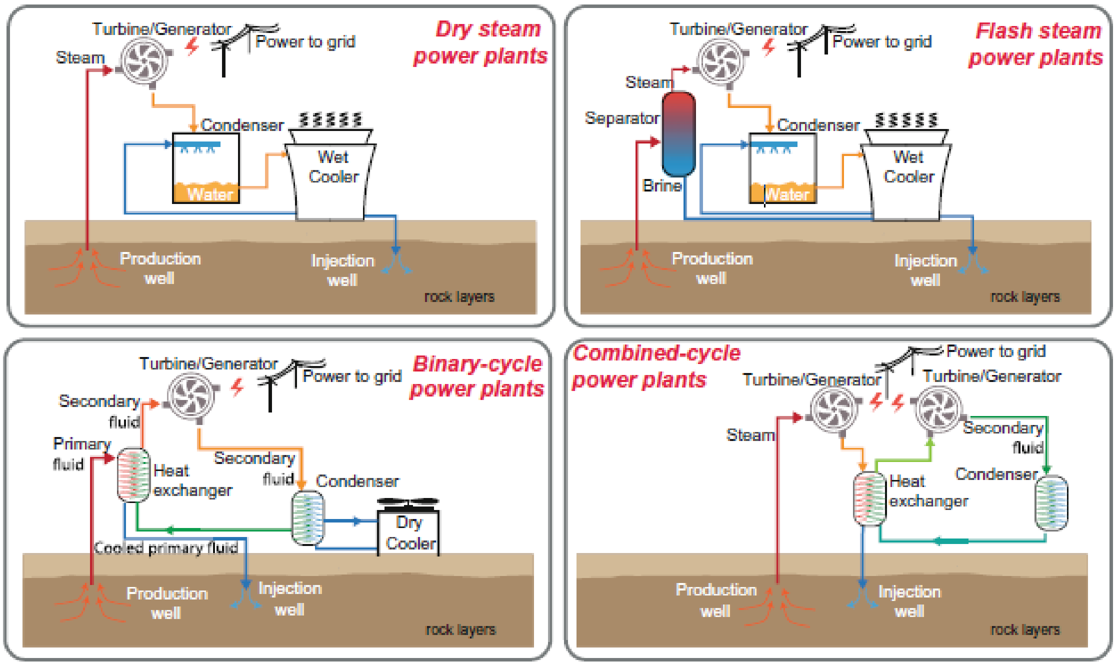


Figure 3.6. Simplified flow diagram for dry steam (top left), single flash (top right), binary-cycle (bottom left), and combined-cycle (bottom right) geothermal power plants (Source: Manzella, 2019)

Stober and Bucher (2013) say that thermal fields with different temperatures should be handled with different approaches to be efficient (Figure 3.7). Although regions with high thermal gradients are advantageous areas due to short drilling depths, they can become attractive for investment if production and reinjection values are suitable. In regions with normal thermal gradients, the system must provide local and district heating network throughout the year, and the heat must be presented to different receivers according to the temperature value, to gain profit despite the costs of deep drip holes. While water with a temperature of 100 °C is provided to the user for heating, water that comes out of heating and has a temperature of 50 °C can be offered to greenhouse use, and water that falls to 20 °C after being used in greenhouse cultivation can be offered to fish farming use (Stober and Bucher, 2013). In this model, the long-term problems of injecting the thermal fluid at a temperature almost 10 times lower than it is removed are not mentioned.

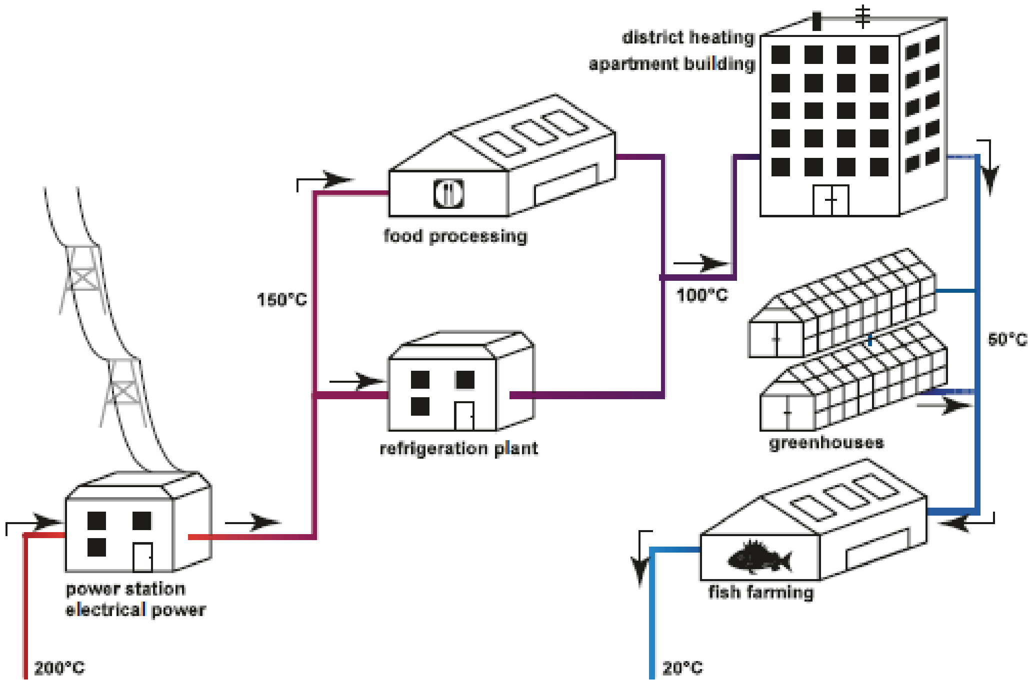


Figure 3.7. Serial use of thermal energy produced by a hydrothermal doublet system (Source: Stober and Bucher, 2013)

3.4. Environmental Impacts of Geothermal Power Plants

In the literature, there are studies on the life-cycle assessments, operationalisation, and management of plants of geothermal energy, and there are few studies on the community-level environmental, economic, and social effects of geothermal energy. In recent community-level studies, environmental effects and social acceptability of geothermal energy are emphasized. Geothermal energy has both negative and positive effects on the environment.

3.4.1. Air Pollution

The use of geothermal energy has both positive and negative effects on air quality. Geothermal energy has lower CO_2 values when compared to fossil fuels and other renewable energy sources. These low CO_2 emissions have a positive effect on air quality (Soltani et. al., 2021).

Geothermal resources contain gases such as H_2S, NH_3, CH_4, CO_2 and radon, and gas emissions occur in power plants operating with dry and flash steam technology (Soltani et. al. 2021). Hydrogen sulfide is oxidized to sulfur dioxide and then to sulfuric acid. It is the most important pollutant, as it can cause acid rain. Similarly, boron mixed with soil and surface waters with rainfall can have serious effects especially on vegetation (Barbier, 2002).

H_2O and other toxic gases emitted from the steam turbines are disturbing for the people living around the power plant. Since the emitted gas levels will vary depending on the system used in the power plants and the characteristics of the site, it is necessary to make measurements on a plant basis for the net effects of pollutants. In addition to the gases emitted, the increased traffic due to the power plants can adversely affect the air quality. As explained in the previous chapter 3.3.2., binary-cycle systems are the most optimal system in terms of air pollution since they do not emit gas during electricity generation.

3.4.2. Land Use

Compared to other power plants, geothermal power plants require less space (Table 3.1). However, the fact that geothermal fields are generally located in rural areas where agricultural production is carried out causes the power plants to put pressure on these areas (Tomaszewska et. al., 2021). In addition, pipes located between hot water wells and power plants cause visual pollution.

Table 3.1. Comparison of different power plants based on land use (Source: Soltani, et. al. 2021)

Power plant	Land use (m^2/MW)	Comparison
110 MW geothermal flash plant (excluding wells)	1260	Baseline
20 MW geothermal binary plant (excluding wells)	1415	1.12
56 MW geothermal flash plant (including wells, pipes, etc.)	7460	5.92
25 MW wind farm (10 × 2.5 MW)	16,000	12.69
670 MW nuclear plant (plant site only)	10,000	7.93
47 MW (avg) solar thermal plant (Mojave Desert, CA)	28,000	22.22
2258 MW coal plant (including strip mining)	40,000	31.74
10 MW (avg) solar PV plant (Southwestern US)	66,000	52.38

3.4.3. Noise Pollution

Activities such as installation of geothermal power plants, drilling, testing, discharging, and bleeding of wells, water cooling, turbine building cause noise. This noise can be disturbing especially for people living in less noisy rural areas than city life. Durable mufflers (Citron, 1977), and sound shields, and silencers (Soltani et. al., 2021) should be used in order to reduce the noise to a level that is not disturbing.

3.4.4. Water Pollution

Geothermal fluids and steam condensates containing minerals such as sodium, potassium, lithium, chloride, bicarbonate, sulphate, borate, and silica can affect water quality to such an extent that they can have devastating effects on flora and fauna (Citron, 1977). For this reason, reinjection of fluids used in geothermal energy production is very important in terms of underground and surface water quality. In addition to the fluids, the gases released during the production process become rainfall and pollute the soil and surface water. Barbier (2002) claims that because the pollutants are in vapor form in *vapor-dominated* sites, pollution can be controlled more easily compared to *water-dominated* and *hot water* sites.

3.4.5. Seismicity

Geothermal fields are found in high temperature and moving geological layers due to their formation. Volcanic activities and earthquakes are common in these high temperature zones. There is a public opinion that reinjecting the thermal fluid used can increase seismic activity. Barbier (2002) states that an increase in low-magnitude activities was observed in the study where the relationship between seismicity and reinjection was analysed in the Lardello, Italy geothermal power plant, and that the increase in these low-level activities has a positive effect on seismicity when the stress accumulated on the rocks is relieved with small shocks instead of one big shock.

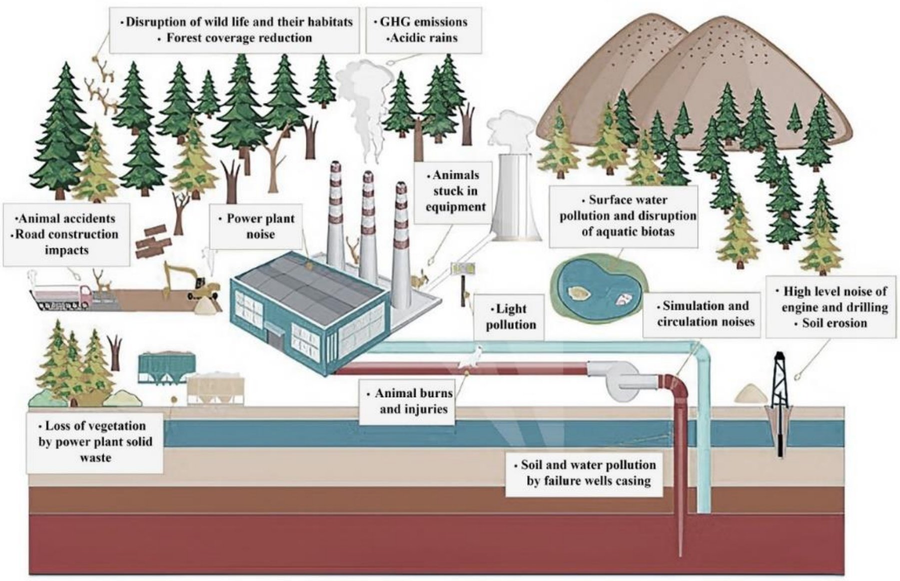


Figure 3.8. Environmental impact of geothermal power plant associate biodiversity, flora, and fauna (Source: Soltani et. al., 2021)

The pollutant effect of geothermal power plants on an environmental factor also affects other factors (Figure 3.8). The toxic gases released by the power plants not only negatively affect the air quality, but also affect the flora by causing acid rain. The deterioration of the flora negatively affects the animals living there. For this reason, the negative effects of geothermal power plants should be handled with a holistic approach in which all environmental factors are addressed.

3.5. Social Acceptability of Geothermal Power Plants

Social acceptance is an important factor for the development and spread of geothermal energy. In the literature, social acceptance is generally associated with the level of knowledge about geothermal energy and participation in the planning phase. Arnstein’s (1969), creates a ladder with eight rungs to explain citizen participation to planning process (Table 3.2). According to the model, participation begins with the provision of information that can shape citizens' thoughts and decisions, and continues with consultation, where feedback is received from the citizen (Cardullo and Kitchin, 2019). The suggestions of the citizens are included in the placation phase. Arnstein (1969) grouped the last three steps of the ladder as citizen power, and divided it into the partnership, where the citizen is the co-creator, delegated power, in which citizen have a dominant role in decision-making process, and citizen power, where the citizen is the decision maker (Cardullo and Kitchin, 2019).

Table 3.2. Arnstein’s ladder of citizen participation

(Source: Cardullo, and Kitchin, 2019)

Form and Level of Participation	
Citizen Power	Citizen Control
	Delegated Power
	Partnership
Tokenism	Placation
	Consultation
	Informing
Non-participation	Therapy
	Manipulation

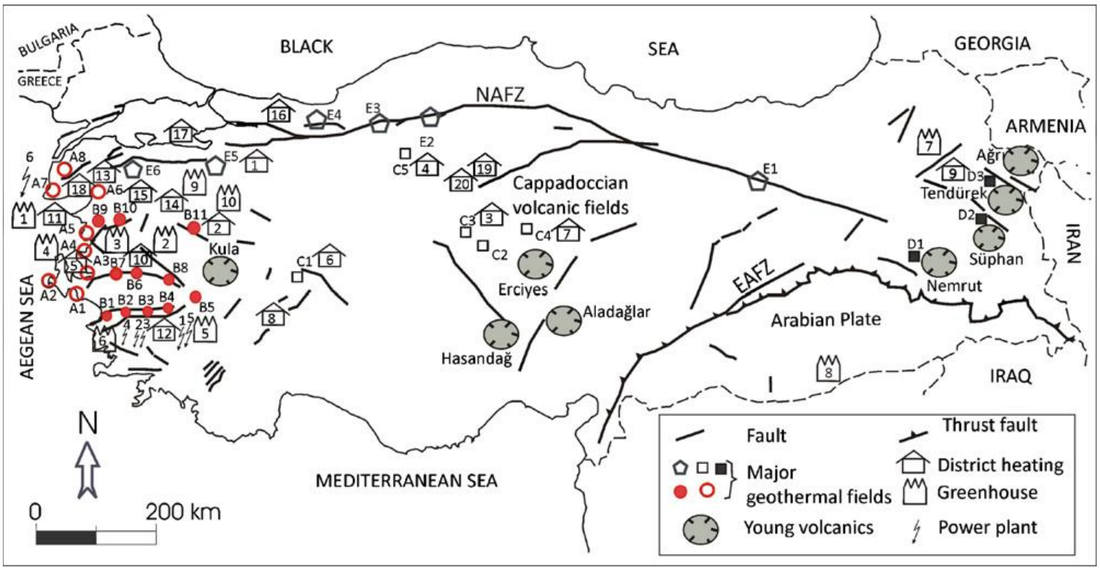
Dowd et al. (2011) in his study examining the social acceptance of geothermal energy, uses survey method to collect information, and states that the participants generally support geothermal energy, and the level of knowledge about geothermal energy has increased, but there are some concerns about the amount of water used and the effect of drilling activities on seismicity.

Carr-Cornish and Romanach (2014), in their study in which they examined the social perception about geothermal energy in the example of Australia, first applied a questionnaire. After the survey, they gave the participants two articles describing the risks and benefits of geothermal energy, and the participants repeated the survey after reading these articles. According to the results of the first survey, 58% of the participants approached the use of geothermal energy positively, while this rate increased to 74% after they read the articles. This study shows that there is a positive relationship between the level of knowledge about geothermal power plants and social acceptance. Similarly, Malo et. al. (2019) used the survey method in their study in Quebec, Canada, and investigated the participants' knowledge of deep and shallow geothermal energy systems, their approach to establishing a geothermal power plant in their own region, and what should be considered if a geothermal power plant is established. 12% of the participants in the survey, who positively evaluated geothermal energy production in their place of residence, changed their decision when they learned that the hydraulic fracturing method could be used in geothermal energy facilities. In addition, more than half of the participants answered the question of what their concerns would be if a deep geothermal energy system was established in their place of residence, as groundwater pollution.

Pellizone et. al. (2019) investigated the people's knowledge about geothermal energy as well as the trust in decision makers. According to the results of the research, the people living in the study area think that the decision makers do not act for the common good, and that the researchers and scientists are reliable and impartial. Pellizone et. al. (2019) states that the people’s need for informative studies on geothermal energy is an issue that should be taken seriously by researchers.

3.6. Geothermal Energy in Turkey

Turkey is in the Alpine-Himalayan belt, which is one of the largest geothermal belts. Turkey ranks eighth in the ranking of countries rich in geothermal energy (Baba and Armannsson, 2006). As can be seen from the Map 3.4, most of the geothermal fields are in Western Anatolia. Geothermal energy studies in Turkey started in the 1960s (Serpen et. al., 2009).



Map 3.4. Location of major geothermal fields in Turkey

(Source: Serpen et. al., 2009)

According to the Cumulative Impact Assessment Report (2020), there are 347 geothermal fields with a temperature of 30 ºC and above in Turkey, of which 88% have low and medium temperatures and 12% have high temperatures. 153 of these fields are suitable for electricity generation. In terms of geothermal power capacity, Turkey ranks fourth in the world with an installed power of 1,576 MW (Table 3.3).

Turkey aims to increase its electricity production from renewable energy sources to 30% by 2023, and research shows that it will reach the 2023 target of geothermal and biomass-based energy production (Prill, 2019). Serpen et. al. (2009) mentions that local governments focus on the use of geothermal energy resources for health tourism due to their economic attractiveness and that geothermal fluids are suitable for cloth washing because they contain silica and soda.

Table 3.3. Geothermal installed power capacities of world countries

(Source: The Cumulative Impact Assessment of Geothermal Resources in Turkey Report, 2020)

Country	**MW**
USA	3.700
Indonesia	2.289
Philippines	1.918
Turkey	1.576
Kenya	1.193
New Zealand	1.064
Mexico	1.005
Italy	916
Iceland	755
Japan	550
Others	1.011

Most of the studies focus on the geothermal energy potential in Turkey, the established areas, the usage areas of geothermal energy (Prill, 2019; Serpen et. al. 2009; Acar, 2003; Balat, 2006). Few studies cover the environmental impacts and social acceptance of geothermal power plants on a local scale (Baba and Armannsonn, 2006; Kömürcü and Akpınar, 2009; Baba, 2015). Çetiner et. al. (2016) took university and high school students as a sample in his study in which the public's thoughts about geothermal energy and acceptability were measured. According to the results of the study in which the survey method was applied, most of the participants do not have detailed information about the environmental effects of geothermal energy. In addition, 75.9% of the participants think that geothermal energy has a triggering effect on earthquakes (from Prill 2019).

The Cumulative Impact Assessment of Geothermal Resources in Turkey Report (2020), prepared in partnership with the European Bank for Reconstruction and Development and the Ministry of Environment and Urbanization, is an important study as it focuses on the cumulative environmental, social, and socio-economic impacts of geothermal energy. Denizli, Aydın and Manisa provinces, where geothermal activities are intense, were determined as the study area. A data index values recommended by experts and academics were created at the focus meetings, and sensitivity maps were created based on the weightings of valuable environmental and social components. In the next stage of the study, polluting factors on sensitive areas were analysed. As a result of the analyzes and field studies, it has been determined that the local people have a negative attitude towards geothermal energy and its effects, since geothermal energy activities are mostly carried out by private companies, and suggestions have been developed for the future of geothermal energy. The study is guiding in terms of the way in which the spatial, environmental, and social dimensions of geothermal energy are handled.

As can be understood from the Cumulative Impact Assessment of Geothermal Resources in Turkey Report (2020), the development of spatial analysis methods is a key issue to reveal the effects of geothermal energy. Baba and Armannsson (2006) mention that there are problems such as soil and water contamination occurring in the geothermal fields and their impact areas in Turkey, and that examining the spatial distribution of environmental effects using geographical information systems is important for the development of geothermal energy. Kömürcü and Akpınar (2009) claims that if the problems caused by geothermal energy are overcome, it will be an important factor for a sustainable future.

3.7. Summary

In this chapter of the study, the historical development of geothermal energy, hot temperature zones in the world, usage of thermal energy, geothermal systems, environmental effects and social acceptances of geothermal power plants and geothermal energy studies in Turkey were examined. Geothermal energy has been used for many purposes such as hygiene, heating, and treatment for centuries. Today, with sustainable policies gaining importance on a global scale, countries are turning to renewable energy sources, and geothermal energy investments, which is one of the renewable energy sources, are increasing day by day.

Geothermal energy is distributed proportionally on a global scale and is less affected by climate conditions compared to other renewable energy sources. Geothermal fields in the world have different temperatures due to their locations. Countries located above hot temperature areas, especially in plate boundaries, are rich in geothermal energy.

Geothermal energy is used through different systems for different purposes depending on the temperature. While shallow/near surface systems are used for heating and cooling activities in low and medium temperature areas, electricity is produced with deep geothermal systems in high temperature zones. Deep systems are divided into four as dry steam, flash steam, binary-cycle, and combined-cycle power plants according to the temperature of the thermal fluid. These power plant models have different environmental effects and today, binary-cycle power plant applications are becoming widespread.

Geothermal power plants have environmental impacts such as air, noise and water pollution, land use changes, and seismicity. These environmental effects significantly affect the acceptability of geothermal power plants. In the studies that measure the social acceptance of geothermal energy, the level of knowledge, concerns, and acceptance conditions of people about geothermal energy are emphasized mostly by using the survey method. Studies show that for the social acceptance of geothermal energy, it is necessary to inform the public about geothermal energy and to ensure their participation in the planning processes. For this reason, in this study, in which the effect of geothermal energy on the quality of life is measured, the environmental dimension of the quality of life is discussed in the context of geothermal energy and it is considered appropriate to add participation as an environmental parameter (Figure 3.9). Since the studies included the information and consultation rung of participation, these two stages were examined in the participation dimension.

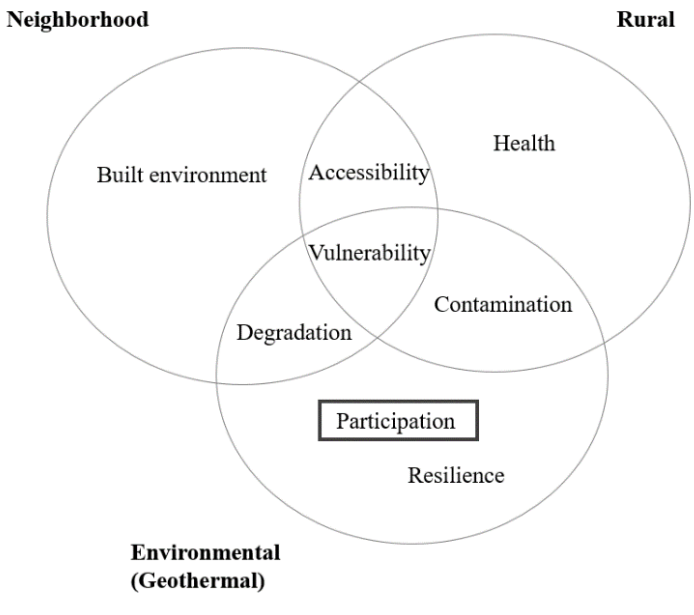


Figure 3.9. Dimensions of perceived quality of life

Studies on geothermal energy in the context of Turkey have been examined and it has been determined that studies generally focus on the development of geothermal energy in Turkey, its usage patterns, regions where geothermal energy is used, and capacity. Although there are few studies on the environmental effects and social acceptance of geothermal energy, there is no study investigating the effect of geothermal energy on quality of life in Turkey.

When the studies in Turkey are examined, it has been observed that geothermal energy is handled with an integrated approach in the Cumulative Impact Assessment of Geothermal Resources in Turkey report (2020). The cumulative impact assessment report has been a guide in terms of the way this study is handled, and the weighting values specified in the report were used in the spatial analysis.

CHAPTER 4.

CASE STUDY

4.1. Case Study Methodology

For the case study, the built environment, accessibility, vulnerability, health, degradation, contamination, resilience, and participation dimensions were determined as a result of the literature review. In the objective part of the study, weighted overlay, and kernel density analyzes were applied to the socio-spatial layers with the ArcGIS program, and an evaluation based on semi-structured interview data was made in the perceived quality of life part. Due to data availability, health and participation dimensions were evaluated in the perceived quality of life part of the study. It has been decided that evaluating the accessibility dimension as objective attributes is more appropriate in terms of the scope of the study.

Population change, elderly population, agricultural and forest land, hydrology, and protection areas, built environment, cropland change, and resilience maps were created for socio-spatial sensitivity analysis. For social sensitivity, population data for the years 2016 and 2020 obtained from TSI, and neighbourhood-based depopulation and elderly population analysis were performed. In the spatial sensitivity part, agricultural, and forest lands, hydrology, and protection areas, built environment, cropland change and resilience analyzes were performed.

CORINE project data was used for agricultural and forest lands analysis, and the Cumulative Impact Assessment of Geothermal Resources in Turkey Report (2020) data was used for hydrology and protection areas. For the built environment analysis, archaeological protection zones, military zone, urban and rural settlements, and area to be afforested data included in the Izmir-Manisa 1/100.000 scale Environmental Plan were used. The cultivated area change was calculated by using the data on the amount of cultivated land in 2016 and 2021 on the basis of neighbourhoods obtained from the

Alaşehir District Directorate of Agriculture and Forestry. In order to determine the neighbourhoods with high socio-spatial sensitivity, a weighted overlay analysis was applied according to the data index values suggested by the academicians and experts participating in the Cumulative Impact Assessment of Geothermal Resources in Turkey (2020) study (Table 4.1).

Table 4.1. Weights of indicators

(Source: The Cumulative Impact Assessment of Geothermal Resources in Turkey Report, 2020)

Analysis	**Indicators**	**Weight**
Demographic structure	Depopulation rates below -53,5	8,05
	Elderly population ratio above %14	8,75
Forest	Broad-leaved forest	9,3
	Coniferous forest	8,7
	Mixed forest	8,2
	Natural grasslands	8,6
Agricultural lands	Water surfaces	9,5
	Planted farmland	8,8
	Permanently irrigated land	6,87
	Non-irrigated arable land	8,73
	Special crop land	8,43
	Pastures	8,57
Hydrology	Irrigation area	9,85
	Stream	9,22
	Stream protection area	9,17
Built environment	First degree archaeological protection areas	9,53
	Military zone	8,45
	Urban settlement	6,15
	Rural settlement	7,23
	Area to be afforested	8,77
Degradation	Change in cultivated area	8,67
Resiliency	Fault lines	8,5
	Floodplains	7,1
	Landslides	8

In the accessibility analysis, existing and planned geothermal power plants data from the Cumulative Impact Assessment of Geothermal Resources in Turkey Report (2020) were used. Similar to the study of Biagi et. al. (2018), existing and planned geothermal power plants are considered as dissamenities in the accessibility analysis. The density of existing and planned geothermal power plants was calculated using the kernel density tool on ARCGIS. Geothermal wells explosion areas data was used in contamination dimension, seismicity, floodplains, and erosion data were used in resiliency dimension. As a result of spatial analysis, the neighbourhoods where the perceived quality of life research will be carried out were determined.

The impact of geothermal energy use on perceived quality of life was analysed with data collected by snowball sampling and semi-structured interview methods. Snowball sampling is a suitable method for qualitative research on a special topic that needs insiders information (Biernacki and Waldorf, 1981). In the snowball sampling method, the researcher determines the first participant, and the next participants are determined by the previous subjects' proposal. This process continues until the required sample is supplied. The researcher is obliged to explain to the participants that they do not have to recommend other people.

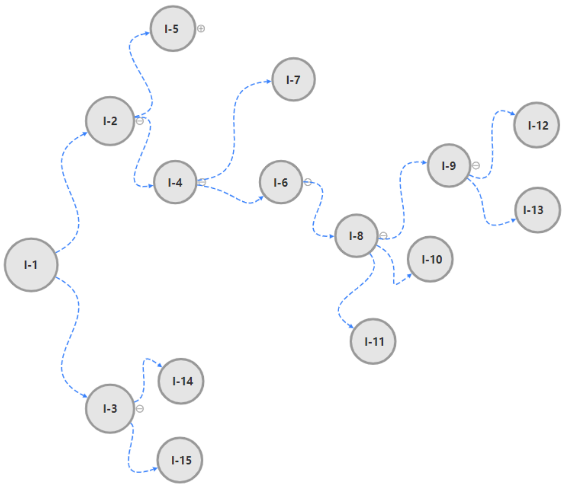


Figure 4.1. Snowball network of interviewees

For this study, the headman of Alhan neighbourhood was determined as the first key informant in line with socio-spatial analysis. In total, 16 key informants were identified, but because one informant did not accept the interview request, 15 people were interviewed between 1-5 November 2021 (Figure 4.1). The interviews were made face-to-face and by phone call and lasted an average of 30 minutes. The interviewees reside in the neighbourhoods of Alhan, Piyadeler, Gürsu, Yeniköy, Çağlayan, Kemaliye and Akkeçili. Key informants included seven neighbourhood headmen, an agricultural engineer, a civil engineer, an irrigation cooperative manager, and four farmers (Table 4.2). All the participants, who are headmen, engineers, and heads of cooperatives, are also engaged in farming.

Table 4.2. Profession and neighbourhood of interviewees

Name	**Profession**	**Neighbourhood**
Interviewer 1	Headman	Alhan
Interviewer 2	Headman	Gürsu
Interviewer 3	Headman	Piyadeler
Interviewer 4	Headman	Yeniköy
Interviewer 5	Headman	Çağlayan
Interviewer 6	Agricultural Engineer	Yeniköy
Interviewer 7	Farmer	Alhan
Interviewer 8	Civil Engineer	Kemaliye
Interviewer 9	Headman	Akkeçili
Interviewer 10	Irrigation Cooperative Manager	Kemaliye
Interviewer 11	Headman	Kemaliye
Interviewer 12	Farmer	Akkeçili
Interviewer 13	Farmer-Retired	Akkeçili
Interviewer 14	Farmer	Piyadeler
Interviewer 15	Farmer-Housewife	Piyadeler

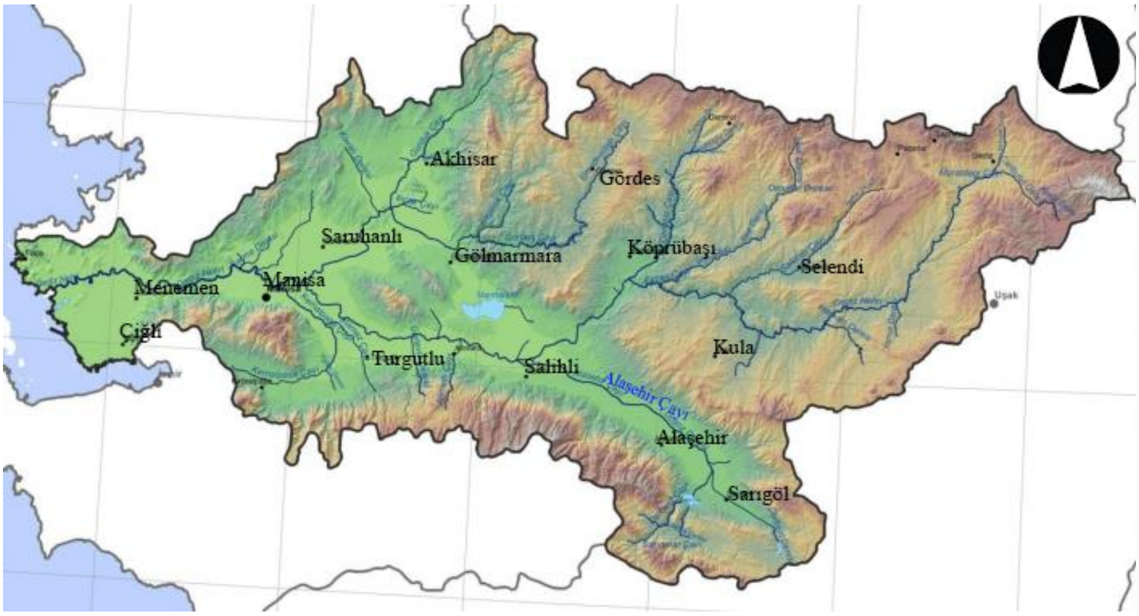
Participants were asked a total of six questions about environment and health related challenges caused by geothermal energy use, its impact on economic development on the neighbourhoods, precautions, and participation processes (Appendix). The interview results were evaluated together with the weighted overlay and kernel density analysis maps in the results and discussion part of the thesis.

4.2. General Characteristics of Alasehir

4.2.1. Location and Geographic Structure

Alasehir is in the eastern part of the Gediz plain, which is one of the east-west oriented plains in Western Anatolia, on co-ordinates 38.3613^o North and 38.5272^o East

(Map 4.1). The Gediz graben, in which the Alasehir plain is located, is one of the largest grabens in Turkey. The heights of the mountains surrounding the basin on three sides are not very high. Murat, which is the highest mountain, located at 2.312 metres in the east. It is followed by Bozdağlar (2.159 metres), Simav (1.664 m), Umurbaba (1.555 m), Çulha (1,553 metres) and Nif Mountains (1.510 metres). The height of the mountains decreases continuously from east to west. Mountains in the west have an altitude of 400–800 metres.

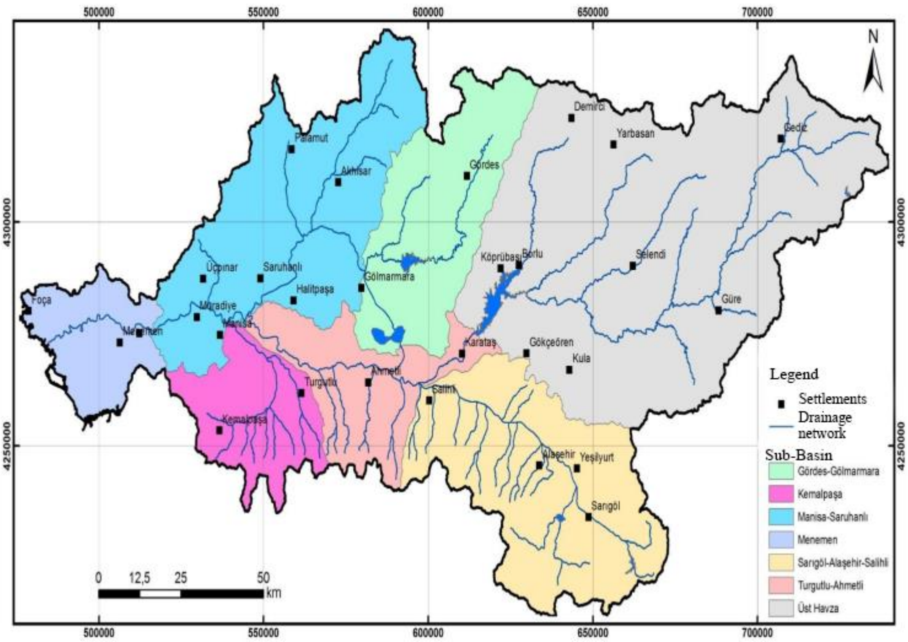


Map 4.1. Topography map of Gediz Basin

(Source: Gediz Basin Management Plan, 2018)

The provinces of Manisa, İzmir, Uşak, Kütahya, Denizli, Balıkesir and Aydın are located within the borders of the Gediz Basin. The main province forming the basin in terms of area is Manisa, followed by Uşak, İzmir and Kütahya. The most important plains in the basin are Adala, Ahmetli, Menemen, Akhisar, Selendi, Kapaklı, Alaşehir and Üzümlü plains.

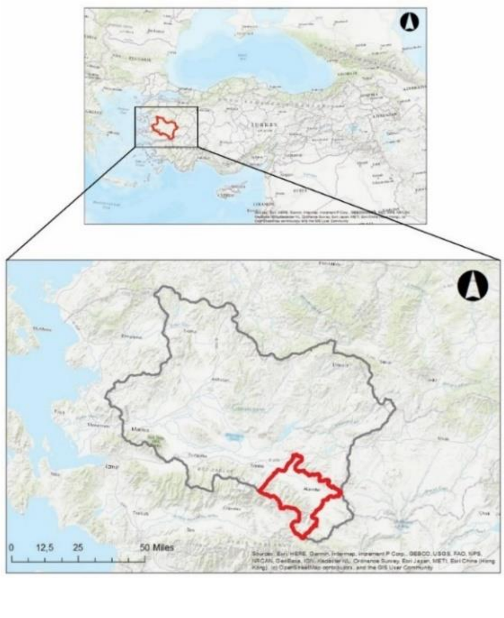
Alaşehir Stream, a branch of the Gediz River, flows through this graben. There is Bozdağlar mass in the south of the district and Uysal Mountains mass in the north. Due to the fact that the Alaşehir plain is located within the Western Anatolian Fault Zone, the earthquake risk in the region is high. According to the records of the Kandilli Observatory, an earthquake with a magnitude of 6.5 occurred in 1969, causing loss of life and property (Url 4).



Map 4.2. Distribution of Gediz Sub-Basin

(Source: Gediz Basin Management Plan, 2018)

Alasehir is one of the 17 districts of Manisa Metropolitan City and has a surface area of 977 km^2. It is surrounded by Salihli in the west, Sarıgöl and Esme in the east, Nazilli and Kuyucak in the south, and Kula province in the north. Alaşehir, which is 189 meters above sea level, is 110 km away from Manisa City Center (Map 4.3).



Map 4.3. Location of Alasehir

4.2.2. History

Alaşehir district has been a settlement since ancient times. It was within the borders of the Arzawa Country during the Hittites period, remained under the rule of Lydia in the Iron Age, and then came under the rule of the Sardeis Satrapy center (Karahan, 2017). The city was founded by II. Attalos Philadelphos (King of Pergamum) next to the Gavurtepe Mound, under the name of Philadelphia. It was an important settlement as it is located on the Silk Road. A significant earthquake occurred in the city in 17 AD. Strabon mentions that the walls of the houses are cracked due to the earthquakes that occur constantly, that is why most of the people live as farmers in the fertile lands outside the city, and he is surprised that few people live in such an insecure city (from Erdoğan, 2013).

Figure 4.2. Old picture of Alasehir

(Source: Url 7)

During the Roman Period, the city was called "Little Athens" due to the temples and festivals held in the city. The Church of Saint Jean, one of the first seven churches of Christianity, was built in 40 AD (Url 5) (Figure 4.3). Today, the church is still visited by Christian tourists.

Philadelphia, which remained within the borders of Byzantium after the division of the Roman Empire, joined the Selçuklu lands in 1093. In 1390, the city was under the rule of the Ottoman Empire, and it was invaded by Timur in 1402. The city joined the Ottoman lands again in 1425 (Erdoğan, 2013).

Figure 4.3. Saint Jean Church

(Source: Url 8)

There are various rumours among the people about where the name Alasehir comes from. According to a rumour, during the Byzantine rule, the city was named Al-Sehir by Turkmen immigrants because it was famous for leather and red silk. According to another rumour, after Yıldırım Bayezid conquered the city, he climbed the hill above the Sarıkız fountain and called the city “Ala”, which means beautiful, and the city began to be called Ala-sehir.

The city has an important place in the history of the Turkish War of Independence since the first congress in the Aegean Region was held in Alaşehir on 16-25 August 1919 (Url 6). The building where the Alaşehir Congress was held has been restored and is used as a library today (Figure 4.4).

Figure 4.4. Alaşehir library before (left) and today (right)

(Source: Url 9-10)

4.2.3. Demographic Characteristics

Alaşehir District consists of 87 neighbourhoods. According to the data of the Turkish Statistical Institute, the population of the district, which was 57,013 in 1965, increased to 105,145 in 2020 (Figure 4.5). The population of Alaşehir district constitutes 7.25% of the total population of Manisa Province. On the basis of total population, Alaşehir ranks seventh in Manisa districts. In the Alaşehir Revision Zoning Plan Explanation Report dated 05.07.2012, four different calculation methods, namely the Least Squares Method, the Arithmetic Increment Method, the Exponential Method, and the Combined Interest Method, were used to determine the estimated population of the Alaşehir district for 2025, and by taking the average of the results, population is predicted to be 125,113.

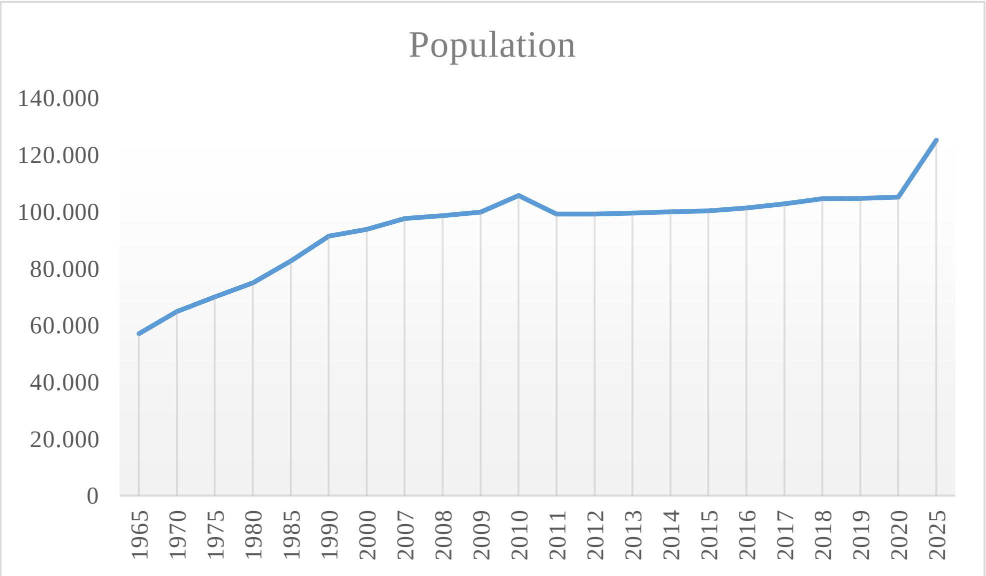


Figure 4.5. Population of Alasehir

According to the data of the TSI for 2020, the five neighbourhoods with the highest population are Istasyon, Kurtulus, Yenimahalle, Beseylül and Kavaklıdere. With 9.463 people, Istasyon is the neighbourhood with the highest population, while Kurtulus ranks second with 8.045 people. While the first four neighbourhoods in the ranking of the neighbourhoods with the highest population are located in the district center, the Kavaklıdere neighbourhood, which is in the fifth place, is the settlement that has transformed from a town to a neighbourhood with the Law No. 6360. Settlements with a population of less than 100 people are Bahçedere, Gürsu and Matarlı neighbourhoods.

4.2.4. Socio-Economic Characteristics

There is a direct relationship between the economic structure and geographical features of the Alasehir district (Karakuyu, 2008). Alaşehir has an agricultural production-oriented economic structure due to its fertile lands. Karakuyu and Özçağlar (2005), claims that the economy of Alasehir is especially dependent on the cultivation of *sultani* grapes and the cultivation of *sultani g*rapes has become a monoculture.

The fact that grape cultivation is the main economic activity has led to the development of the food industry in the district. There are many fresh vegetable and fruit processing facilities in the district center. There is also the Grape Agriculture Sales Cooperative (TARİS) Integrated Facilities, which has an area of 44.250 m^2 and employs 530 people. The Suma Factory and Sarıkız Mineral Water Factory are other large industrial establishments that provide employment.

4.2.4.1. Agricultural Production

According to the data received from Alasehir District Directorate of Agriculture and Forestry, a total of 457.143,3 tons of agricultural products are grown in Alasehir District in 2020. The products grown were examined in seven main groups as fresh fruit, nuts, vegetables, grains, tobacco, fodder crops and cotton, and with an annual production of 410.082,1 tons, fresh fruit stands out as the most produced agricultural product. . Grain products take the second place in terms of production amount with an annual production of 28.153.6 tons. Cotton production is in the last place with 125 tons.

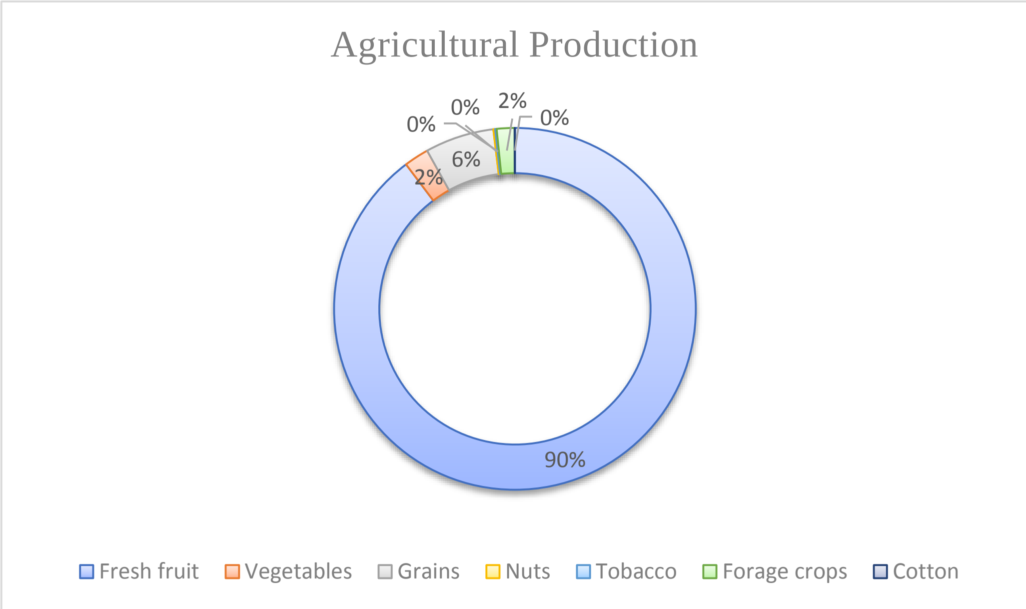


Figure 4.6. Agricultural production types in Alaşehir in 2021

Fresh fruit production constitutes 90% of the total agricultural production (Figure 4.6). It is observed that among the fresh fruit species, dried grapes and seedless grapes are the most produced fresh fruit species with an annual production of 206.010 and 153.000 tons, respectively (Figure 4.7).

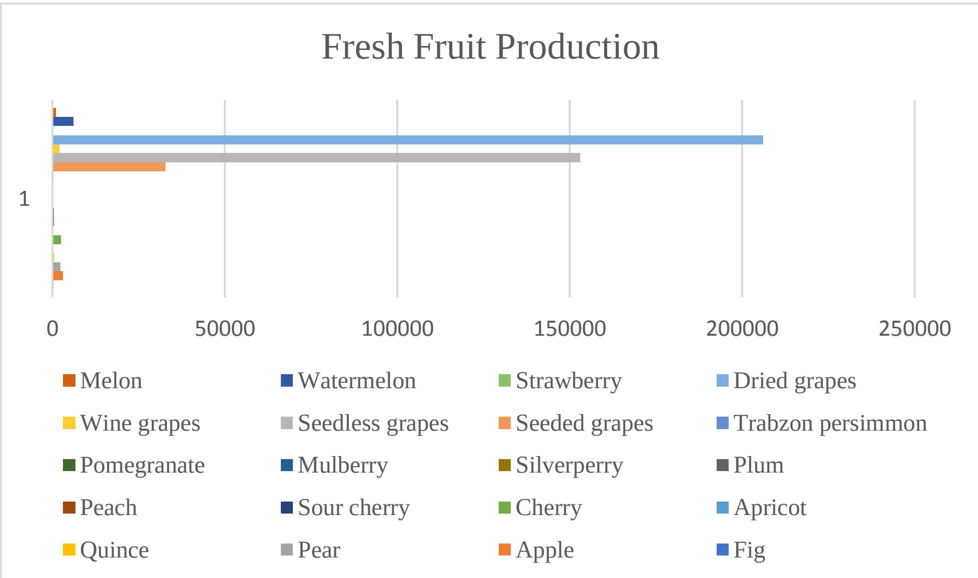
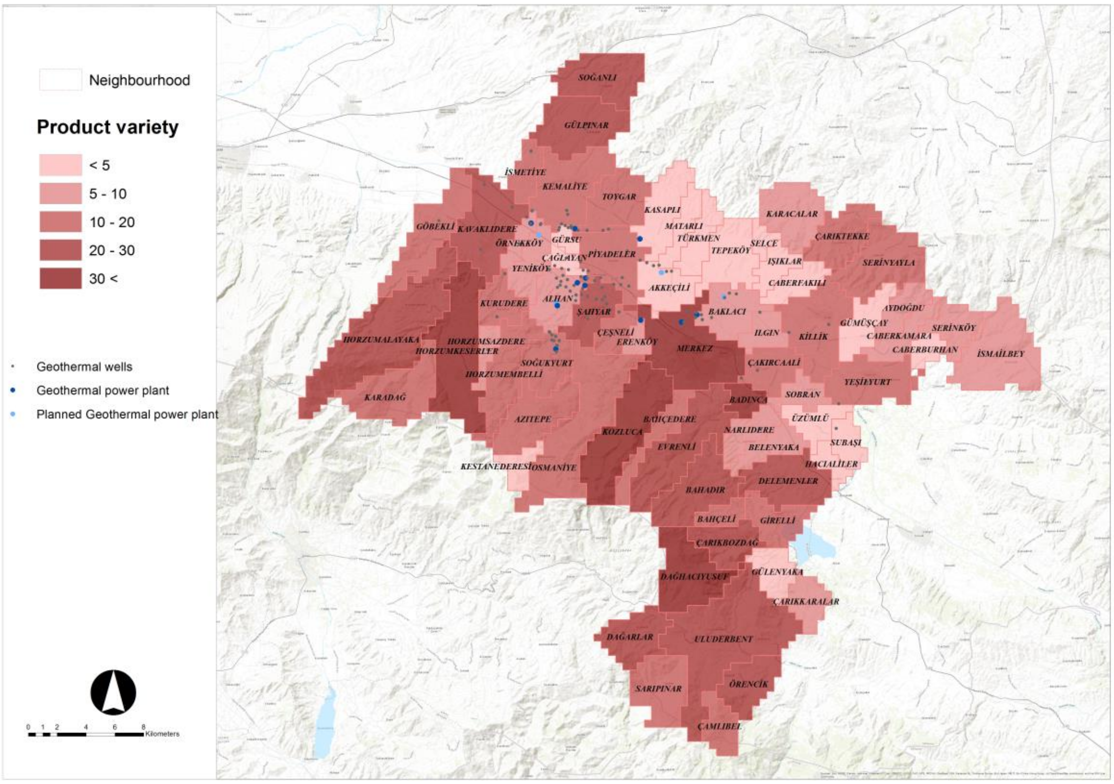


Figure 4.7. Fresh fruit production in Alasehir in 2021

The richest neighbourhoods in terms of product diversity in Alasehir, are Daghacıyusuf and Kozluca with 36 different product types. These two neighbourhoods have high altitude values. The product variety in Alasehir city center and Badınca neighbourhood is higher than other settlements on the plain. It can be observed that the poor neighbourhoods in terms of product diversity cluster in the northwest of the city center (Map 4.4).



Map 4.4. Product variety in Alasehir in 2021

4.2.4.2. Industrial Structure

There are 105 industrial facilities registered with the Alasehir Chamber of Commerce and Industry within the borders of the Alasehir. There are facilities in the food, energy, manufacturing, and mining industries in the district. Industrial facilities producing food constitute 66% of the total facilities (Figure 4.8). After food, the manufacturing industry ranks second in terms of the number of facilities. The energy industry has a rate of 11% and lastly, there is one marble quarry.

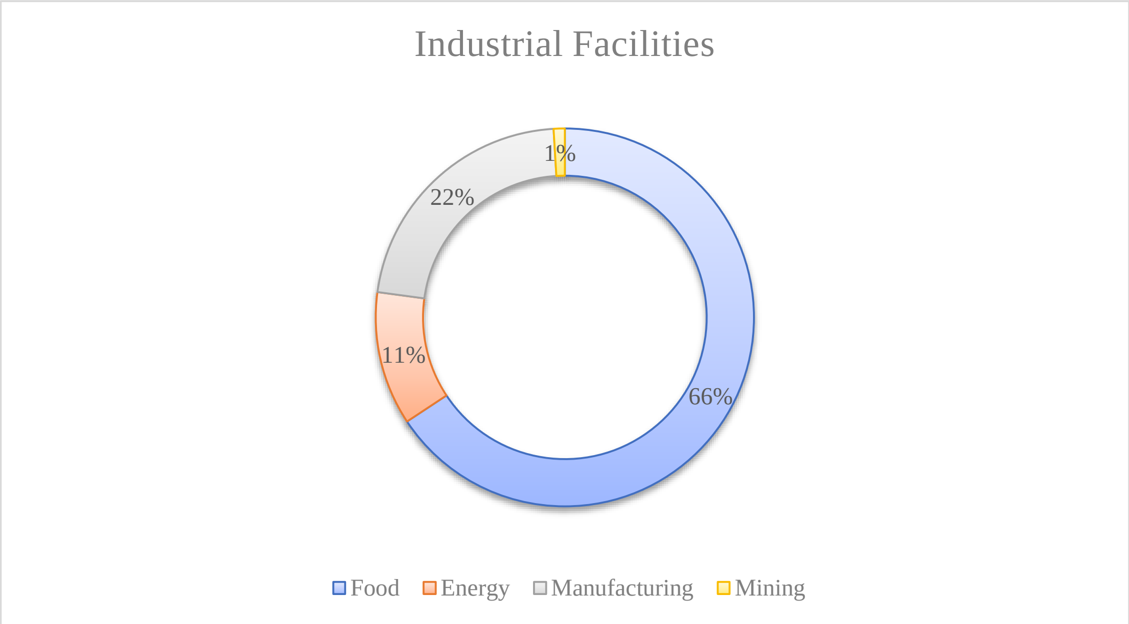
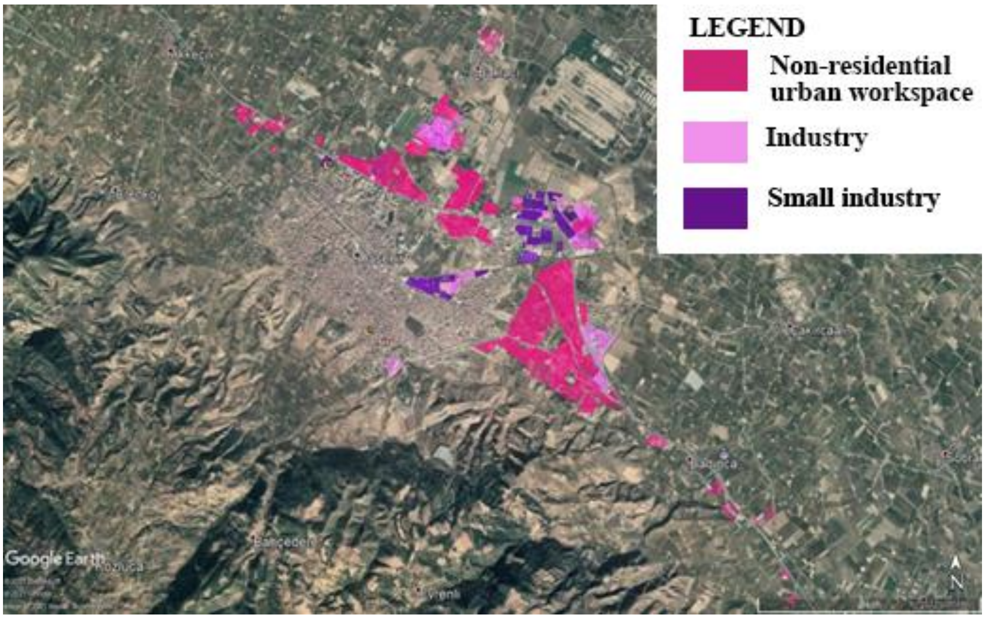


Figure 4.8. Industrial facilities in Alasehir in 2019

When the number of facilities producing food in Alasehir district is compared with the total number of facilities, it comes to the forefront as the dominant mode of production. There are 21 different production methods in food facilities, and the number of facilities that process fresh vegetables and fruits, packaging, storage and freezing constitutes 64% of the total food facilities.

There are two industrial districts and two automobile sales zones in Alasehir. According to the data obtained from the Alasehir New Small Industrial Site Cooperative, there are 128 shops in the area known as the Old Industrial Site. Industrial facilities constitute a large part of this area, and Merchants Site with 146 workplaces are also located in Alasehir.



Map 4.5. Industrial area in Alasehir District Center in 2021

Small industry, industry, storage, and non-residential urban working areas within the borders of Alasehir 1/1000 Scaled Revision Zoning Plan are show in Map 4.5. There are approximately 28 hectares of small industrial area, 108 hectares of non-residential urban working area, 35 hectares of industrial area in Alasehir district center and there is a total of 509 hectares of industrial area throughout the district. Most of the industrial areas in the district center were built with local zoning plans, and this fragmented approach caused the industrial areas to be dispersed and irregularly located.

4.2.4.3. Trade Rates

The Customs Directorate, located in Alasehir District, was established under the Directorate of Customs with the decision of the Council of Ministers in 2006. While it was serving as Mobile Customs affiliated to Manisa Customs Directorate, it became an Independent Customs in 2007.

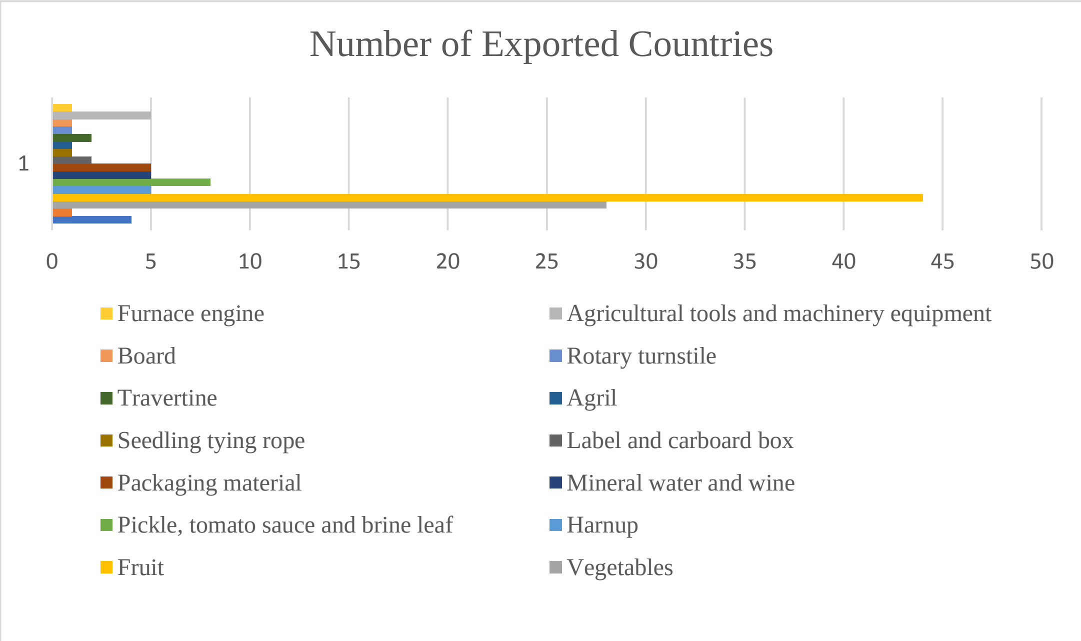


Figure 4.9. Export values between 2019 and 2020

According to the data obtained from the Alasehir Customs Directorate, goods were exported to 45 countries between the years 2019-2020 (Figure 4.9). The total statistical USD value of the exports made is 491.839.399 $. The product with the highest total statistical value in USD and exported to 44 different countries is the fruit species (Figure 4.10). Vegetable products take the second place on the basis of the number of countries they are exported to and their USD value.

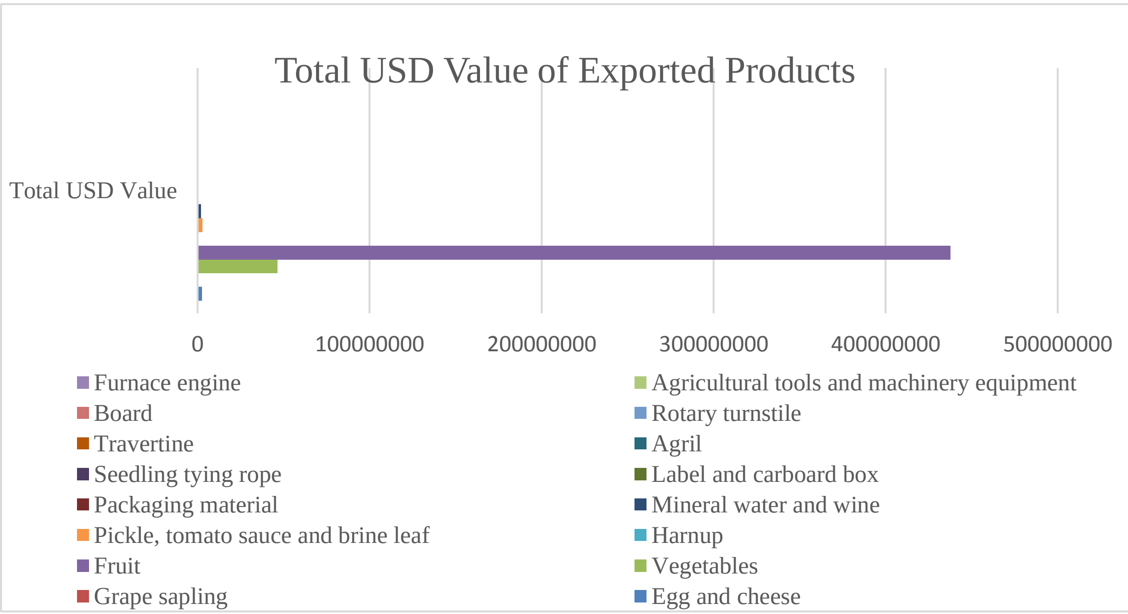
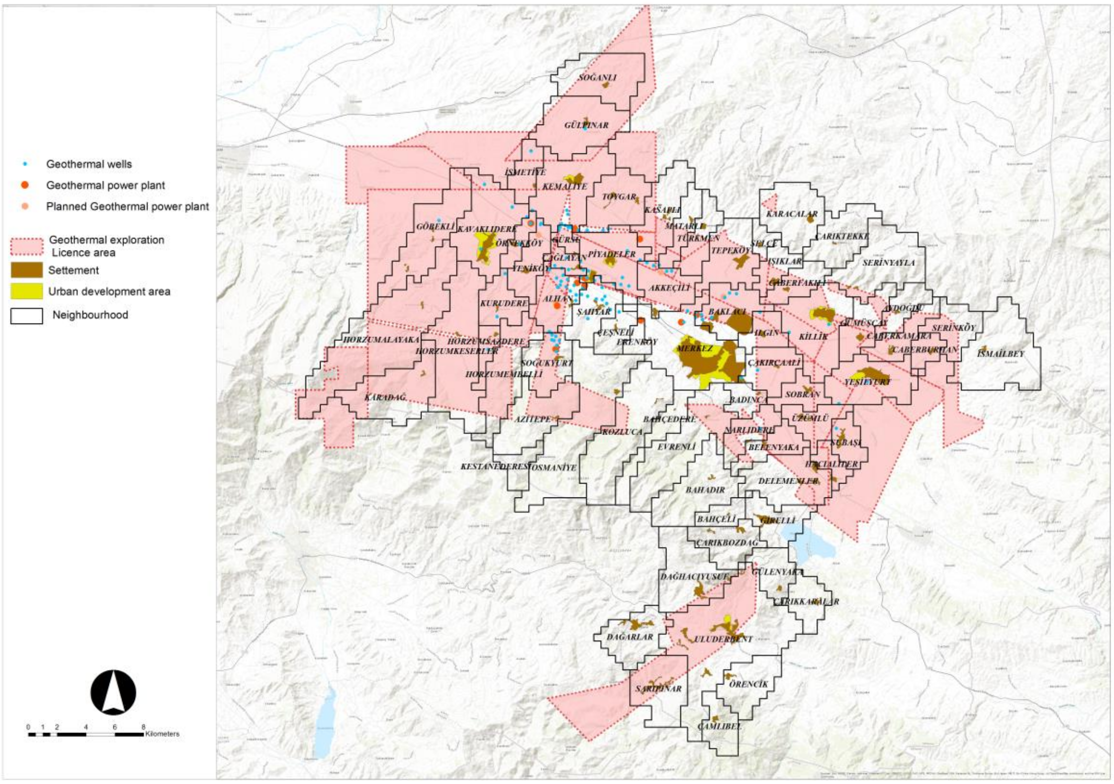


Figure 4.10. Total value of exported products in Alasehir

4.3. Geothermal Energy in Alasehir

The geothermal field in Alaşehir has the hottest water wells in Turkey with a temperature of 287 ^{o}C. Drilling activities in Alaşehir has increased especially after 2011 (Prill, 2019). Here are 11 existing geothermal power plants and 108 geothermal wells in the district, and six power plants are planned. Existing and planned geothermal power plants are located to the west of the city center. As can be seen on the Map 4.6, the geothermal license area covers a large portion of the district. Part of Alaşehir district center and 61 neighbourhoods are located within the geothermal license area. Except for Çeşneli and Erenköy neighbourhoods, all the neighbourhoods to the west of the district center are within the license area.



Map 4.6. Existing and planned geothermal power plants, wells, and exploration licence area in Alasehir

Baba (2015) stated that serious environmental problems may occur during the drilling phase and mentioned that thermal and chemical contamination occurred as a result of the explosion that occurred during the drilling phase in the Gediz graben. The said explosion occurred in Alaşehir, which was determined as the case of this study.

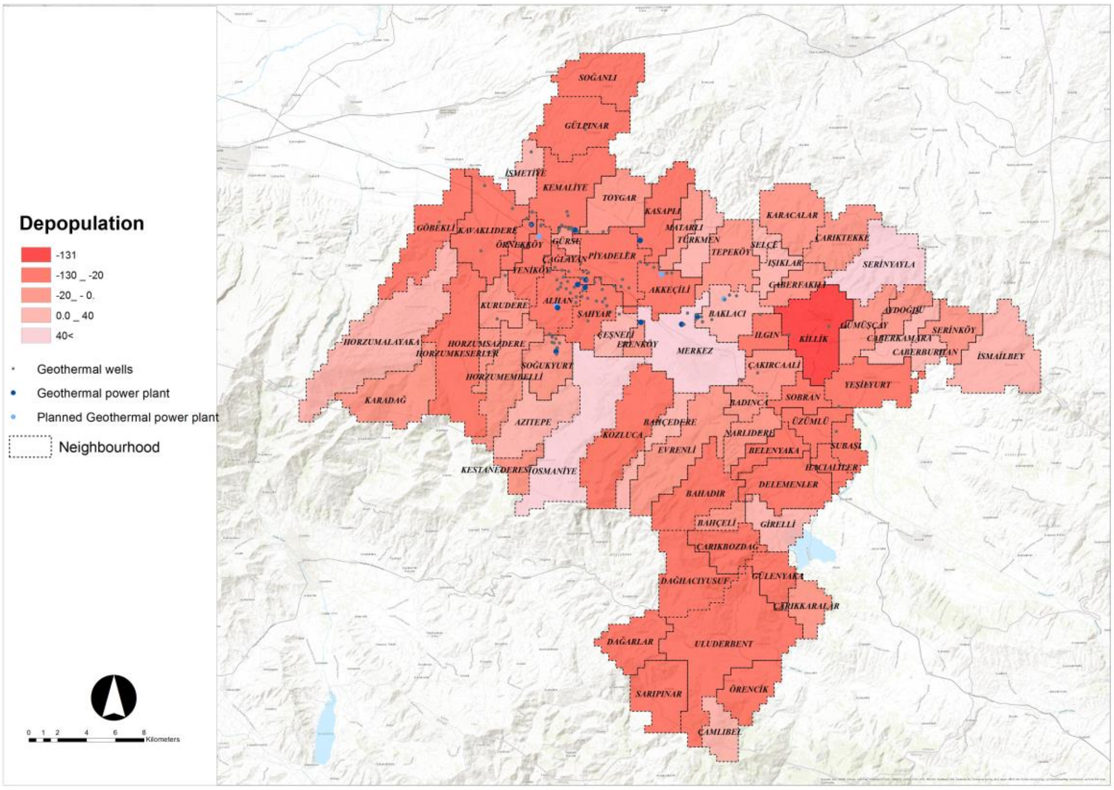
4.4. Socio-Spatial Analysis

In the socio-spatial analysis, Alaşehir district was evaluated as the city center and rural neighbourhoods. There are a total of 87 neighbourhoods in Alaşehir, of which 15 are central neighbourhoods and 72 are rural neighbourhoods. However, due to the fact that the cadastral boundaries of Yuvacalı neighbourhood are not determined in the neighbourhood boundaries map taken from Alaşehir Municipality, Yuvacalı and Toygar Neighbourhoods were evaluated within the same boundary in spatial analysis.

4.4.1. Population Change

Population change on a neighbourhood basis is calculated by subtracting the total population of the district in 2020 from the population in 2016. In accordance with the depopulation data, it can be observed on Map 4.7 that the total population of Alaşehir increased by 3,832 people between 2016 and 2020. Alaşehir city center has the highest increase with an increase of 5221 people. While population growth was observed in 16 rural neighbourhoods, the remaining 57 rural neighbourhoods' population decreased.

Osmaniye neighbourhood, located in the southwest of the city center, is the rural neighbourhood with the highest increase with 44 people, while the rural neighbourhoods with the least population increase are Bahçedere and Horzumalayaka. Killik neighbourhood, ranks first in the list of neighbourhoods with a decreasingpopulation,with a decrease of 131 people. Kemaliye neighbourhood, which is in the northwest of the district center is the second neighbourhood with a decreasing population.

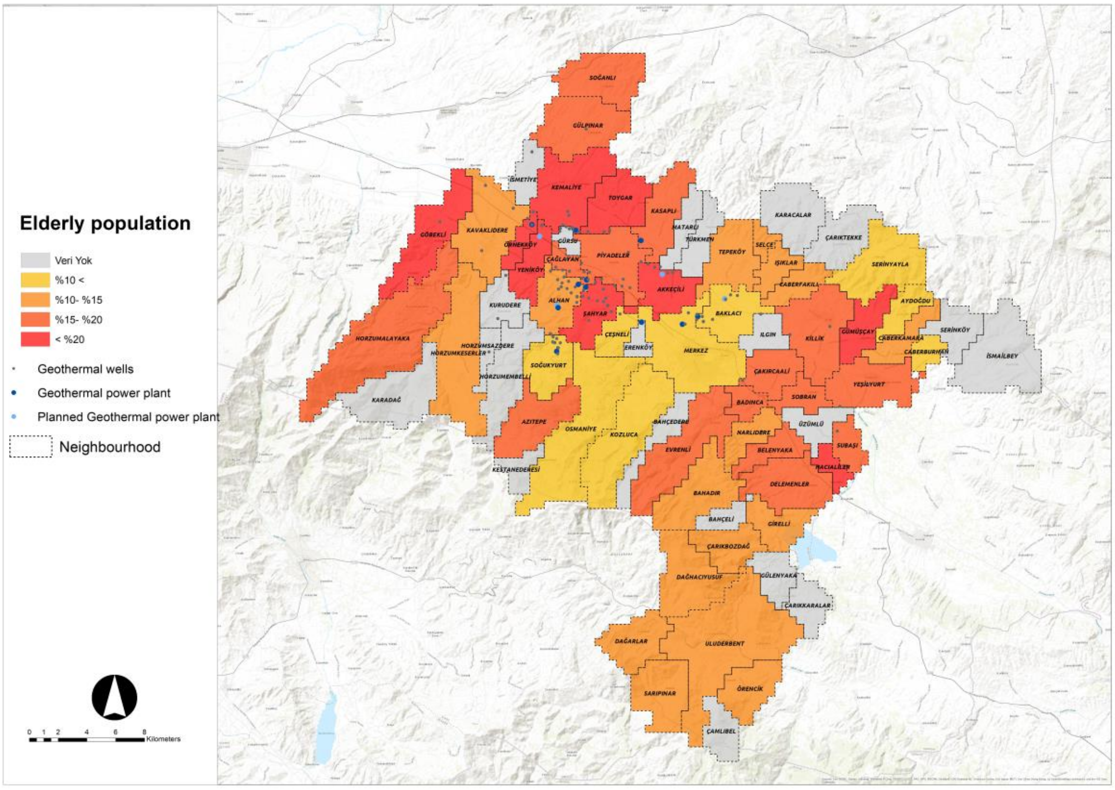


Map 4.7. Population change by neighborhood in Alaşehir

4.4.2. Elderly Population

The elderly population ratio is calculated by dividing the population over 65 years of age in 2020 by the total population of the neighbourhood. Since TSI does not provide age range data for the neighbourhoods with a population of less than 250, the elderly population ratio could not be calculated for 22 neighbourhoods with a total population of less than 250 people. The ratio of elderly population in Alaşehir is 14%. This rate is above the Turkey average of 9.5% and the Manisa Province average of 11%.

In the neighbourhoods where the elderly population ratio is calculated, the ratio of the elderly population varies between 4% and 24%. It is observed that the neighbourhoods with a high rate of elderly population are clustered in the west of the city center. Neighbourhoods with a high rate of elderly population are Göbekli, Örnekköy, Yeniköy, Kemaliye and Akkeçili, respectively. The proportion of elderly population in 8 rural neighborhoods (Caberburhan, Aydoğdu, Serinyayla, Soğukyurt, Kozluca, Çeşneli, Baklacı and Osmaniye) and city centers is below 10% (Map 4.8).

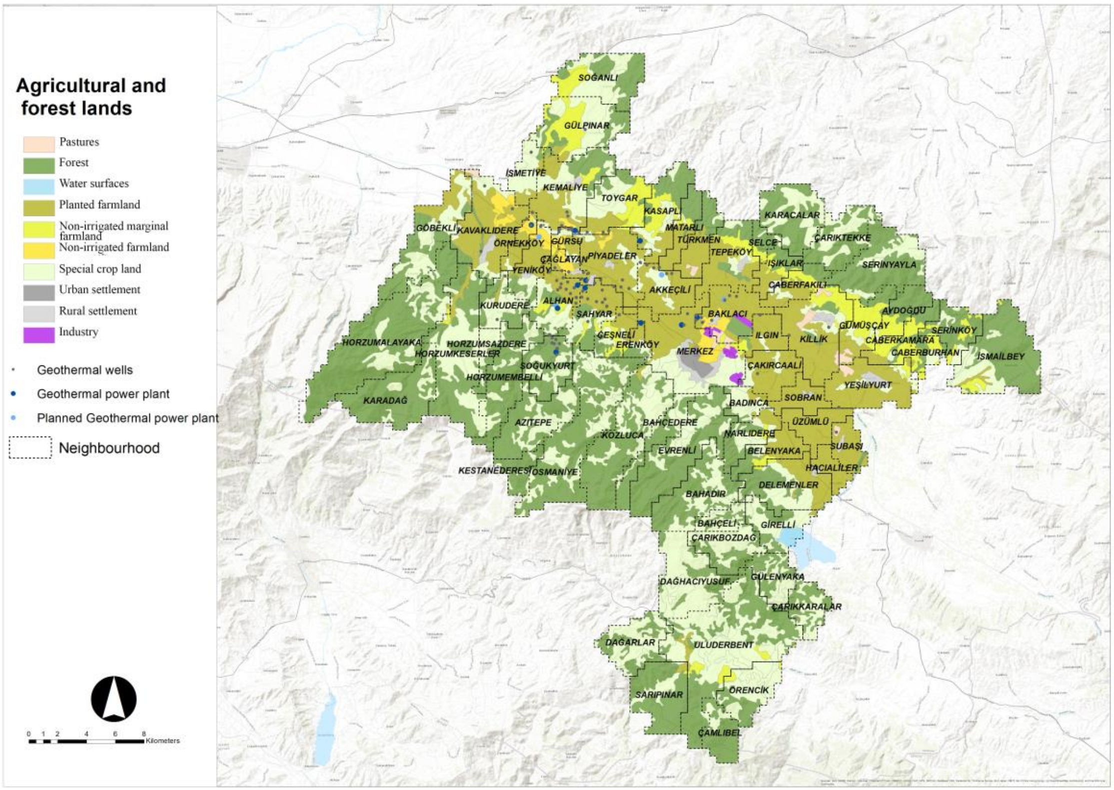


Map 4.8. Elderly population by neighbourhood in Alasehir

4.4.3. Agricultural and Forest Lands

For the spatial distribution of agricultural and forest lands in Alaşehir, the 2018 Coordination of Information on the Environment (CORINE) data prepared by the European Environment Agency (EEC) on satellite images was used. Most of the agricultural lands in Alaşehir district consist of planted agricultural lands, and 41 of 87 neighbourhoods have planted agricultural lands. Neighbourhoods with cultivated agricultural land are clustered in the plain (Map 4.9).

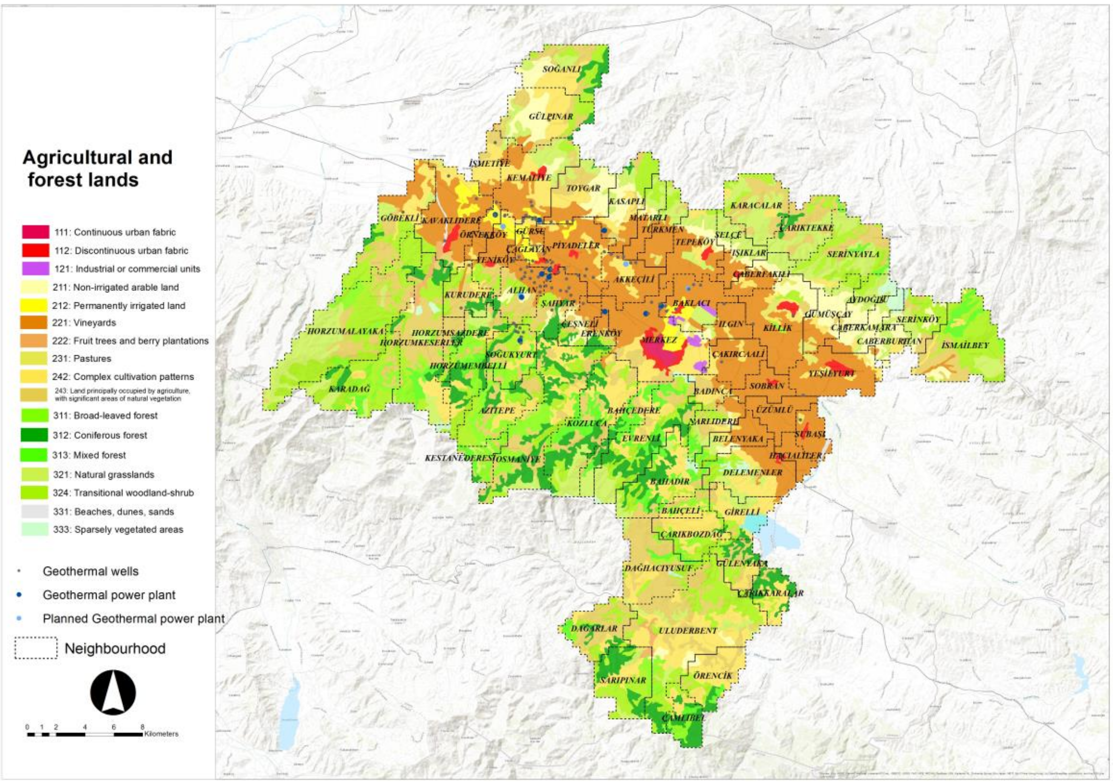
According to the data on cultivated area provided by Alaşehir District Directorate of Agriculture and Forestry for the year 2021, Killik neighbourhood ranks first with 13,883 decares of cultivated area. Killik neighbourhood is followed by Piyadeler, Kavaklıdere, Kemaliye, Gulpınar, Yeşilyurt, Gobekli, Akkeçili, Tepekoy and Toygar neighbourhoods.



Map 4.9. Agricultural and forest lands in Alaşehir

Most of the dry marginal agricultural lands are in the north of the county, between planted agricultural lands and forest areas. Of the agricultural land classes, the one that occupies the least area in the district is the dry absolute agricultural land. Dry absolute agricultural lands are in Kavaklıdere, Örnekköy, Yeniköy, Gürsu, Çağlayan, Kemaliye, Piyadeler, Baklacı neighbourhoods and in the north of the district center (Map 4.10).

The special product lands are scattered in the district and are observed as the dominant land class in the southeast of the district center and in the neighbourhoods close to the Aydın border. There are forest and special product lands in the mountainous regions in the north and south of the district.

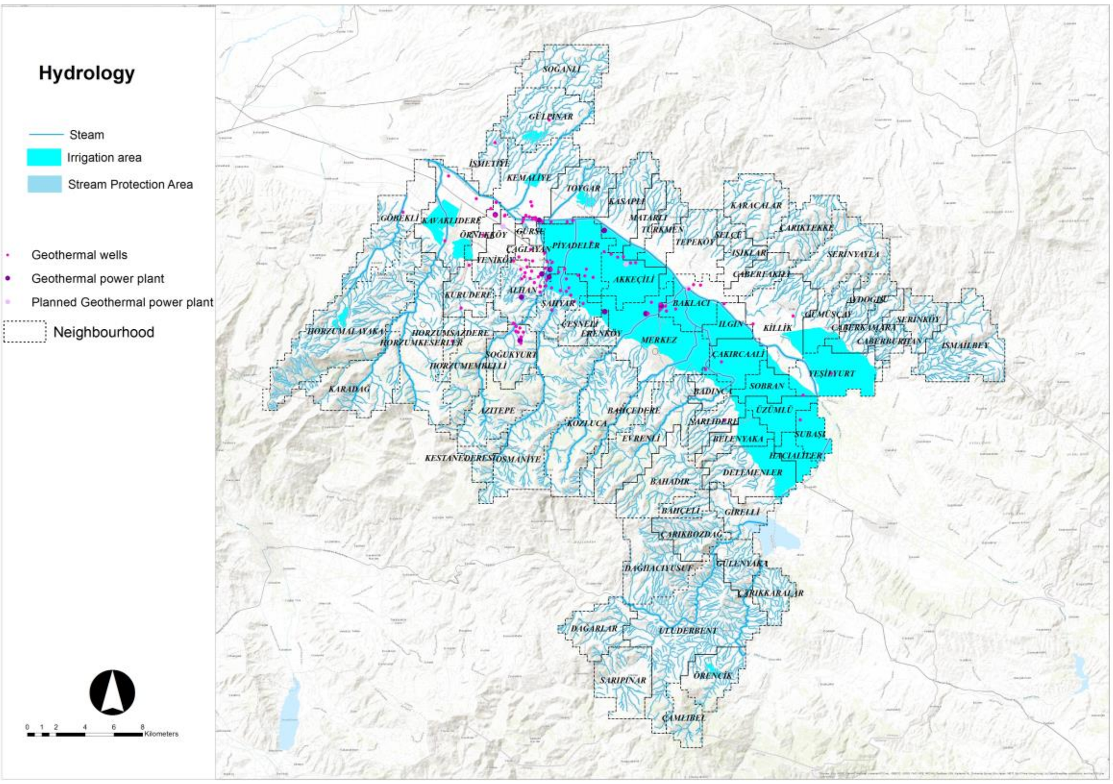


Map 4.10. Detailed map of agricultural and forest lands in Alaşehir

4.4.4. Hydrology and Protection Areas

The Alaşehir Stream, which is a branch of the Gediz river and passes through the Alaşehir plain, is the most important water source for the district. The length of the stream is 115 km (Gediz Basin Management Plan, 2018). For the hydrological analysis, a protection limit of 100 meters for the main drains and 50 meters for the stream beds has been determined (Map 4.11).

There are 13 irrigation fields in the district. Within the scope of Turkey Irrigation Modernization Component 1, the Alaşehir Irrigation Renewal Project area is located within the borders of Delemenler, Hacıaliler, Subaşı, Sobran, Üzümlü, Badınca, Çakırcaali, Ilgın, Baklacı, Akkeçili and Yeşilyurt neighbourhoods.

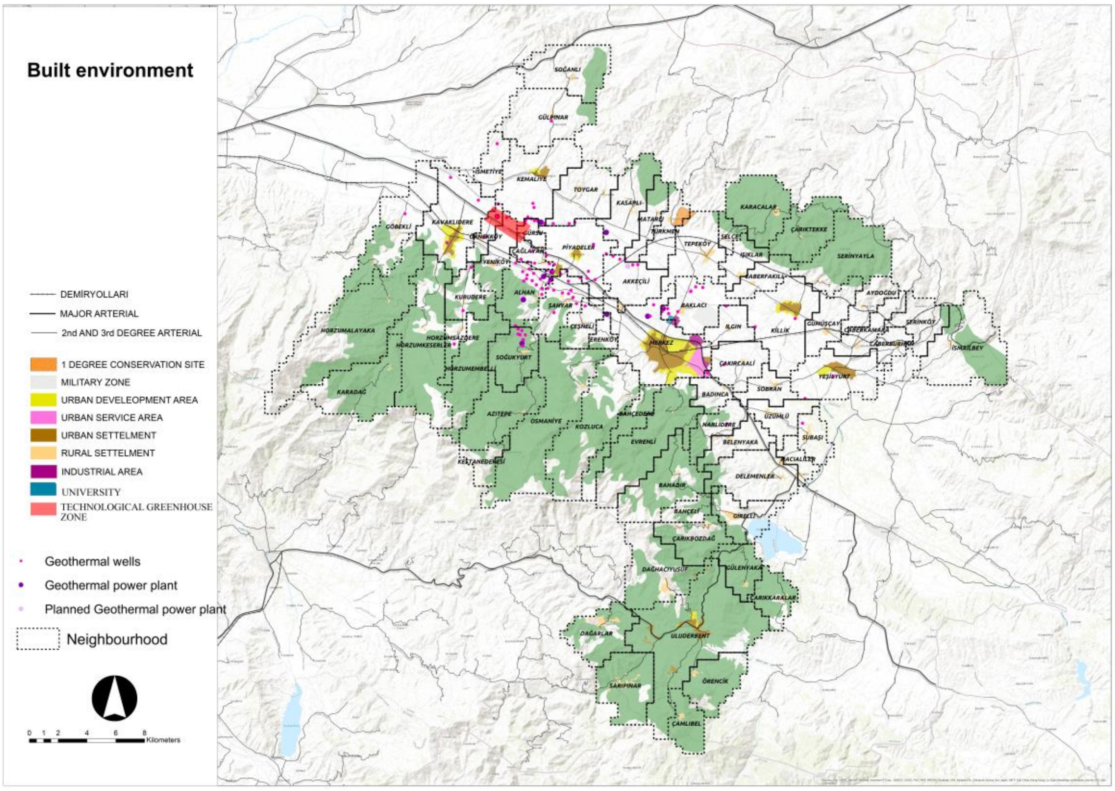


Map 4.11. Hydrology of Alaşehir

4.4.5. Built Environment

İzmir-Manisa 1/100,000 scale Environmental Plan Data was used for the built environment analysis (Map 4.12). In line with the analysis, Alaşehir City Center and Kavaklıdere, Kemaliye, Piyadeler, Killik Yeşilyurt and Uluderbent neighbourhoods are located within the boundaries of the plan as urban built-up areas. All remaining neighbourhoods are rural settlement areas.

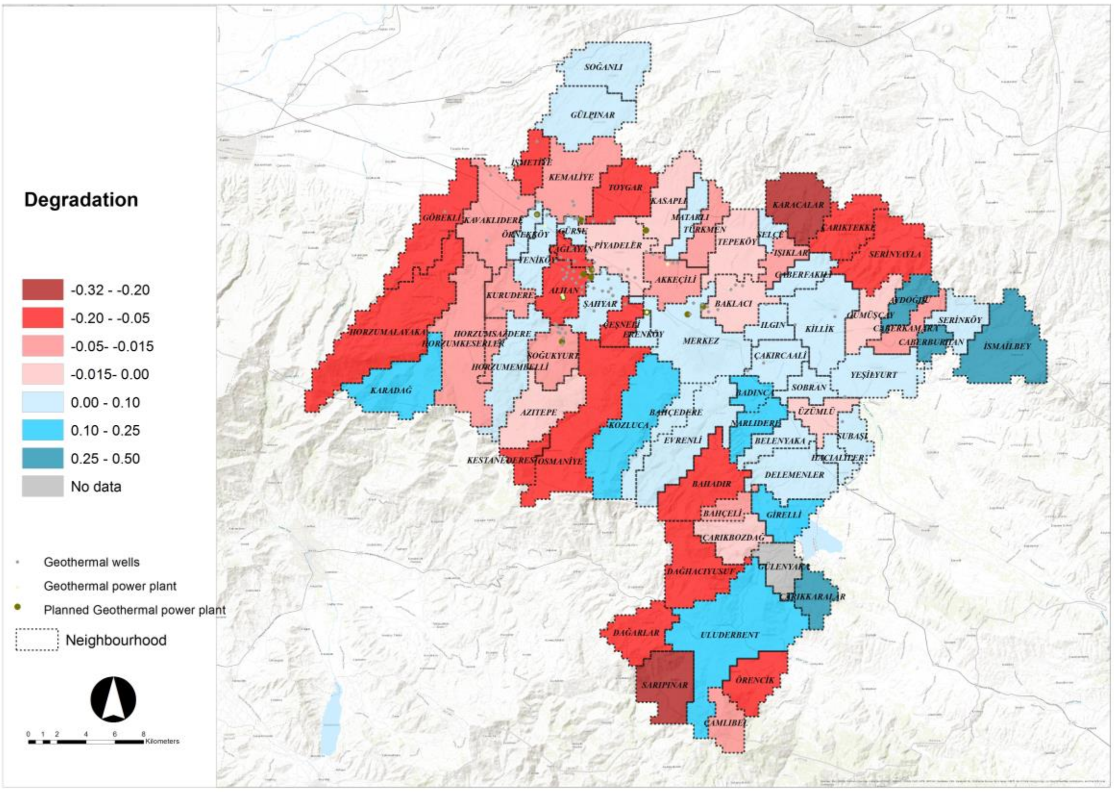
There is a Training Regiment Command of the Turkish Armed Forces, Celal Bayar University Alaşehir Vocational School, and a wastewater treatment plant within the borders of Baklacı neighbourhood. A large part of Alaşehir city center and a part of Türkmen and Tepeköy neighbourhoods are located within the boundaries of the First-Degree Archaeological Site. In the northeast of Gümüşçay neighbourhood, there is a Third-Degree Archaeological Site and a natural protected area. The areas determined as the Area to be Afforested in the Environmental Plan are located in the east and northwest of the district center. It is planned to build a Technological Greenhouse Zone within the borders of Örnekköy, Yeniköy, Gürsu, Çağlayan and Kemaliye neighbourhoods.



Map 4.12. Built environment

4.4.6. Cultivated Area Change

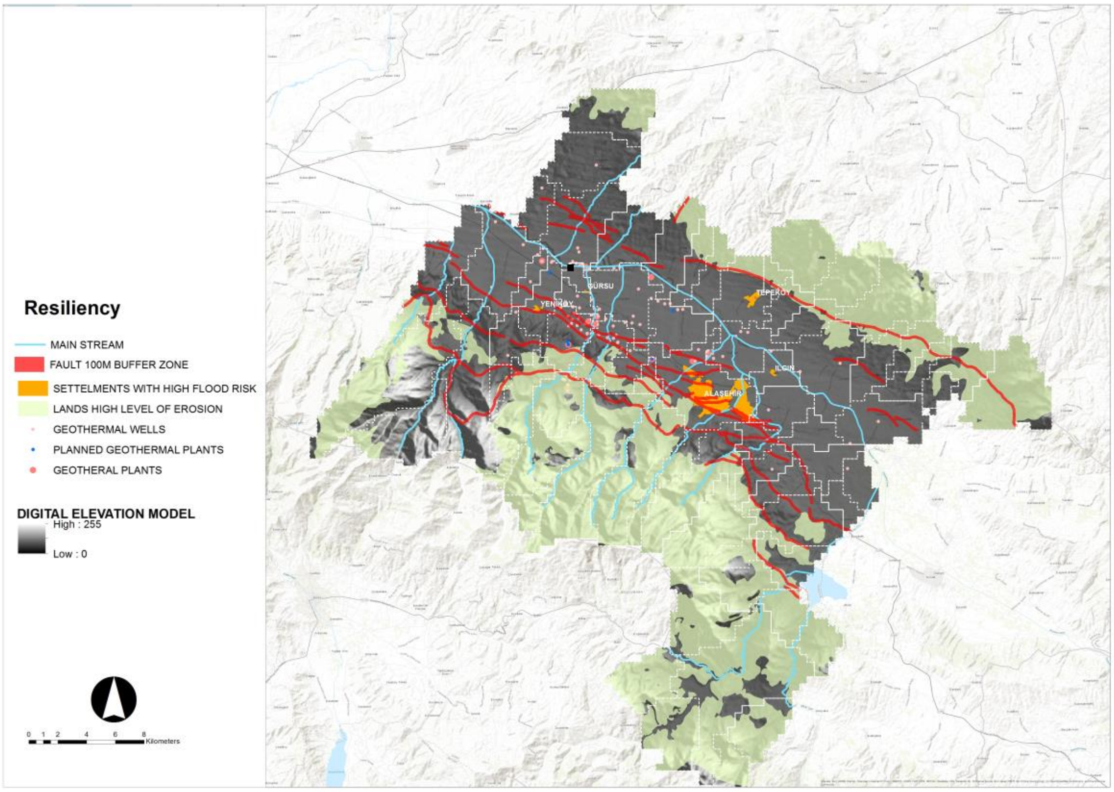
For the degradation analysis, the "Farmer registration system parcel production document throughout the district" for the years 2016 and 2021, obtained from the Alaşehir District Directorate of Agriculture and Forestry, was used (Map 4.13). The cultivated area change is obtained by dividing the amount of cultivated area in 2021 and the amount of difference between 2016 and 2021. According to the results of the analysis, the neighbourhoods where the amount of cultivated land has decreased at a high rate are Karacalar, Sarıpınar and Alhan neighbourhoods, respectively. neighbourhoods with the highest rate of increase in cultivated area are Çarıkkaralar, Caberburhan and Aydoğdu neighbourhoods, respextively.



Map 4.13. Cultivated area change by neighbourhood in Alasehir in 2021

4.4.7. Resilience

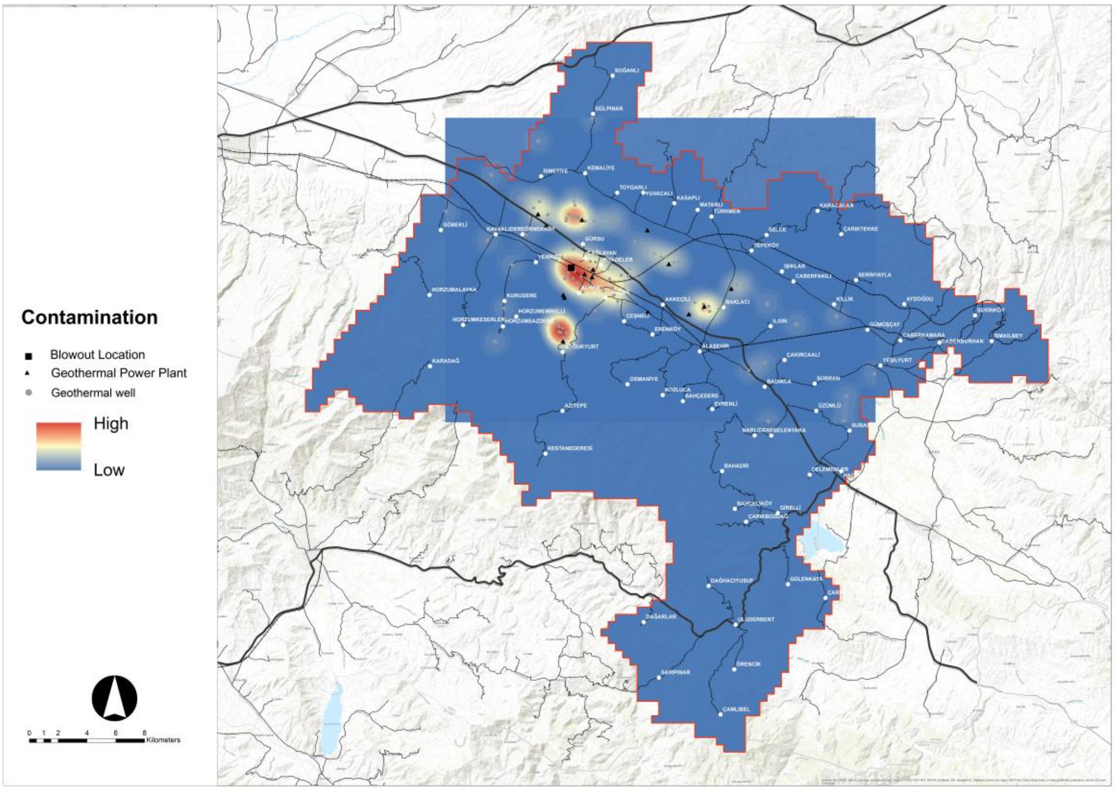
Fault lines, settlements under flood risk and areas with high erosion rates were used for the resiliency analysis (Map 4.14). Fault lines are located on the northern and southern borders of the plain. Alaşehir city center and Yeniköy, Ilgın, Tepeköy and Gürsu neighbourhoods are settlements under high flood risk. The areas with high erosion level are the mountainous settlements in the northern and southern parts of the district



Map 4.14. Resilience

4.4.8. Contamination

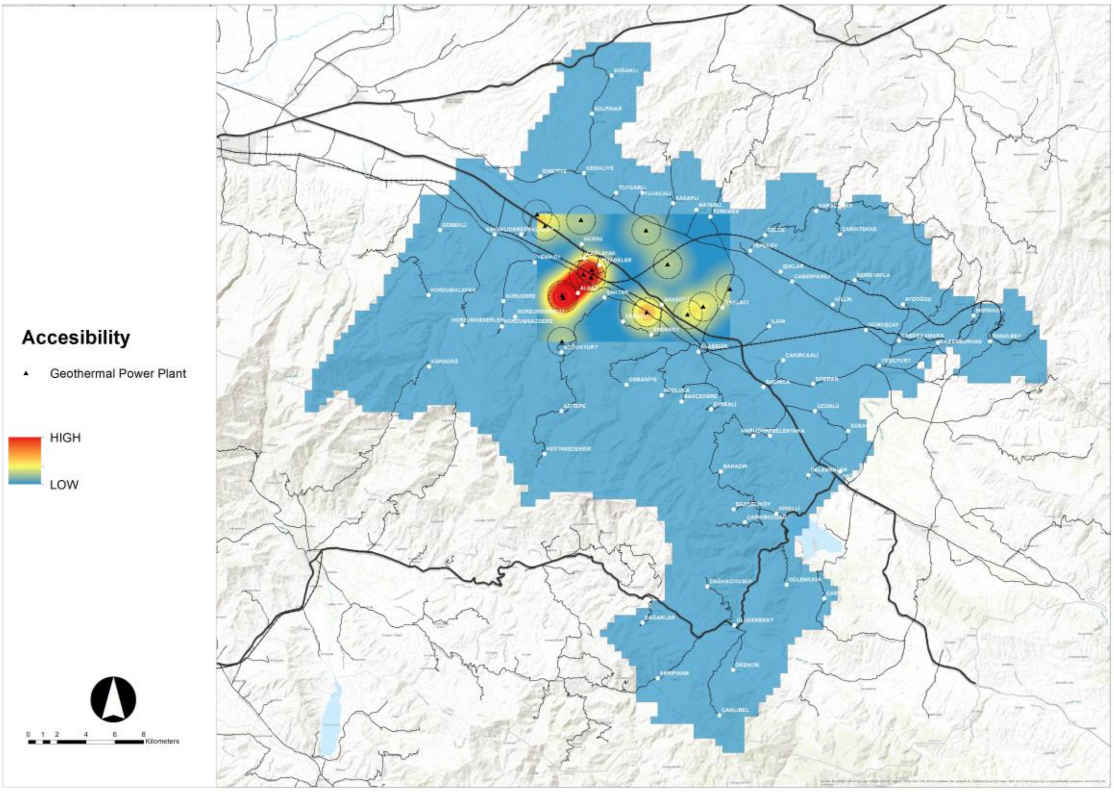
Blowout points data were used for contamination analysis. Blowout points data was obtained from the study of Rabet et. al. (2017). Kernel Density tool in ARCGIS was used for explosion points (Map 4.15). The areas where clustering is observed in the analysis results are close to the neighbourhood centres of Alhan, Piyadeler, Çağlayan and Şahyar. Clustering is also observed in the northwest of Soğukyurt and Gürsu neighbourhood centres.



Map 4.15. Contamination from blowout

4.4.9. Existing and Planned Geothermal Power Plants Density

For the accessibility analysis, the existing and planned geothermal power plants and the rural and urban settlement areas data obtained from the İzmir-Manisa Planning Region 1/100.000 scale Environmental Plan were used (Map 4.16). In this analysis, existing and planned geothermal power plants were evaluated as disamenities and density analysis was applied with the "Kernel Density" tool in the ARCGIS. According to the results of the analysis, the Alhan neighbourhood center is located in the region where the existing and planned geothermal power plants are highly concentrated. While Piyadeler and Çağlayan neighbourhoods are in the region with medium population density, Akkeçili, Çeşneli, Baklacı and Erenköy neighbourhoods are the least densely populated region.



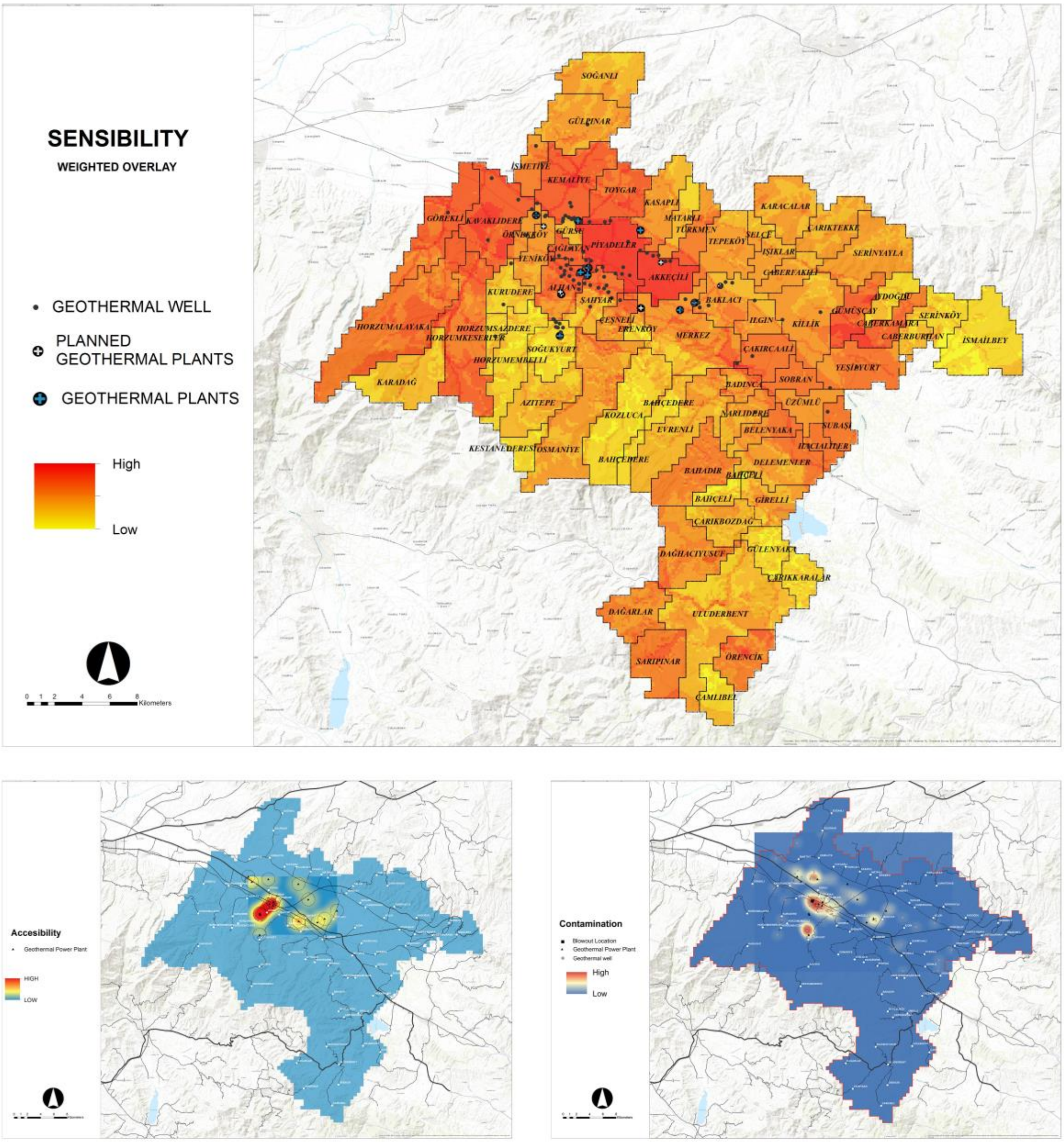
Map 4.16. Accessibility to existing and planned geothermal power plants

4.5. Results and Discussions

While determining the people to be interviewed, the sensitivity, accessibility and contamination maps created as a result of socio-spatial analyzes were evaluated together (Map 4.17). A sensitivity map was created by applying weighted overlay analysis to population change, elderly population, agricultural and forest lands, hydrology, and protection areas, built environment, cropland change and resiliency layers. Map was made with the aim of detecting the settlements with the highest socio-spatial sensitivity. According to the map, the two neighbourhoods with the highest sensitivity are Piyadeler and Akkeçili.

The accessibility map created was used to determine the distance of existing and planned geothermal power plants to the settlements. According to the map, the Alhan neighbourhood center is located in the region where the current and planned geothermal energies are the most intense.

Finally, a contamination map was created in order to determine the settlements where the geothermal energy originating explosion points are concentrated in the region. It has been determined that the clustering areas are close to the Alhan, Piyadeler, Çağlayan and Şahyar neighbourhood centres.



Map 4.17. Sensibility, accessibility, and contamination analyzes

While determining sensitivity, accessibility and contamination analyzes together, it has been determined that there are existing and planned geothermal power plants or wells in sensitive areas. As a result of the depopulation analysis, except for the city center and Baklacı neighbourhood, it is observed that the neighbourhoods with geothermal power plants lose population and Kemaliye is the neighbourhood with the highest population decrease among these neighbourhoods. In line with the elderly population analysis, the west of the district, where the geothermal power plant and wells are dense, has a high elderly population rates. According to the agricultural and forest lands analysis, except for Tepeköy, there are geothermal wells in the top neighborhoods with the most cultivated land in the district, and a geothermal power plant is located in Piyadeler, which is in the second place in most cultivated land ranking. In the analysis of hydrology and protection areas, it is determined that the geothermal power plant which is located on the border between Kemaliye and Gürsu districts, is the closest power plant to the Alaşehir Stream. Some geothermal wells in Kavaklıdere, Örnekköy, Kemaliye, Gürsu, Çağlayan, Alhan, Soğukyurt, Şahyar, Piyadeler and Baklacı neighbourhoods are located within the 100-meter protection zone of the main drainages. The geothermal wells in the Kurudere, Alhan and Soğukyurt neighbourhoods are located within the 50-meter protection zone of the river. Five geothermal power plants in the district, one geothermal power plant planned to be built in Akkeçili and many geothermal wells are located within the Alasehir Irrigation Renewal Project boundaries. According to the built environment map, there is a geothermal power plant and 5 wells within the borders of the Technological Greenhouse Zone. In line with the degradation analysis, the geothermal power plant is located in the Alhan district, which ranks third in the neighborhood with the highest loss of planted area in the district. In the resiliency map, it is observed that the fault line passes through the neighborhoods with geothermal power plant and wells.

The area for the semi-structured interview was determined by evaluating these analyzes together. The semi-structure interview questions used for the perceived quality of life evaluation contain the dimensions of built environment, vulnerability, health, contamination, degradation, resilience, and participation obtained as a result of the literature review. In this part of the study, the measured sub-categories of the quality-of-life dimensions are as follows:

- Built environment: visual pollution, and traffic
- Vulnerability: income, employment opportunities, and community development
- Health: physical and psychological health
- Contamination: water, soil, air, noise pollution and odour
- Degradation: change in land use and biodiversity

- Participation: informing and consultation

4.5.1. Results

4.5.1.1. Built environment

The majority of the participants expressed their opinions about the impact of geothermal power plants on the built environment. Increasing heavy vehicle traffic, pipelines and steam are the main reasons for the impact of geothermal energy on the built environment. During the construction of geothermal power plants and wells, heavy vehicles destroying village roads and irrigation channels and reducing their functionality is the most frequently mentioned impact. Interviewee 9 mentioned that some companies in the region cover the damage caused while others do not. Another built environment effect is that heavy vehicles cause dust, and this dust affects the product quality in close ties.

Figure 4.11. Vineyard next to the geothermal power plant in Yeniköy, Alaşehir

(Source: Taken from Interviewee 6)

Figure 4.12. Vineyard next to the geothermal power plant in Yeniköy, Alaşehir
(Source: Taken from Interviewee 6)

Interviewees state that the visual impact of the conveying pipes is negligible. Their main concern is the possibility of an explosion or leakage in the pipes. Interviewee 15, who lives in Piyadeler neighbourhood, states that she is worried about the explosion of the geothermal pipeline located under the main road line. It is said that the steam emitted from the geothermal power plants produces a fog throughout the plain, and the steam is so effective that it is difficult to work in the vineyards near the power station.

Figure 4.13. Pipelines of geothermal power plants in Piyadeler

(Source: Taken by the author, 2021)

4.5.1.2. Vulnerability

When asked how geothermal power plants affect the local economic development and income level, it is stated that there is no positive effect on the general economic development, except for the few people working in the power plants from the surrounding neighbourhoods and the residents of the neighbourhood who sell their lands to energy companies. Local people work in geothermal power plants in business lines such as security, cleaning, and renovation. The majority mentions that the land on which geothermal power plants are to be built is being sold at prices that exceed its value, and that the people selling their land are making a living from real estate investments with the income they generate.

12/15 Interviewees state that the decrease in product efficiency after the construction of the power plants leads to loss of income. Interviewee 7 states that in case of income loss caused by the direct impact of energy companies, one year of income loss can be obtained by the companies through the court, but the damage to the product lasts for 4-5 years. The owners of vineyards (Interviewees 6,7,8, and 12), which are located on the border of geothermal power plants, say that the decrease in yield in vineyards also has a negative impact on property values.

It is thought that geothermal greenhouse cultivation will contribute to economic development. 9/15 participants believe that geothermal-based greenhouse activities will become widespread if fluids are provided in the neighbourhoods, they live in. A greenhouse cooperative has been established in order to carry out geothermal greenhouse cultivation in the district. While the Interviewee 7, said that government support is needed for geothermal-based greenhouse cultivation, Interviewee 10, mentioned the difficulty of meeting the cost of geothermal-based greenhouse cultivation by the public. While greenhouse cultivation is generally demanded in the region, 1/15 interviewee stated that they would not be successful because greenhouse cultivation was far from the production method, they were accustomed to.

3/15 participants thought that the use of renewable energy contributes to the country in terms of reducing energy dependence but has no effect on local development. Interviewee 9, believe that geothermal power plants should invest in education and that an institution which provides education on geothermal for disadvantaged children is the most appropriate way to contribute to the economic development of the region in the long run. Similarly, Interviewee 10 says that the education and cultural investments of the energy companies in the region will contribute to the economic development.

4.5.1.3. Health

The majority of the participants state that the impact of geothermal energy on health is a subject that needs to be investigated, and although there is no obvious physical impact at the moment, there may be an increase in diseases related to respiratory tract in the long term. Interviewees 14 and 15, who emphasized the negative impact on health, live in Piyadeler neighbourhood, where the geothermal power plant is located close to the settlement.

Although the participants did not make clear comments about the impacts on physical health, they did explain more about the psychological effects. Impacts on psychological health come to the fore as concerns about environmental and economic problems that cause decreased productivity. During the semi-structured interview phase of the study, several participants stated that they wanted to have a face-to-face interview on the grounds that they were worried about energy companies might be trying to get information from them.

4.5.1.4. Contamination

All the participants expressed their opinions in the questions asked about the relationship between geothermal energy and contamination. It was the most emphasized issue in the interviews. Participants say that the most important impact of geothermal power plants and wells is the deterioration of underground and surface waters. It is claimed that the geothermal fluid was released into the stream water in Piyadeler, Gürsu, Alhan and Kemaliye neighbourhoods. As a result of irrigation of the vineyards with contaminated water, the roots of the vines are burned, and the vineyard becomes unable to produce any crops. Interviewee 2 states that the vineyard of approximately 200 decares has not yielded for 3 years due to the mixing of wastewater into the stream used as an irrigation water source in Gürsu district. Interviewee 15 states that as a result of irrigation with stream water mixed with hot water, their vineyards were damaged, and they had to uproot the vines (Figure 4.14). It has been mentioned that geothermal power plants in Piyadeler district also negatively affect drinking water.

After water pollution, the steam is the most mentioned pollutant. It is stated that dew droplets formed due to steam cause fungal disease in grapes and productivity decreases. Evaluations of odour and noise pollution vary depending on the distance from the living and working areas of the participants to geothermal wells and power plants. In some neighbourhoods, since the geothermal power plant and wells are far from the neighbourhood center, they only negatively affect the people who have vineyard around the power plant, while in some neighbourhoods, all of the people who participated in the study and resided in the same neighbourhood stated that they were disturbed by smell and noise due to their proximity to the settlement. While Interviewee 10 who lives in Kemaliye neighbourhood states that there is no odour and noise problem since the power plant is far from the settlement area, Interviewee 8, who has a vineyard close to the geothermal power plant in the same neighbourhood, states that he is disturbed by the smell and noise. Similarly, Interviewee 1, who lives in the Alhan neighbourhood, states that there is a smell from time to time depending on the direction of the wind, while Interviewee 7, who has a vineyard belonging to his family near the geothermal power plant in the Alhan neighbourhood, mentions that the smell is at a level that prevents them from working in the vineyard. While all the participants living in Akkeçili neighbourhood stated that they were uncomfortable with the smell, all the participants living in Piyadeler neighbourhood mentioned both noise and undesirable odour problem.

Figure 4.14. Vines uprooted from the burning vineyard

(Source: Taken by the author, 2021)

4.5.1.5. Degradation

8/15 participants expressed their opinions on the land use and biodiversity impacts of geothermal energy. While it was stated that wildlife was not affected due to the location of geothermal energy in the plain, it was stated that trees by the stream and the fauna of stream were damaged due to the release of hot water into the stream in Alhan and Kemaliye neighbourhoods. In the interviews, it was determined that the participants thought that the energy companies bought more land than they needed. Interviewee 9 states that people's perception of agricultural lands has changed due to the fact that companies buy lands above their value, and most of them want to sell their lands to companies and leave the neighbourhood. Interviewee 9 claims that they are trying to compensate for the geothermal-induced decrease in productivity by using more pesticides, and therefore, the number of agricultural residues increases and negatively affects the balance of the nature.

4.5.1.6. Resilience

In order to increase the resistance to the negative impacts caused by geothermal energy usage, inspection of the reinjection activities and preventing the release of waste fluid to water resources are considered as a primary measure. Participants claim that energy companies are released wastewater into the stream water especially at night. It is also stated that the use of filters should also be evaluated. Interviewee 4 says that the gases in the steam should be investigated, and the emission of toxic gases should be prohibited. 4/15 participants think that it is too late to take action. All of the participants say that new power plants and wells should not be established in the region.

Interviewee 10 states that "if there are technologies to go 3000 meters below the ground, there must be technologies that will produce energy without harming the environment". It is thought that paving the roads for dusting caused by heavy vehicles during the power plant construction and well drilling phases will contribute to reducing the damage caused by the dust to the grapes. Interviewee 5, who lives in Çağlayan neighbourhood, stated that the system used in his neighbourhood does not emit steam, and that he thinks that if other power plants in the plain use this system, the problem of steam and odour will be solved.

4.5.1.7. Participation

Participation dimension is handled through information and consultation. First of all, interviewees were asked whether they were informed about the establishment of geothermal power plants in the region. All of the participants stated that they were not informed before the geothermal power plants were established. Interviewee 1 says that after the explosion in the neighbourhood, information was given by the energy company authorities. During the interviews held in the Piyadeler neighbourhood, it is claimed that a few residents were taken to Buharkent by the power plant company to prove that there was no harmful effect.

Interviewee 10 stated that when the company officials came, the residents of Kemaliye neighbourhood thought that a factory would be opened. Similarly, Interviewee 12 mentions that the rumour that mineral and oil exploration works were carried out during the field research started.

6/15 participants state that information is given by the company authorities after the power plants are constructed. The participants do not find the explanations reliable because the company officials do not mention the possible negative impacts of geothermal energy wells and power plants. 5/16 participants think that public institutions should be provided information, before the power plant is built.

As a result of the interviews, two main opinions come to the fore regarding information. While some of the participants thought that most of the people would not have sold their land if they had been informed before the power plant was established, some of them stated that high prices were the most important factor in selling the land. 5/15 participants stated that in Sarıgöl, the neighbouring district of Alaşehir, they were able to unite thanks to the awareness of the people after the problems experienced in Alaşehir and they prevented the establishment of geothermal energy facilities in the district. Interviewees 7, 8, 14 and 15 say that the energy company wanted to buy their vineyard, but they did not sell their land because they are aware of the negative impacts on the environment. However, Interviewee 7 stated that he was a victim because his neighbour sold his place to an energy company and that he regretted not selling it.

All of the participants think that the most important reason for not acting together is the fact that the power plants buy the lands at high prices. Interviewee 5 says that if he opposes the power plants, he will have problems with his neighbours who want to sell their land. Interviewee 8 states that he was subjected to psychological pressure from the residents of the neighbourhood because he did not sell his vineyard.

In addition, another reason why geothermal power plants proliferate, and many people sell their vineyards to power plants is expropriation. Participants mention that although the local people do not want to sell their vineyards, energy companies make purchases through expropriation. 2/15 participants state that their vineyards were sold through expropriation. Interviewee 14 had to sell his vineyard to a power company after a nearby geothermal well exploded. 7/15 interviewees say that people prefer to deal with energy companies because vineyards are sold at low prices through expropriation. Interviewee 14 describes the expropriation process by saying, " the part of the land up to one meter deep belongs to us, so we have no choice but to sell it." Interviewee 2 mentions that the expropriation process is disadvantageous for both the seller and the energy company. Expropriation is not a preferred method for energy companies due to the expropriation litigation process, and for local people due to lower prices than those offered by the companies. Both parties aim to reach an agreement without resorting to expropriation method.

4.5.2. Discussion

According to the results of the field research, the most important perceived impact of geothermal power plants on the quality of life in Alaşehir district is the decrease in agricultural productivity. Participants evaluate the impacts of geothermal energy on their lives through their livelihoods. Indicators of different quality of life dimensions have been evaluated according to whether they have an impact on agricultural production by interviewees.

While the participants state that they are concerned about the damage of the geothermal fluid transport pipes to the agricultural lands by explosion and leakage, they think that the visual effect of the pipes is negligible. Similarly, it was stated that heavy vehicle traffic during the construction and operation phase of the power plant, and the dust caused by the deterioration of the village roads and irrigation channels that provide access to the vineyards negatively affect the quality of life in terms of causing diseases to the grapes.

When asked about the impact of geothermal energy on economic development and income, the participants state that there is no economic benefit other than individual benefit. While the quality of life of those who sell their vineyards to energy companies increases, the quality of life of those who live close to the power plant or who have vineyards around it decreases. According to interviewees, the fact that energy companies are buying lands for high prices will cause a serious decrease in agricultural lands in the long run.

It was concluded from the interviews that when the power plants were first established, there was an expectation that fluid would be provided for greenhouse and home heating uses, but the lack of fluid was an important issue in the public's relationship with energy companies. Local people interviewed think that energy companies are acting in their own interests.

During the field research, the demand to investigate the effects of geothermal energy on health, air, water, and soil is expressed. Majority of the participants think that geothermal energy will cause negative impacts on health in the long run. While the odour and noise evaluations vary according to the distance of living and working areas from the power plant, the participants agree that geothermal energy causes soil and water pollution. While those living close to the power plant state that solving the odour and noise problem in the short term will directly increase their daily quality of life, all of the participants, regarding from their distance to power plants say that unless precautions are taken regarding soil, water and air pollution, their quality of life will deteriorate in the long run, and they will have to look for other livelihoods and living spaces.

According to participants, geothermal power plants do not have a negative impact on wildlife. However, in some neighbourhoods, it has been claimed that the plants near the stream and the animals living in the stream were adversely affected as a result of the water contamination.

The question about participation was perceived as opposition. Interviewees consider the information part, which is the first stage of participation, as a condition of acting together in order to prevent the establishment of geothermal power plants in the region. They think that their participation in the process will no longer have any effect, as they are not informed and cannot act together due to the mentioned reasons.

While public concern was expressed about the impacts of drilling activities on seismicity in the study of Down et. al. (2011), no seismicity concern was noted by the participants in this study.

CHAPTER 5.

CONCLUSION

In this study, the perceived quality of life impact of geothermal energy plants was examined in the context of selected neighborhoods of Alaşehir that are close proximity to the source. On a neighbourhood basis, socio-spatial sensitivity areas, density of existing and planned geothermal power plants and geothermal well explotion points were analysed with spatial and demographic data using ARCGIS tools. As a result of these analyzes, which constitute the objective part of the study, the closest neighbourhoods to the geothermal power plants were determined and a perceived quality of life analysis was carried out with the semi-structured interviews and snowball sampling method. The main purpose of the study is to consider the possible impact of a specific domain such as geothermal energy on the perceived quality of life with a systematic approach. For this purpose, the three research questions stated in the introduction part of the thesis are as follows:

1. What are the dimensions, indicators, and tools for measuring domain specific quality of life ?
2. How can an objective and a perceived assessment of quality of life be integrated in order to face complex environmental and community challenges ?
3. What types of quality of life dimensions can explain the perceived assessments of geothermal-related quality of life ?

In order to answer the research questions, the definition of the concept of quality of life, measurement methods, neighbourhood, rural and environmental quality of life studies, the historical development of geothermal energy, its usage, geothermal systems, environmental impacts and social acceptability of geothermal power plants, and geothermal energy studies in Turkey were examined. While literature findings explain the first research question, both literature and case study findings explain the second and third questions.

Regarding RQ1, dimensions, indicators, and tools for measuring domain specific quality of life vary depending on the scale and characteristics of the study area. While the indicators used in quality of life studies at the neighbourhood scale stand out under the dimensions of built environment, accessibility and degradation, health, contamination, and accessibility come to the fore in rural quality of life studies. In studies where the environment is handled as sustainable living and natural environment, contamination, resilience, and degradation dimensions are examined. Socio-demographic indicators such as age, sex, gender, income are analysed in all three domains and are grouped under the vulnerability parameter. When the studies investigating the environmental impacts and social acceptance of geothermal power plants are examined, it has been determined that participation is an important dimension in terms of social acceptance of geothermal energy use.

To find an answer to the second research question, objective and subjective methods used in quality of life studies were examined. While secondary data is used in objective quality of life studies, primary data obtained by face-to-face interview or survey method is used in subjective studies. Geographical information systems are used in research that connects objective and perceived quality of life. In this study, analyzes with objective indicators were used to determine the area where the perceived quality of life research would be conducted, and it was concluded that ARCGIS is a suitable tool for socio-spatial analysis.

With regard to RQ3, built environment, vulnerability, health, degradation, contamination, resilience, and participation dimensions of quality of life, which were determined as a result of literature research, were analysed through the case of Alaşehir. Case study findings showed that perceived assessments of geothermal-related quality of life mostly related with agricultural production. The perceived quality of life in Alaşehir, where the main economic activity is agricultural production, is handled through the source of income. All of the interviewed participants associated the impact of geothermal energy on different dimensions of life quality with agricultural production.

The study examines the impact of geothermal energy on perceived quality of life, and it should be taken into account that the results focus on the perceived assessments of people living in the most sensitive areas. In this study, it has been determined that the use of geothermal energy negatively affects the perceived quality of life in such areas, since the economy of Alaşehir is predominantly based on agricultural production and this single-sector structure causes economic resilience to experience fragility.

In line with this result, analysis of socio-economic charachteristics, environmental concerns and fragility factors should be considered during the planning process of uses with significant socio-economic and environmental impacts such as geothermal power plants. Development of site-specific indicators and analysis methods at the site selection stage of the power plants in order to spread the use of geothermal energy, which is a renewable energy source, will contribute to reducing the perceived negative impacts on quality of life. Site-specific analysis during the geothermal power plants’ site selection process need to be adopt by the decision makers. In addition to the site selection phase, the planning process should include analyzes that will reveal the expectations and concerns of different interest groups. In order to prevent possible problems and negligence that may occur during the installation and operation phase of power plants, it is necessary to make legislative arrangements that enable the participation of these interest groups.

When the analyzes in the objective part of the study and the interview results were evaluated together, it was determined that there was a strong relationship between the impacts of geothermal energy on the perceived quality of life and the assets of case study area. For this reason, objective socio-spatial analyzes are considered to be an important element in the interpretation of the results obtained in perceived quality of life studies.

In studies where quality of life is handled together with an objective and a subjective approaches, the objective part is mostly analyzed through demographic and socio-economic charachteristics or accessiblity of services. In environmental quality of life studies, physical and natural environment variables are analyzed as a result of an objective approach. This study contributes to the quality of life studies with its multidimensional measurement method. The method reveals which dimensions have strong and weak relationships with domain-specific quality of life and investigated the relationships between dimensions. According to the findings of the study, contamination parameter should be taken into account, in quality of life studies related to renewable energy use and the relationship between socio-spatial fragility and quality of life should not be ignored, where rural settlements are handled as case.

Due to the availability of data in the socio-spatial part of the research, health and participation parameters could not be analyzed and since the age range data was not produced by TSI for the neighborhood with a population below 250 people, these neighbourhoods could not be included in the elderly population analysis. Since the socio-spatial change on the neighborhood basis is important in terms of the scope of the study, while the agricultural land and population changes were examined, the economic change could not be discussed in the objective part of the study due to the lack of data.

Marans and Stimson (2011), mentions that in quality of life studies, it is necessary to measure how conditions change over time by means of indicators. While the changes in the population and cropland variables used in the objective part of this study over time could be measured, how the other variables changed could not be measured due to the lack of data. For this reason, the relationship between the perceived quality of life and the change of objective conditions over time could not be evaluated in this study.

The findings of this study open a further research opportunity in examining the relationship between geothermal energy power plants as well as other energy power plants such as wind, biogas etc., and perceived quality of life in settlements which have different assets. Determining which of the quality of life dimensions used in this study will come to the fore in cities with different economic structures (such as industry, finance, tourism etc.) and fragility factors will contribute to the domain-specific quality of life literature.

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APPENDİX

Görüşme Soruları

1. Mahallenizdeki jeotermal santrallerin neden olduğu temel zorluklar ve sorunlar nelerdir? (Örn. su, toprak, hava, gürültü, kirlilik, koku, arazi kullanım değişikliği, biyolojik çeşitlilik ve yaban hayatı vb.)

2. Jeotermal santrallerin yapımı sizin ve ailenizin, akrabalarınızın, komşularınızın fiziksel ve psikolojik sağlığını nasıl etkiledi?

3. Jeotermal santraller ekonomik kalkınmayı ve içinde yaşadığınız çevreyi nasıl etkilemektedir? (Örn. tarımsal üretim ve diğer sektörler- jeotermal seracılık)

4. Jeotermal santrallerin neden olduğu sorunları ortadan kaldırmak/azaltmak için ne gibi önlemler alınmalıdır?

5. Sizce halkın planlama sürecine katılımı bu sorunların azalmasına katkı sağlar mı/mıydı?

6. Mahallenizde bir jeotermal enerji santralinin inşası genel yaşam kalitenizi uzun vadede nasıl etkiler? / Lütfen jeotermal enerji kaynaklarının yaşam kaliteniz üzerindeki etkisini değerlendirin.

Çok iyi									Çok kötü
10	9	8	7	6	5	4	3	2	1