# SUSTAINABLE DEVELOPMENT AND ENGINEERING SOLUTIONS FOR THE TOURISM, AGRICULTURE, AND FOOD SECTORS


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## Editor's Preface

Sustainability is an essential goal for ensuring the well-being of current and future generations. Tourism, agriculture, and food systems play pivotal roles in this endeavor, as they are interconnected sectors with significant environmental, economic, and social impacts. Recognizing their importance, this book, **"Sustainable Development and Engineering Solutions for the Tourism, Agriculture, and Food Sectors,"** brings together the insights and expertise of academics, including faculty members from food technology and organic farming programs, to offer innovative and practical solutions.

The chapters in this book explore key topics such as sustainable agricultural practices, organic farming methods, eco-friendly tourism strategies, and engineering solutions that optimize resource use while minimizing waste. Each contribution highlights the collaborative and interdisciplinary approach required to address sustainability challenges effectively.

This work reflects the shared efforts of contributors who are committed to advancing sustainability within their fields. By merging theoretical and practical perspectives, this book provides valuable guidance for researchers, professionals, and students alike. It is our hope that the ideas presented here will inspire further progress toward achieving sustainable development goals.

We extend our gratitude to all authors, reviewers, and our fellow editors for their invaluable contributions. Their dedication has been instrumental in shaping this publication. Together, we aim to support and encourage sustainable practices that benefit both society and the environment.

**Editors**

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# CHAPTER I

## THE CRITICAL ROLE OF PLANTS IN HUMAN NUTRITION AND SUSTAINABLE AGRICULTURAL APPROACHES

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## INTRODUCTION

Throughout history, humans have developed various solutions to meet their basic needs for nutrition, shelter, and clothing. Agriculture has played a central role in fulfilling these fundamental requirements. Nutrition, in particular, is directly dependent on agricultural activities, as it is derived from plant-based and animal-based foods. Similarly, clothing relies on plant-based sources such as cotton and flax, as well as animal-based materials like leather and wool. Therefore, it is evident that agriculture is an indispensable element for humanity (Taban, 2018).

In the 21st century, rapid population growth and migration from rural areas to urban centers have led to a contraction of agricultural lands and placed pressure on the sustainability of agricultural production. This issue must be addressed within the framework of food security and sustainable development goals. Plant production processes are vital not only for food supply but also for ensuring the sustainability of ecosystem services.

Global climate change threatens agricultural lands and necessitates rethinking production cycles. This book focuses on sustainable development and engineering solutions in the tourism, agriculture, and food sectors. In this context, we will discuss the role of plant production in human nutrition and its critical importance in terms of sustainable development.

## 1. POPULATION GROWTH AND THE DECLINE OF AGRICULTURAL LANDS

The world population is rapidly increasing. It took more than 200,000 years for the global human population to reach 1 billion after the emergence of modern humanity, yet it has taken only 219 years to grow to 8 billion (Kight & Lysik, 2022). While it took thousands of years for the global population to reach 1 billion, the pace of growth has significantly accelerated in recent times. For instance, it took 123 years for the population to increase from 1 billion to 2 billion, but today, this process has been shortened to just 13 years (Table 1).

**Table 1.** Time taken for the world population to increase by 1 billion

| Population (billion) | Year | Time Elapsed (years) |
|---|---|---|
| 1 | 1804 | |
| 2 | 1927 | 123 |
| 3 | 1960 | 33 |
| 4 | 1974 | 14 |
| 5 | 1987 | 13 |
| 6 | 1999 | 12 |
| 7 | 2012 | 13 |
| 8 | 2025 | 14 |

According to UN calculations, the world population was 6.127 million in 2000, 7.349 million in 2015, and 8.053 million in 2023 (Table 2). Projections suggest that the global population will reach 8.501 million by 2030, 9.772 million by 2050, and 11.2 billion by 2100 (Table 2) (https://www.un.org/development/desa/pd/).

**Table 2.** World population by year*

| Years | 2000 | 2015 | 2017 | 2023 | 2030 | 2050 | 2100 |
|---|---|---|---|---|---|---|---|
| **Population (Million)** | 6.127 | 7.349 | 7.550 | 8.053 | 8.501 | 9.772 | 11.184 |

***** https://www.un.org/development/desa/pd/ (Access Date 21.10.2024)

In Turkey, the population, which was 27.553280 in 1960, reached 85.372377 as of December 31, 2023 (Table 3). According to population growth projections covering the years 2018-2080, Turkey's population, which was 80.810525 in 2017, is projected to reach 86.907.367 by 2023 and 86.907.367 by 2040 (TUIK, 2018). It is estimated that the population will increase until 2069, reaching its peak at 107.664,079, and then begin to decline, decreasing to 107.100.904 by 2080 (TUIK, 2018).

**Table 3.** Population and agricultural land in our country by year (TUIK, 2024)

| Year | Total Population | Agricultural Area (ha) |
|---|---|---|
| 1960 | 27.553.280 | |
| 1965 | 31.000.167 | |
| 1970 | 34.772.031 | |
| 1975 | 39.185.637 | |
| 1980 | 43.905.790 | |
| 1985 | 49.178.079 | |
| 1990 | 53.994.605 | 27.856.000 |
| 1995 | 58.522.320 | 26.834.000 |
| 2000 | 63.174.483 | 26.379.000 |
| 2005 | 67.743.052 | 26.606.000 |
| 2010 | 72.137.546 | 24.394.000 |
| 2011 | 73.058.638 | 23.614.000 |
| 2012 | 75.627.384 | 23.782.000 |
| 2013 | 76.667.864 | 23.806.000 |
| 2014 | 77.695.904 | 23.941.000 |
| 2015 | 78.741.053 | 23.934.000 |
| 2016 | 79.814.871 | 23.711.000 |
| 2017 | 80.810.525 | 23.347.000 |
| 2018 | 82.003.882 | 23.180.000 |
| 2019 | 83.154.997 | 23.099.000 |
| 2020 | 83.614.362 | 23.145.000 |
| 2021 | 84.680.273 | 23.473.000 |
| 2022 | 85.279.553 | 23.883.000 |
| 2023 | 85.372.377 | 23.971.000 |

As in the rest of the world, the rapid population growth in our country has made it necessary to create new settlement areas. The continuous expansion of these areas year by year, industrialization, the creation of new industrial zones, and the construction of infrastructure to meet basic needs such as highways, dams, and airports have led to a gradual reduction in agricultural lands.

Due to these adverse developments, the agricultural land area in our country, which was 27.856.000 hectares in 1990, decreased to 23.971.000 hectares in 2023 (Table 3). The largest decrease in agricultural land occurred in 2019, with the area shrinking to 23.099.000 hectares.

The simultaneous decrease in agricultural lands and rapid population growth have made food production a significant issue. As in the present day, ensuring balanced and healthy nutrition for our population will remain a critical matter in the future (Taban, 2021).

Improving both the yield and the quality of agricultural products has become essential due to population growth. Obtaining high-quality and abundant crops from agricultural lands depends on adhering to appropriate cultivation techniques. Among these, the healthy nutrition of plants, i.e., fertilization, is the most important.

## 2. WHY SHOULD WE GROW HEALTHY PLANTS?

Organisms consuming plant products need to be nourished with plant-based foods that contain the necessary minerals, proteins, vitamins, and other nutrients in sufficient and balanced amounts to ensure healthy development.

All living organisms on Earth depend on one another to sustain life. This interdependence is especially significant in terms of nutrition. Plants hold a critical and unique place in nutrition since they form the primary food source for humans and domestic animals.

Unlike humans and animals, plants are extraordinary organisms capable of performing photosynthesis. Through photosynthesis, plants absorb water from their environment and carbon dioxide from the air, converting these into organic matter, thus sustaining their growth. In contrast, since humans and animals lack the ability to synthesize organic matter from inorganic substances, they must obtain the necessary nutrients ready-made, primarily from plant-based foods. Plants form the first link in the food chain, and the nutrients they contain directly influence the development of animals and humans (Taban, 2021).

## 3. THE RELATIONSHIP BETWEEN MINERAL SUBSTANCES AND DEVELOPMENT

Plants, humans, and animals require inorganic substances (water and minerals) to develop healthily. As living organisms cannot synthesize inorganic substances within their bodies, they must obtain them from external sources. Depending on the required amounts, these substances are categorized as macro elements when needed in large quantities and micro elements when needed in smaller quantities.

Plants absorb the elements in their structure from their growing environment or the atmosphere. Plants can uptake at least 90 elements dissolved in the soil solution (Barak, 1999). However, the reasons why plants absorb so many elements and the functions of many of these elements in plants are not yet fully understood.

Plant nutrients are defined by Kacar (2012) as "elements used in the construction of organic matter, in which the physical energy of light is stored as chemical food energy through photosynthesis, and which are absorbed more or less by plants from their growing environment."

There are ongoing debates in various sources about whether certain elements are absolutely essential for all plants. This variability arises from scientific developments and the inclusion of new elements in the list of essential plant nutrients (Bergmann, 1992; Marschner, 1995; Mengel et al., 2001).

According to the latest literature, 17 elements meet the criteria for being considered essential plant nutrients, while some other elements are categorized as beneficial nutrients (Table 4)

**Table 4.** Nutrients identified as essential and beneficial (Kacar, 2012)

| Macro Elements | Micro Elements | Beneficial Elements |
|---|---|---|
| Carbon (C) | Iron (Fe) | Aluminum (Al) |
| Hydrogen (H) | Manganese (Mn) | Cobalt (Co) |
| Oxygen (O) | Copper (Cu) | Selenium (Se) |
| Nitrogen (N) | Boron (B) | Silicon (Si) |
| Phosphorus (P) | Zinc (Zn) | Sodium (Na) |
| Potassium (K) | Molybdenum (Mo) | Vanadium (V) |
| Calcium (Ca) | Chlorine (Cl) | |
| Magnesium (Mg) | Nickel (Ni) | |
| Sulfur (S) | | |

Plants obtain hydrogen from water ($H_2O$), oxygen from oxygen gas in the air and water, carbon from carbon dioxide ($CO_2$) in the air, and other essential plant nutrients from elements dissolved in the soil or, in soilless cultivation (hydroponic systems), from nutrient solutions.

Humans and animals also require mineral elements, just like plants, for healthy development. The mineral elements needed by humans and animals are shown in Table 5. Similar to plant nutrients, elements required in large amounts are called macro elements, while those needed in smaller amounts are referred to as micro elements.

**Table 5.** Essential Mineral Elements for Humans and Animals*

| Macro Elements | Micro Elements | |
|---|---|---|
| Carbon (C) | Iron (Fe) | Selenium (Se) |
| Hydrogen (H) | Manganese (Mn) | Aluminum (Al) |
| Oxygen (O) | Copper (Cu) | Fluorine (F) |
| Nitrogen (N) | Boron (B) | Lead (Pb) |
| Phosphorus (P) | Zinc (Zn) | Silicon (Si) |
| Potassium (K) | Molybdenum (Mo) | Vanadium (V) |
| Calcium (Ca) | Chlorine (Cl) | Arsenic (As) |
| Magnesium (Mg) | Nickel (Ni) | |
| Sulfur (S) | Cobalt (Co) | |
| Sodium (Na) | Chromium (Cr) | |
| | Iodine (I) | |

* McDowell, (2003); Graham et al.., (2007); Stein, (2010)

In terms of human health, iron (Fe), zinc (Zn), iodine (I), selenium (Se), calcium (Ca), magnesium (Mg), and copper (Cu) are the most essential mineral elements (Kacar, 2012). For animal health, chromium (Cr), cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), and zinc (Zn) are the most important microelements (McDowell, 2003).

Each mineral element within living organisms plays significant roles individually and in combination. In humans, minerals are crucial for various vital functions, including the normal growth of bones and teeth, maintenance of acid-base balance, regulation of body fluids, proper functioning of the nervous system, muscles, and organs, enzyme activity, and the synthesis of certain substances (Işıksoluğu, 1987). In societies with imbalanced and insufficient nutrition, individuals face various health issues due to inadequate intake of essential nutrient elements (White & Broudley, 2009; Stein, 2010). For this reason, approximately 2,500 years ago, Hippocrates, the father of medicine, stated, "Let food be your medicine, and medicine be your food."

Today, micronutrient deficiencies affect over three billion people worldwide, and this number is increasing. Zinc, iron, iodine, selenium, and cobalt deficiencies are among the most common micronutrient deficiencies in humans (Welch and Graham, 2004; Graham, 2008; White and Broadley, 2009).

Zinc deficiency is particularly prevalent in people living in underdeveloped and developing countries (WHO, 2002).

The primary reason for zinc (Zn) and iron (Fe) deficiencies in humans is the widespread consumption of cereals and legumes, which have low bioavailability of these elements (Hurrel, 2001). These plants contain high levels of phytic acid, fiber, and tannins, which significantly reduce the bioavailability of Zn and Fe (Raboy, 2001). Therefore, increasing Zn and Fe content and/or reducing factors like phytic acid that negatively affect the bioavailability of micronutrients is crucial for enhancing the micronutrient content of staple foods in human diets. For instance, in low-income countries, it has been reported that malnutrition-related deaths among children under five years old are attributed to deficiencies in vitamin A (6.5%), zinc (4.4%), iron (0.2%), and iodine (0.03%) (Black et al., 2008).

## 4. THE IMPORTANCE OF PLANTS IN HUMAN NUTRITION

### 4.1. Historical Development of Banana Production and Incentives

Photosynthetic organisms are autotrophs capable of synthesizing the organic compounds they need (enzymes, amino acids, fats, proteins, etc.) through photosynthesis.

However, photosynthesis is not performed only by plants. Some bacteria, euglenoids, and algae are also photosynthetic organisms. These organisms not only synthesize their own food through photosynthesis but also provide a food source for other organisms.

Organisms that cannot perform photosynthesis are heterotrophs. Such organisms must obtain the nutrients they need from external sources to sustain life. In this case, the source is plants.

Nearly all mineral substances, essential amino acids, vitamins, antioxidants, carbohydrates, proteins, and fats that support human nutrition are derived either directly from plant-based foods or from animals that feed on plants. Therefore, the nutrition of humanity depends on the healthy nutrition of plants. Plants grown with proper nutrition produce high-quality foods that support human health and well-being.

While plants can synthesize all 20 amino acids required for protein synthesis, humans can synthesize only 12 of these amino acids in their bodies (Table 6).

**Table 6.** Amino Acids That Cannot Be Synthesized by the Human Body and Must Be Obtained Through Plants

| Amino Acids That Cannot Be Synthesized by the Human Body | Amino Acids That Can Be Synthesized by the Human Body | |
|---|---|---|
| Valine | Alanine | Glycine |
| Leucine | Aspargine | Proline |
| Isoleucine | Aspartic Acid | Serine |
| Theronine | Cysteine | Tyrosine |
| Methionine | Glutamic Acid | Arginine* |
| Phenylalanine | Glutamine | Hystidine* |
| Tryptophan | | |
| Lysine | | |

(*) They are required to be obtained externally for nutritional purposes only in special circumstances. These amino acids must be supplied externally in newborns and patients with uremia. Uremia is a condition caused by the retention of urea in the body instead of being excreted through urine. It is also the term given to a condition accompanied by fluid, electrolyte, and hormonal imbalances resulting from impaired kidney function.

In addition to amino acids, vitamins are organic compounds that cannot be synthesized by the human body and must be obtained from plant-based foods.

## 5. THE MOST ESSENTIAL VITAMINS FOR HUMAN NUTRITION AND THEIR IMPORTANCE

Vitamins primarily function in metabolism by forming the coenzyme of enzymes in enzymatic reactions and play significant metabolic roles. Vitamins cannot be synthesized by the human body and therefore must be obtained externally through food (Chample and Harvey, 1997).

### 5.1.Vitamin A

Vitamin A deficiency is a 13ajör public health issue in low-income countries, particularly among women and children, where it is one of the leading causes of morbidity and mortality (Imdad et al., 2011). Deficiency reduces the functionality of epithelial tissue, making it easier for infections to enter the body and increasing susceptibility to infectious diseases (Baysal, 2011).

This vitamin is found in many foods, including green leafy vegetables, spinach, broccoli, carrots, pumpkins, melons, and mangoes.

### 5.2.Vitamin C

Fruits and vegetables are rich in vitamins and minerals and serve as the primary sources of vitamin C, which is essential for health. More than 90% of dietary vitamin C comes from fruits and vegetables (Lee & Kader, 2000).
Vitamin C is a potent antioxidant due to its ability to easily donate electrons (Carr & Maggini, 2017). Its deficiency impairs immunity and increases susceptibility to infections, raising the risk and severity of pneumonia (Hemilä, 2017).

Vitamin C's antioxidant properties allow it to neutralize the harmful effects of oxidative stress (Noratto et al., 2017). Oxidative stress contributes to pathological conditions and diseases such as cancer, neurological disorders, hypertension, diabetes, and asthma (Ullah et al., 2016; Chikara et al., 2018; Choi et al., 2018; Yılmaz et al., 2018; Massaro et al., 2019).

Common sources of vitamin C include citrus fruits, cruciferous vegetables, green leafy vegetables, lettuce, tomatoes, potatoes, carrots, red peppers, and broccoli.

### 5.3 Vitamin D

Research has shown a link between vitamin D and respiratory infections, with deficiencies making individuals more susceptible to such infections (Holick, 2006). Vitamin D plays a critical role in innate immunity by promoting the production of antimicrobial peptides (Kroner et al., 2015). Adequate levels of vitamin D in the body have been shown to reduce the risk of respiratory infections. Rich sources of vitamin D include fish, egg yolks, beef liver, and mushrooms (Hejazi et al., 2016).

### 5.3. Vitamin E

Vitamin E protects cell membranes from damage caused by free radicals (Traber & Atkinson, 2007). It also boosts the immune system by activating alpha-tocopherol, a form of vitamin E that declines with aging (Moriguchi & Muraga, 2000; Wu & Meydani, 2014).

## 6. PLANT NUTRITION

When examining plant nutrition, it becomes clear that plants differ significantly from humans and animals in how they obtain nutrients. Plants are capable of producing their own food through photosynthesis, whereas humans and animals depend on plants for their nutrition. Plants with the ability to photosynthesize are classified as autotrophs, while humans and animals are heterotrophs.

Green plants synthesize organic matter through photosynthesis by absorbing carbon dioxide. Humans and animals, as well as other organisms, derive their energy from solar energy stored within organic matter synthesized by plants (Kacar, 2012). The unique ability of plants to photosynthesize underscores their importance in human and animal nutrition. For this reason, ensuring plants receive adequate nutrition is crucial. The quality of human and animal nutrition and the maintenance of a healthy lifestyle depend on the proper nourishment of plants.

## 7. WHAT SHOULD WE DO?

To establish a sustainable agricultural system, it is necessary to first improve plant production processes. In today's world, increasing both the quality and quantity of plant-based production is a primary goal. However, achieving this objective requires prioritizing environmentally friendly and sustainable practices. The following strategies should be implemented:

- **Promoting Soil and Plant Analysis:** Regular soil and plant analyses should be conducted to optimize fertilizer use in agricultural production. This approach enhances crop productivity while minimizing the environmental harm caused by excessive fertilizer use.
- **Utilizing Micronutrients:** Addressing micronutrient deficiencies increases the nutritional value of produced foods, contributing to both

human and animal health. Foliar applications of micronutrients such as zinc and iron should be encouraged.

- **Adopting Organic and Biotechnological Approaches:** Alongside chemical fertilizers, organic and biotechnological solutions should be widely adopted. Organic fertilizers enhance the organic matter content of soil, supporting sustainable agriculture.
- **Efficient Use of Water Resources:** Agricultural irrigation systems should be optimized for efficient and effective water use. Modern irrigation techniques such as drip and sprinkler irrigation should be promoted.
- **Education and Awareness Programs:** Farmers should be educated about sustainable agricultural practices to encourage their widespread adoption. Additionally, raising consumer awareness can support demand for more sustainable production methods.
- **Improving Policies and Incentives:** Governments should develop policies that support sustainable agricultural practices and encourage innovative approaches in this field.

## CONCLUSION

Implementing these strategies will not only ensure the sustainability of agricultural production but also reduce environmental impacts, contributing to a more livable world. Prioritizing such approaches in the agricultural sector is essential to achieving sustainable development goals.

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# CHAPTER II

## THE IMPACT OF AGRICULTURAL DROUGHT ON TOMATO PLANTS

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## INTRODUCTION

Drought constitutes a significant abiotic stress factor that constrains agricultural production and results in substantial yield reductions (Zhang et al., 2020). Over the past century, the global community has witnessed pronounced global warming, with the average global surface temperature during the period from 2011 to 2020 being 1.090°C higher than that recorded between 1850 and 1900 (IPCC, 2021). Drought is among the most pressing natural disasters impacting regions such as Asia and Africa, affecting large populations and closely linked to the phenomenon of climate change (Muralikrishnan et al., 2021). Drought is characterized by an imbalance between soil moisture and water availability; insufficient water in the soil leads to a decline in plant yield. Water is the most critical resource for plants, with plant tissues comprising approximately 80-95% water (Jaganathan et al., 2017). Furthermore, the water content of plant tissues varies; for instance, seeds typically contain less water than mature plant tissues, with water content levels ranging from 10-15% (Bewley and Black, 1994). As plants develop, their water content tends to increase, particularly in leaves, which can contain water content exceeding 90% in certain species (Taiz and Zeiger, 2010). Stems and roots also contain notable amounts of water; however, their water content is generally lower than that of leaves, typically ranging from 70-85%. (Marschner, 2011).

The high water content in plant tissues is crucial for various physiological processes, such as photosynthesis, nutrient transport, and maintaining turgor pressure. Consequently, the water stress that plants experience affects all tissues, starting from the seed, and leads to a decrease in yield. Drought sensitivity in plants varies based on genotype, duration of stress, and intensity of the stress. Drought stress promotes plant dehydration, generating osmotic stress, which subsequently causes further damage to cells and plant tissues. As a result, yield and quality losses occur (Wang et al., 2003).

Plants have developed a series of mechanisms, including morphological, biochemical, physiological, and molecular adaptations, to cope with this stress condition. To avoid drought stress, plants shortened their life cycle (Chaves et al., 2003), improve their root systems, reduceleaf area, and limit transpiration (Xu et al., 2010). Additionally, plants enhance stress tolerance by improving osmotic adaptability, and increasing cell wall elasticity, (Zhang et al., 2022) and by altering metabolic pathways to enable the plant to survive under severe stress conditions (e.g., increased antioxidant metabolism) (Kapoor et al., 2016) (Figure 1).

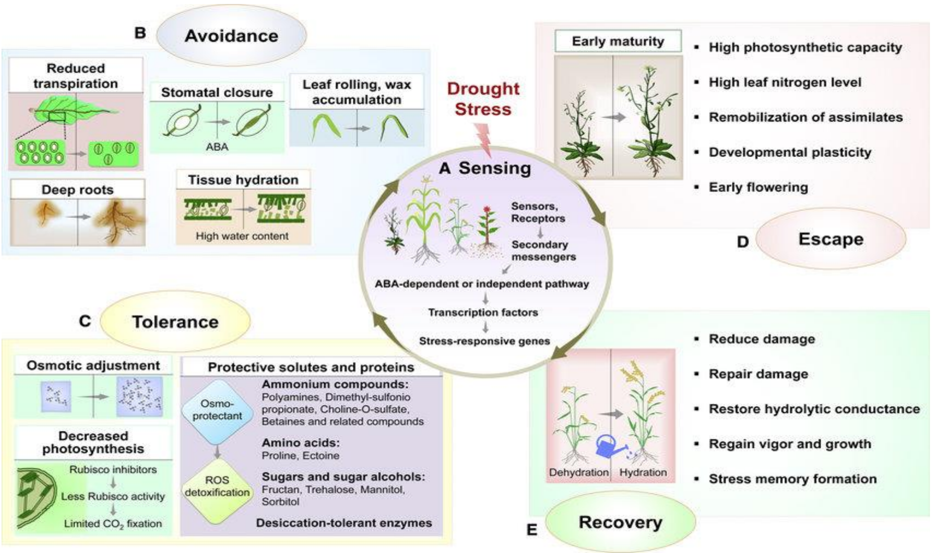


**Figure 1.** Plant responses to drought stress (A) aredepicted,along with the major changes utilized by plants in each of the processes, which include avoidance (B), tolerance (C), escape (D), andrecovery (E) (Shelake et al., 2022).

Phenolic metabolism exhibits a remarkable range of biological functions that can significantly influence drought stress tolerance (Sanchez-Rodriguez et al., 2011). Understanding the biochemical responses to drought is crucial for gaining a comprehensive insight into plant resistance mechanisms to water stress (Anjum et al., 2011).

When exposed to abiotic stresses, plants typically experience an increase in the production of reactive oxygen species (ROS). This rise in ROS levels subsequently elevates the concentration of antioxidant compounds and enhances the activity of certain antioxidant enzymes, such as ascorbate peroxidase, catalase, and superoxide dismutase. These responses help plants cope with stress (Figure 2).

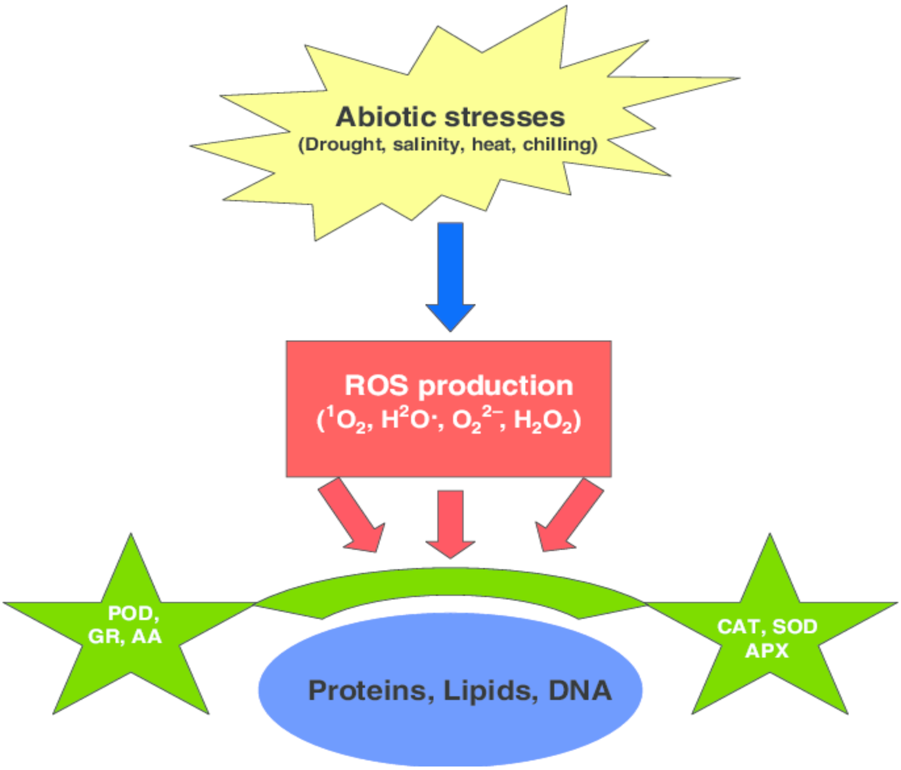


**Figure 2.** Role of antioxidant enzymes in reactive oxygen species (ROS) (Farooq et al., 2009).

## DROUGHT STRESS IN TOMATO PLANTS

Tomato (*Solanum lycopersicum* L.), an annual plant from the *Solanaceae* family, is native to South and Central America. It was first cultivated by the Mexicans and has since spread worldwide.The tomato is a widely consumed vegetable globally, known for its excellent flavor, nutritional value, and consumer preference. According to the FAO, approximately 189 million tons of tomatoes are produced across 5.1 million hectares(FAO, 2022). China is the leading producer, with 68.3 million tons, followed by India with 20.6 million tons and Turkey with 13 million tons (Figure 3).

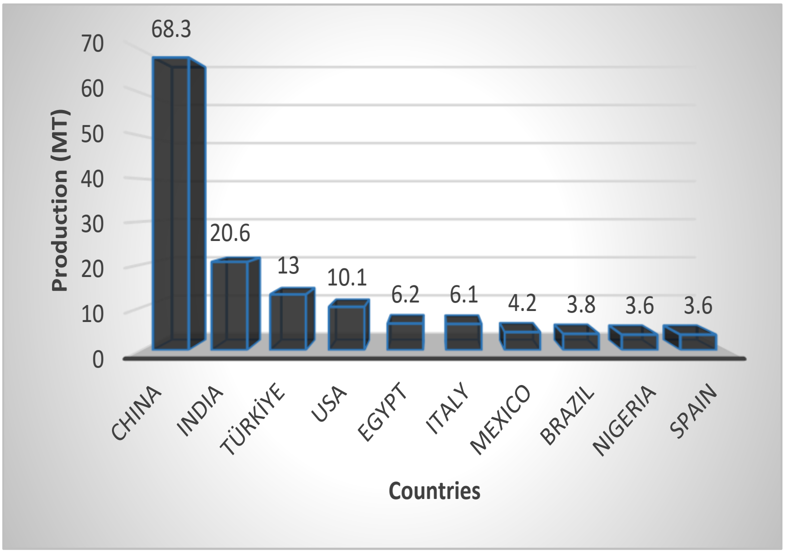


**Figure 3.** Production of the top 10 tomato producing countries in the World (FAO, 2022)

According to the data from the Ministry of Agriculture and Forestry, Tomato production in 2022/23 (Table 1) (Ministry of Agriculture and Forestry, 2024).

**Table 1.** Türkiye tomato supply and demand (1,000 tons)

| | **2018/19** | **2019/20** | **2020/21** | **2021/22** | **2022/23** |
|---|---|---|---|---|---|
| **Production** | 12.150 | 12.842 | 13.204 | 13.095 | 13.000 |
| **Consumption** | 9.013 | 9.511 | 10.890 | 10.219 | 10.673 |
| **Human consumption** | 9.013 | 9.511 | 9.256 | 8.686 | 9.072 |
| **Cons. per capita (kg)** | 109.9 | 114.4 | 110.7 | 102.6 | 106.4 |
| **Imports** | 35 | 17 | 75 | 156 | 414 |
| **Exports** | 1.155 | 1.220 | 1.928 | 2.574 | 2.286 |
| **Self sufficiency (%)** | 110.6 | 110.7 | 117.0 | 123.7 | 117.5 |

The growth of the tomato, an essential crop grown all over the world, is significantly affected by drought stress (Jiang et al., 2019).This sensitivity negatively impacts both yield and quality. By 2050, the global population is expected to exceed 9.1 billion, with more than 70% of food needs relying solely on agriculture (Castañeda et al., 2016). Given this, it is crucial to take necessary measures against factors that negatively impact agricultural production and cause a decrease in crop yields.

Understanding how important crops like tomatoes are affected by drought, particularly developing varieties that are resistant to water stress, is vital for ensuring stability in food production. Different tomato genotypes exhibit varying levels of drought tolerance. Some varieties are better equipped due to genetic traits that confer resistance. For example, certain genotypes can maintain turgor pressure to keep plant cells hydrated under water-limited conditions. Genotypes with deeper and broader root systems are better able to access underground water reserves. Additionally, some tomato varieties can synthesize compatible solutes that help them withstand osmotic stress while maintaining cellular functions despite water loss.

In tomato plants, drought stress leads to various morphological and physiological consequences, including plant height, dry weight, root/shoot ratio, yield, relative water content, and chlorophyll content. Drought stress generally has a significant impact on physiological parameters such as transpiration rate, net photosynthetic activity, reactive oxygen metabolism, osmotic regulation, stomatal conductance, relative water content of leaves, and water holding capacity (Yang et al., 2021).

To increase resilience in areas susceptible to water scarcity, it is crucial to understand stress reactions and develop tomato cultivars that can withstand drought. Recent research has focused on the contribution of genetic selection and breeding techniques to improving drought tolerance (Ashraf, 2010).

Wild tomato species, such as *Solanum pennellii*, serve as important genetic resources for enhancing the drought tolerance of cultivated tomatoes. Research on these wild species has revealed their ability to maintain higher water use efficiency and osmotic regulation under water stress conditions. Wild tomatoes generally possess genetic diversity that enables them to survive in drought-prone environments, making them valuable for breeding programs aimed at developing drought-resistant varieties (Tanksley and McCouch, 1997).

Additionally, studies have shown that wild tomato species can produce higher levels of protective metabolites, such as proline and sugars, which help them combat water deficiency (Van der Weerden et al., 2015). Notable species include *S. pennellii*, *S. peruvianum, S. habrochaites*, *S. cheesmanii, S. chilense, S. pimpinellifolium*, and *S. lycopersicum* var. *cerasiforme*, all of which are reported sources of drought tolerance (Mukherjee et al., 2020; Ramírez-Ojeda et al., 2021).

Recent studies indicate that wild species exhibit higher water use efficiency compared to their cultivated counterparts. In a study by Lupo and Moshelion (2024) involving *S. lycopersicum* cv. M82 and *S. pennellii* C. LA716, cultivated tomatoes demonstrated higher stomatal conductance and leaf area but were more sensitive to drought stress, responding more quickly to water scarcity. In contrast, wild tomatoes had lower transpiration and stomatal conductance values, but they managed to retain water for a longer period, allowing them to cope with drought more effectively. Consequently, while cultivated tomatoes achieved higher yields, morphological traits were prioritized over physiological efficiency, leading to increased sensitivity to water stress. Another study involving various wild species and commercial varieties showed that commercial tomatoes were the most sensitive to water stress. In contrast, LA 716 (*S. pennellii*) exhibited the highest tolerance, followed by 'LA 1401' (*S. galapagense*) and 'LA 1967' (*S. chilense*) (Zeist et al., 2024).

The primary reason that commercial *S. lycopersicum* varieties are highly sensitive to various abiotic stresses, particularly drought, is the strong selective pressure placed on genetic diversity in breeding programs, which has narrowed the genetic base in subsequent populations. Dominate breeding programs for tomatoes have focused on yield, which has resulted in increased sensitivity to important stress factors such as drought (Tanksley and McCouch, 1997).

Wild tomato species are essential genetic resources for morphological, physiological, and biochemical traits that contribute to drought tolerance, but they are commercially undervalued due to their small and pubescent fruits (Figure 4).


**Figure 4.** Some wild tomato species (*S. huaylasense* and *S. habrochaites*)

Among wild tomato species, particularly *S. pennellii*, have genetic diversity that allows them to cope better with drought. Incorporating these species into breeding programs can significantly enhance the drought tolerance of tomatoes(Figure 5).


**Figure 5.** Some *S. pennellii* species are used in breeding programs.

To obtain new tomato varieties with both drought resistance and commercial characteristics, it is necessary to incorporate wild species that do not possess the desired fruit quality and morphological traits into breeding programs. This can be achieved through backcrossing. Thus, leveraging the genetic resources of wild species becomes crucial for increasing water use efficiency in agricultural production and effectively combating drought.

## CONCLUSION

Today, factors such as the growth of the global population, rapid industrialization, and climate change are increasing the usage and scarcity of water resources, threatening the sustainability of water in the future. The efficient management, conservation, and sustainability of water resources are of vital importance for humanity's continued existence. Drought is creating destructive impacts on agricultural production, water resources, human life, and the environment, becoming a global disaster (Haile et al., 2020). This situation directly affects the growth and development of agricultural products (Dietz et al., 2021). Tomato, one of the most widely produced vegetables in the world and in our country, is among the crops most affected by drought. Considering the increasing challenges posed by climate change and the growing demand for food production, it is essential to focus on developing plants that are more resistant or tolerant to water stress. In particular, the inclusion of various wild species in breeding programs is critical to ensuring future food security and maintaining agricultural productivity sustainably. Incorporating wild tomato species into breeding programs for drought tolerance is a promising strategy. Ongoing advancements in genetic technologies, such as genomic selection and CRISPR-based gene editing, are making it increasingly possible to integrate these traits into commercial tomato varieties. As a result, tomatoes can be made to withstand harsh environmental conditions while maintaining high yield and quality.

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# CHAPTER III

## THE *LEGIONELLA* PROBLEM IN TOURISM

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## INTRODUCTION

Technological advancements have gained increasing momentum over the last 30-40 years. These advancements, which positively impact human life, also play a regulatory role. In the tourism sector, the growing supply and demand are affected in a parallel manner. New diseases, health issues, food safety, environmental awareness, and social responsibility policies are continuously evolving. For example, glass materials that were insisted upon for use in hotel kitchens or presentations four years ago are now no longer desired. In our country, when the first case of Legionnaires' disease, caused by *Legionella* bacteria, emerged in 1996, both health authorities and tourism establishments experienced significant concerns. There was a sense of shock and considerable anxiety due to the lack of an action plan regarding necessary preventive measures. In 2001, the Ministry of Health issued regulations establishing procedures and guidelines. Since then, health authorities and tourism businesses have started to place more emphasis on Legionnaires' disease than before.

## 1. *LEGIONELLA*

### 1.1. Definition and History

*Legionella* are Gram-negative bacteria found in freshwater environments. The first *Legionella* strains were identified by Tatlock in 1943 and were initially classified as *Rickettsia*-like organisms (Vural, 2014). In 1947 in Poland and in 1954, Drozanski isolated a bacterium that infected free-living amoebae in soil (Erdoğan and Arslan, 2013). In 1957, an outbreak of pneumonia occurred among workers in a meat-packing plant in Austin, Minnesota (Akbaş, 2007). In July and August 1965, an outbreak characterized by the sudden onset of pneumonia, weakness, fatigue, and cough affected 81 patients at Saint Elizabeth's Psychiatric Hospital, with radiographic evidence of pneumonia. Fourteen of the affected patients lost their lives. However, epidemiological and laboratory investigations at that time were unable to determine the cause (Diederen, 2008). In September 1974, 11 participants at a meeting of the Independent Order of Odd Fellows in Philadelphia developed high fevers and pneumonia (Benitez and Winchell, 2013). In the summer of 1976, a mysterious pneumonia outbreak struck members attending the American Legion convention in Philadelphia, infecting a total of 182 people, with 29 deaths. In early January 1977, Dr. Joseph McDade, working at the Centers for Disease Control and Prevention (CDC), identified the etiological agent behind the outbreak. This discovery solved a significant medical mystery and led to the identification of a new family of bacteria (Muder and Victos, 2002). The bacterium responsible for the outbreak was identified as *L. pneumophila*, part of the *Legionellaceae* family (Pasculle, 1994). Subsequent studies revealed that this microorganism, later named *L. pneumophila*, causes various epidemic and sporadic infections. It had not been previously identified due to its inability to grow on common culture media and poor staining with conventional dyes (Vural, 2014). Within two years, another bacterium causing pneumonia in immunocompromised patients in Pittsburgh and Charlottesville was isolated, identified as a second species, *L. micdadei*. Numerous species have since been identified (Francois, 2014). In Turkey, 17 cases were reported from a facility in Kuşadası in 1994, 16 cases from a facility in Istanbul in 1997, 6 cases from another hotel in Istanbul, and additional cases at various times from hotels in Antalya, Istanbul, and Muğla (Kantaroğlu, 2007).

### 1.2. Classification

In 1979, Brenner, McDade, and Steigerwalt classified the bacterium responsible for the Philadelphia Legionnaires' disease outbreak as *L. pneumophila*, within the *Legionella* genus of the *Legionellaceae* family (Murray et al., 2010). Evidence supporting the recognition of this new species, genus, and family came from an evaluation of phenotypic characteristics and DNA/DNA hybridization results. The total guanine-cytosine (G+C) content in the DNA was found to be 39 %, and the genome size was approximately $2.5x10^9$ daltons (Da) (Harrison and Saunders, 1994). Based on these findings, the *Legionellaceae* family was divided into several genera: *Legionella* (*L. pneumophila*), *Fluoribacter* (*F. bozemanii*, *F. gormanii*, *F. dumuoffi*), *Sarcobium* (*S. lyticum*) and *Tatlockia* (*T. micdadei, T. maceachernii*) (Murray et al., 2010). However, 16S rRNA analysis subsequently confirmed *Legionella* as the only genus within the *Legionellaceae* family, showing that this family is part of the Gamma-2 subgroup of the *Proteobacteria* class (Fields et al., 2002). A group of organisms, termed *Legionella* like *amoebal pathogens* (LLAPs), was identified as organisms that could not be cultured on typical media but could grow only within free-living amoebae (Fields et al., 2002). Among

LLAPs described by Rowbotham, the most frequently encountered pathogen in humans, initially classified as *Sarcobium lyticum* and later identified as *Legionella lytica*, is believed to be the most common (Muder and Victor, 2002). LLAP species are considered potentially pathogenic to humans, although they are challenging to detect with conventional techniques used for *Legionella*, making confirmation difficult. Recent studies suggest that three LLAP strains are now recognized as three distinct *Legionella* species (Fields et al., 2002). Currently, there are 58 identified *Legionella* species and over 70 different serogroups (Burillo et al., 2017). Although all species are potentially pathogenic, *L. pneumophila* is responsible for over 90 % of Legionnaires'' disease cases (Murray et al., 2010). The most common strain causing infection in humans is *L. pneumophila* serogroup 1, followed by serogroups 4 and 6 (Eberly et al., 2007). Other *Legionella* species that commonly cause infections include *L. micdadei*, *L. bozemanii*, *L. dumoffii*, and *L. longbeachae* (Burillo et al., 2017). *L. pneumophila* can be differentiated from other family members through biochemical testing, DNA hybridization, direct fluorescent antibody (DFA) methods, and multilocus enzyme electrophoresis. The cell walls of *Legionellaceae* family members contain high levels of branched-chain fatty acids with ubiquinone, allowing for diagnostic tests like gas-liquid chromatography and cellular ubiquinone analysis (Bilgiler, 1999).

Members of the *Legionella* genus are Gram-negative, aerobic bacilli with widths of 0.3-0.9 μm. They are typically capsule-free, motile due to polar or lateral flagella, and exhibit a thin, pleomorphic appearance. These bacteria range in length from as short as 1.5-2 μm to longer, filamentous forms. In direct smears from clinical samples, they often appear as short, slender rods or coccobacilli. When grown on specific media, their length can vary more, and forms exceeding 20 μm may be observed (Muder and Victor, 2002; Murray et al., 2010). During primary isolation, most *Legionella* species (except *L. oakridgensis*) have a single polar flagellum and numerous fimbriae, although the presence of flagella depends on temperature and nutrient conditions. The species *L. oakridgensis*, lacking flagella, is non-motile. Species within the *Legionellaceae* family possess a trilaminar membrane, both internally and externally, a peptidoglycan layer, and in some species, a polysaccharide capsule (Rodgers et al., 1980).

### 1.3. Epidemiology of *Legionella* Bacteria

Understanding the epidemiology and ecology of *Legionella* is crucial for preventing potential outbreaks. *Legionella* species are widespread in ecosystems, with water and soil serving as their primary ecological habitats (Dowling et al., 1992). Human-made environments, such as potable water systems in buildings and cooling towers that use water vapor, are considered potential sources of proliferation and distribution for *Legionella*. These bacteria are commonly found in natural waters worldwide, including groundwater, lakes, ponds, rivers, and both hot and cold springs (Murray et al., 2010). The ideal temperature range for these bacteria is 20–68 °C. They are acid-tolerant and have been isolated from environmental sources with pH levels ranging from 2.7 to 8.3, allowing them to survive for extended periods under these conditions (Bartram et al., 2007). The optimal temperature for *Legionella* growth is between 32-42 °C, with an ideal pH range of 5.0-8.5. At temperatures below 20 °C, there is little to no bacterial growth, while at 70 °C, they are killed instantly (THSK, 2015). Though less common, some *Legionella* species have also been isolated from soil. *L. pneumophila*, *L. longbeachae* and *L. micdadei* have been documented as species isolated from potting soil in Australia (Muder and Victor, 2002).

*Legionella* species are aquatic, saprophytic bacteria, meaning protozoa play a critical role in their reproduction, growth, and survival in nature. In natural water environments, they grow within the vacuoles of blue-green algae and inside water amoebae and flagellated protozoa. Once they reach maturity, they lyse the host cells, releasing themselves into the water, where they remain free for a short time before finding a new host. Although *Legionella* species are obligate intracellular parasites, they can survive in natural water systems within biofilm layers (Bauer et al., 2008). Within these biofilms, *Legionella* interacts with other microorganisms, some of which inhibit its growth, while others support it. Microorganisms such as *Aspergillus*, *Aeromonas*, *Pseudomonas vesicularis*, *Vibrio fluvialis*, *Streptococcus viridans*, *Staphylococcus*, and *Bacillus* species inhibit the growth of *Legionella*. In contrast, *Cyanobacteria*, *Fischerella* and green algae promote *Legionella* growth (Benitez and Winchell, 2013). In natural water bodies, *Legionella* is typically present in low numbers, allowing for minimal entry into water distribution systems. However, stagnant areas in these systems provide ideal growth conditions. Particularly in sediment at the bottom of water storage tanks, where commensal flora releases polymeric substances, *Legionella* thrives symbiotically. Due to their high resistance to chlorine and biofilm-forming ability, they can survive and continue to multiply. They proliferate quickly in human-made water systems-such as cooling towers, water distribution systems, pools, and water tanks-that provide physical protection, nutrients, and optimal temperatures (Toze et al., 1990).

Since water distribution systems are the primary means by which the bacterium spreads across wide areas, they serve as reservoirs for *Legionella* species. In hospitals, the usual source of *Legionella* colonization in water systems is the water in showers and baths, making it a leading cause of hospital-acquired infections. Additionally cooling towers adjacent to hospital buildings, nasogastric tubes, and respiratory therapy equipment are also less common sources (Muder and Victor, 2002). In community-acquired transmissions, the main causes are contact with contaminated water and the uncontrolled release of industrial waste into water sources. Travel-associated infections are commonly seen among individuals on cruise ships, during land-based vacations involving contaminated water sources like hot tubs, and in hotels with contaminated water systems (Euzeby, 2019).

Areas where *Legionella* species are frequently found and can colonize include:

- Cooling towers and water from air conditioning units
- Hot and cold water systems of buildings
- Water tanks, water reservoirs
- Shower heads and hot water faucets
- Respiratory therapy equipment found in hospitals
- Water pipes of dental units
- Thermal baths, muds, hot tubs, and spas
- Evaporators and nebulizers
- Decorative pools, fountains, sprayers
- Garden irrigation pools, fish farming ponds
- Stagnant water in eye wash faucets and showers related to occupational safety and in sprinkler type fire extinguishing systems
- Room humidifiers (THSK, 2015).

The transmission of *Legionella* bacteria to humans always occurs under the influence of an environmental reservoir. The transmission of the bacterium to an individual and its entry into the lungs can occur through aerosolization, aspiration, or direct entry into the pulmonary system during intubation (Mülazımoğlu, 2002). No evidence has been found to support human to human transmission. If there is no water source, Legionnaires' disease cannot develop either. The likelihood of contracting Legionnaires' disease is related to the level of colonization of the water source, the susceptibility of the exposed individual, and the intensity of exposure to contaminated water. The most common route of transmission is inhaling water aerosols containing *Legionella*, which are dispersed into the air from environmental sources. It is believed that aerosols containing *Legionella*, smaller than 5µm, are created when water is sprayed under force, such as from cooling tower fans, jacuzzis, showerheads, spray humidifiers, and decorative fountains, and are inhaled into the respiratory tract, reaching the alveoli. It has been reported that aerosols containing the bacteria can be carried more than 1.6 km by air currents. *Legionella* can survive in droplets for more than 2 hours and can be transported 1.5-3.0 km away by air currents. Another significant route of transmission is the aspiration of water containing *Legionella* or the passage of bacteria settled in the oropharynx into the respiratory tract. In patients who have undergone surgery for head and neck cancer, a high incidence of aspiration-related nosocomial Legionnaires' disease has been reported. If the instruments directly applied to the respiratory tract of patients have been washed with contaminated tap water, transmission can occur. In skin lesions, infection occurs as a result of the skin absorbing contaminated water. To date, no human to human transmission has been detected. Although very rare, other routes of transmission, such as swimming in contaminated waters, are also among the possibilities (THSK, 2015).

Legionnaires' disease is an illness that remains significant, even though the number of cases has been partially reduced by current measures. A rate of 2-9 % of *L. pneumonia* is detected among patients with community-acquired pneumonia (Topçu et al., 2008). Studies show that the species of *Legionella* are the third most common causative agents in community-acquired pneumonias, following *Streptococcus pneumoniae* and *Haemophilus influenzae*, with a frequency of 1-5 % (Stout et al., 2003). The number of cases reported to the CDC has increased since the year 2000. In 2018, approximately 10.000 cases of Legionnaires' disease were reported in the United States. However, this number likely underrepresents the true incidence as Legionnaires' disease is often not accurately diagnosed. The disease generally occurs in the summer and early autumn, but it can emerge at any time of the year. Factors such as *Legionella* colonization in water systems and the presence of susceptible hosts in hospitals and tourism facilities influence the incidence of *Legionella* associated nosocomial pneumonia (Murray et al., 2010).

The fundamental feature of *Legionella* pathogenesis is its ability to replicate within cells. However, the entire infectious process in both protozoa and mammalian cells is important in terms of pathogenesis, including the adhesion of bacterial cells to host cells, survival, intracellular replication, and cell-to-cell spread. There are striking similarities in the processes by which *Legionella* infects protozoan and mammalian phagocytic cells. The abilities of *Legionella* to infect mammalian and protozoan cells are related because they share common genes and gene products (Zhu, 2015).

Diseases caused by the bacteria of the genus *Legionella* are grouped into 4 categories:

- Legionnaires' disease (Legionnaires'' pneumonia)
- Pontiac fever (Non-pneumonic Legionellosis)
- Subclinical infection (Asymptomatic seroconversion)
- Extrapulmonary inflammatory disease (Extrapulmonary Legionellosis) (Keen and Hoffman, 1989).

It is important to start treatment for *Legionella* infections with suitable medications at the right time in terms of reducing mortality. Despite all developments in the diagnosis and treatment of Legionnaires' disease, patients undergoing cancer treatment and patients infected with HIV have increased morbidity and mortality due to immune system weakness (Topçu et al., 2008).

The most important clinical finding in those infected with *Legionella* is pneumonia. It has a wide range of manifestations, from mild cough and fever to coma and various organ failures. The incubation period is 2-10 days, and in immunocompromised individuals, the duration is usually shorter. The disease initially begins with non-specific symptoms (such as fever, fatigue, muscle pain, loss of appetite, and headache). The cough is initially mild, and blood may be seen in the sputum in a streaked form. Diarrhea is observed in 25-50 % of cases, usually watery and rarely bloody. Nausea, vomiting, and abdominal pain occur in 10-20 % of cases. Fever is almost always present, exceeding 40.5 °C in 19 % of cases. Whether a person will experience the disease in any form or not depends on the density of microorganisms in water reservoirs and the sensitivity of individuals immune systems to risk factors (Kayabek, 2002).

Technology, communication, information, culture and economics are parallel to the developments taking place, currently tourism and tourist health are becoming important. Tourists may get sick as a result of their travel even though they are healthy in their living environment or feel healthy. Particularly, various countries, especially European countries, the USA, and Australia, have established organizations and working groups to have wide and systematic information on the subject. By evaluating the cases infected with *Legionella*, efforts are being made to determine from which country and through which accommodation location the disease was transmitted. The working group EWGLI (European Working Group for *Legionella* Infections), which includes our country, can cause reservation cancellations by disclosing facilities where cases have been detected and measures have not been taken. In order to associate *Legionella* cases listed among infectious diseases in Turkey with travel; it is required that the patient who is traveling has spent at least one night or more away from home, and this duration should not exceed 10 days from the onset of the disease. However, the place of stay cannot be directly indicated as the source of the disease, it is only evaluated as a “suspicious place”.

Although it is assumed that hygiene levels in societies increase proportionally with the level of development, it is also a fact that they may remain insufficient due to educational deficiencies or the introduction of new technologies. For this reason, even in societies deemed advanced, cases of foodborne illnesses originating from home environments still occur (Oosterom, 1998; Aiello et al., 2008). The influence of evolving social trends on the rise of epidemics should also not be underestimated (Sattar et al., 1999). Traveling can further expose individuals to such risks, making it essential to identify travel-related health risks in order to approach protective measures proportionally. Traveler’s Diarrhea (TD) and Malaria are the most common travel-associated illnesses, frequently manifesting within the first two weeks of travel (Steffen et al., 2003). In Istanbul, between 1995 and 1998, a study of 21 large buildings found *Legionella* bacteria in water samples from 41 % of them. This was attributed to the lack of chlorine in the water supply in these buildings (Zeybek, 2000). According to EWGLI, between May 1989 and July 2001, a total of 310 cases of *Legionella* disease were reported from 202 hotels across 18 provinces.

When distributed by province, Muğla ranked first with 91 cases from 59 hotels; Antalya was second with 71 cases from 51 hotels; Istanbul third with 54 cases from 26 hotels; and Aydın (Kuşadası) fourth with 50 cases from 25 hotels. Other affected provinces included Denizli with seven hotels and seven cases, İzmir with seven hotels and eight cases, Balıkesir with five hotels and five cases, followed by Nevşehir, İçel, and Bursa with three to four hotels and similar case counts. An additional five cases were reported with unspecified hotels or provinces. Upon review for repeat notifications, only three tourist facilities showed repeated reports in different years-one each in Istanbul, Kuşadası, and Marmaris. Since 1989, two major outbreaks have been reported: one from a facility in Kuşadası with 17 cases in July-August 1994 and another from a facility in Istanbul with 16 cases in September-October 1997 (Epidemiology Report, 2002).

## 2. TRAVEL RELATED RISK FACTORS

When examining the modes of transmission for travel-related infectious diseases, contaminated water or food ranks first. Diseases transmitted by air or contact follow in second place, and recreational waters, such as pools, are the third most common sources. Addressing these transmission routes individually is insufficient; rather, a comprehensive examination of all these factors is essential for effective and swift resolution (Sanchez et al., 2009). *Legionella* species, commonly found in natural waters, soil, and the environment, can heavily colonize artificial systems such as water distribution networks, room humidifiers, and cooling towers. Compared to other bacteria, they exhibit greater resistance to chlorine but are less resistant to acidic conditions. Therefore, the presence of these bacteria in utility water poses a significant risk. *Legionella* bacteria are a major cause of hospital-acquired pneumonia, with sources in hospitalized patients including drinking water, hot water systems, showers, baths, ventilation systems, nasogastric tubes, humidifiers, masks, respiratory devices, cooling towers, and steam condensers (Köksal et al., 2002). Cases of *Legionella* have been identified not only in any establishment or destination that provides tourist goods or services but also on cruise ships (Pastoris et al., 1999). Outbreaks that occur on ships are more challenging to control compared to those on land. For this reason, cruise tourism, similar to the airline industry, must rigorously implement the highest level of protection and preventive measures across all domains (Mccarter and Jacksonville, 2009).

## 3. TRAVEL-ASSOCIATED *LEGIONELLA* REPORTING

In a globalized world marked by rapid movement, borders have lost much of their significance; a disease emerging in one country quickly becomes an issue for others as well. At this point, the effectiveness of international surveillance clearly relies on the robustness of national surveillance systems. Surveillance can be defined as "the systematic collection and interpretation of data, with rapid feedback of results to relevant units". The objectives of surveillance are to monitor changes in the incidence of a disease, detect outbreaks early, evaluate the effectiveness of preventive measures, identify groups vulnerable to specific agents, uncover clues about the causes of diseases, and establish priorities for resource allocation. Surveillance-based data are essential for policy development, planning and executing actions, and ongoing monitoring and evaluation. Turkey, as a member of the World Health Organization (WHO) and a candidate for the European Union (EU), is an integral part of international surveillance systems (National Strategic Plan for Infectious Diseases, 2004).

One of the most crucial data sources in healthcare is the information obtained through the notification and reporting of infectious diseases. The reliability and accuracy of this data have gained even greater importance in an era where countries and institutions face sanctions due to infectious diseases in the global landscape. In Turkey, efforts to update the "Infectious Diseases Notification and Reporting System" began in 2001, with participation from around 60 individuals from the Ministry of Health and academic circles (Bayazıt, 2005). The updated system was implemented on January 1 2005. In the "Communicable Diseases Surveillance and Control Principles Regulation" published by the Ministry of Health, *Legionella* disease is listed under diseases transmitted by respiratory (airborne) routes, as "legionellosis." When defining probable or confirmed cases, the regulation specifies asking the patient if they have spent at least one night away from home, such as in a hotel or hospital, in the past 15 days (Official Gazette: October 17, 2005, issue 25730). The European Working Group for *Legionella* Infections (EWGLI), established in 1986, receives information on travel-related *Legionella* infections from 37 member countries and shares it through a centralized network system (EWGLINET). Each member country, by signing agreements with EWGLI, agrees to the procedures for reporting, responding to suspected cases within its borders, and understanding the penalties for non-compliance. EWGLI requires each country to designate a single official representative, facilitating information exchange via this liaison. In Turkey, the Ministry of Health's General Directorate of Primary Health Care serves as the official EWGLI representative. EWGLI does not grant accreditation to commercial entities or similar non-governmental organizations (EWGLI, 2005). EWGLINET classifies case reports as either Single Case or Cluster Case. In the relationship between EWGLINET and member countries, official authorities in the country where the infection occurred enter case information, using a unique code, into the Network Coordination Center's site. Detailed data-such as the case's progression, microbiological test results, and locations visited, including room numbers, steam baths, hammams, and other venues is required. These details, entered by the Coordination Center and the relevant country, are visible to other member countries. If other countries have cases linked to the same location or hotel, they can also report them. If there are additional reports related to the case, the Coordination Center informs the official representative of the country where the infection originated. The representative then notifies the provincial health authorities and, from there, the local Health Group Directorate. Officials visit the implicated hotel or establishment to implement necessary prevention measures, take samples, and communicate updates back to EWGLI. If the affected country is not part of this network, EWGLI informs the highest health authority of that nation. For Single Cases, the country's EWGLI representative monitors the case, and case details are retained in the system for two years. If no additional cases of *Legionella* occur at the same hotel within this period, the hotel is removed from the list. For Cluster Cases, periodic reporting is required. If unsatisfactory reports are received, the hotel's name, address, and status are published on the website, and members are informed via automated email. Once satisfactory reports and actions are documented, the status is updated, and members are notified via the same channels (EWGLI, 2005).

### 3.1. *Legionella* and Its Risks

As with any risk management system, managing the risk of *Legionella* disease requires a clear identification of risks. This process begins with a Risk Assessment to determine the situation and evaluate identified risks, followed by moving into the Risk Control phase. While managing risks, it is essential to consider any additional risks that the chosen management approach may introduce. Documentation is also crucial to verify, through internal and external audit results, that the risk is being managed as intended. Although *Legionella* disease is typically waterborne, there is also the possibility of contamination from soil to water. Conducting environmental investigations can be an effective approach in advanced, unresolved cases (Köksal et al., 2002; Yalçın, 2010).

#### 3.1.1. Identifying *Legionella* risks

To identify the risks of *Legionella* disease, it is essential to determine where the causative agents might be present in or around a hotel. In all establishments providing tourist goods and services, water systems, cooling systems, fountain pools, nearby cooling towers, streams, lakes, and any other water- or aerosol-related operations are identified as risk factors. Additionally, considering the incubation period of 2-10 days, the time the tourist spent in their home country should also be regarded as part of the risk and should be investigated (Szymanska, 2004). Some recent studies have found that the incubation period may extend up to 2-3 weeks (EWGLI, Fact Sheet, 2006).

### 3.2. Detection of *Legionella* Risks

Potential sources of travel-related *Legionella* disease (EWGLI, 2005):

- Hot and Cold Water Systems
- Shower and Faucet Heads
- Cooling Towers
- Steam Boilers
- Spa/Natural Pools
- Thermal Waters
- Decorative Pools/Fountains
- Humidifiers
- Respiratory Equipment
- Biofilm Layers

- Wastewater Drains
- Garden Faucets
- Ice Machines
- Water Filters
- Radiator Systems
- Cisterns
- Unused Hotel Rooms
- Dead-End Piping
- Water Heaters
- Water Softening Machines
- Wet Sponges
- Emergency Fire Showers
- Greenhouse Humidification
- Coiled Water Hoses
- Car Wash Machines
- Dental Chair Water -Tanks
- Airport Air Conditioners
- Decorative Pools in Parks
- Transfer Bus Air Conditioning
- Ventilation in Shopping Malls
- Vehicle Air Conditioners (Rental Cars)

In November 1999, an incident in Belgium demonstrated the omnipresent risk of *Legionella* in travel settings: at a local fair, 93 individuals contracted *Legionella*, and five people died due to exposure to a decorative pool and jacuzzi set up by booth owners. This event underscores that whether as participants or organizers, we may encounter *Legionella* risks in any travel context (Schrijver et al., 2002).

### 3.2.1. Investigating *Legionella* risks

In water systems, *Legionella* prevention, control, and environmental monitoring in hotels require the establishment of Risk Management Systems tailored to the hotels specific risk status. Identifying risks before management is crucial, and the most effective method for detection is direct observation, from which insights should be drawn. Effective Risk Management must genuinely shield the hotel from *Legionella* risks and enable proactive measures. If a single case occurs despite such a system, the system must be thoroughly reviewed, with necessary adjustments made to the procedures. If cases continue to arise, the Risk Status should be reassessed. Experts qualified to address *Legionella* include microbiologists, biologists, infection specialists, laboratory technicians, public health experts, technicians, environmental health specialists, or aquaculture engineers trained in this field. The risk of illness from *Legionella* bacteria depends on several factors (EWGLI, 2005):

- Presence of *Legionella* bacteria
- A conducive environment for bacterial proliferation
- Means of transmission to humans
- Bacterial replication within the human host
- Compromise of the human immune system by the bacteria

In determining the Risk Status, all hot and cold water systems within the hotel, along with water flow paths, should be diagrammed. Any subsequent modifications must be updated on this diagram, which should always remain current.

Diagrams should include the following essential elements (EWGLI, 2005):

- The source of water connection to the system
- Lines indicating potential contamination points from the water’s entry to the system up to hot and cold water tanks, cooling towers, or machinery and areas that pose a *Legionella* risk
- Potentially contaminating equipment
- Dead-ends and malfunctioning points
- Airflows from cooling towers into the building
- Comprehensive documentation of the Risk Status

All hotel employees should be informed about the *Legionella* risks, protective measures taken, and ongoing monitoring procedures. Control measures in place at the hotel should be regularly monitored, and corrective actions should be implemented if discrepancies arise. The risk status should be reassessed at least every two years (EWGLI, 2005).

#### 3.2.2. Hot and cold water systems

Water is vital in everyday operations within establishments, and since water is one of the primary sources where *Legionella* disease can thrive, its disinfection and temperature management are crucial. *Legionella* bacteria proliferate most effectively in temperatures between 35-46 °C, making lukewarm water a consistent risk factor (Turner and Handley, 2008). To mitigate this risk, the return temperature for hot water should be at least 50 °C, while cold water should not exceed 25 °C (WHO, 2007).

##### 3.2.2.1. Pressurized system

In a pressurized water system, the goal is to supply the water installation through a single main booster pump. Hot water distribution in pressurized systems can be applied in both return circulation systems, which are suitable for large buildings, and in some smaller structures that lack a return circulation. In systems with a return circulation, hot water circulates continuously, ensuring that the water temperature remains consistent across all faucets and connections, regardless of their distance from the heater. Hot water systems pose a significant risk for *Legionella* proliferation. For instance, there is a substantial risk in the lower parts of the water heater, where incoming cold water mixes with existing hot water, as well as in the sections of piping between the hot water source and outlets especially during periods of non-use. Water systems can become contaminated by *Legionella* entering from the main pipe into the cold water storage, though this poses minimal risk under normal conditions. *Legionella* will only proliferate in cold water systems or in distribution pipes when temperatures rise. Natural circulation hot water systems are particularly prone to increasing the risk of *Legionella*. Maintaining consistent water temperature at every point in the distribution system presents an additional challenge. If the water return temperature is set as the minimum threshold, then temperature losses will not disrupt the system as a whole (Turner and Handley, 2008).

##### 3.2.2.2. Design and construction

In commercial buildings, hot and cold water storage systems may be designed with larger-than-usual dimensions due to certain uncertainties in the design phase. This situation requires additional safety precautions. Plumbing repair systems must comply with national regulations. In designing hot and cold water systems, particular attention should be given to using materials. Its do not promote microbial growth, covering water storage tanks with appropriate lids, installing insect screens in air vents open to the atmosphere, and avoiding multi-part storage tanks due to potential irregular flow and stagnation issues. Additionally, hot and cold water systems should be designed to allow for thorough cleaning during repairs, and if thermostatic mixing valves (TMVs) are installed, they should be positioned as close as possible to the point of use. It is also essential to ensure that a thermostatic valve does not supply multiple showerheads; if it does, the showerheads must be frequently cleaned with pressurized water (EWGLI, 2005).

#### 3.2.2.3. Hot water systems

The hot water storage and supply capacity should be selected to prevent any drop or fluctuation in water temperature. Pipes that allow for an increase in water volume should be adequately sized and positioned appropriately within the water circulation system. If multiple water heaters are used for storage, they should be connected in parallel. When temperature control is used as a regulatory measure, each water heater should distribute water at a minimum temperature of 60 °C. If temperature is being used specifically to control *Legionella* the return temperature of the hot water to the heater should ideally be designed to remain at 55 °C and must not fall below 50 °C. Hot water taps should be capable of supplying water at an ideal temperature of 55 °C, and at no time below 50 °C within one minute of activation. Water thermometers should be installed at both the outlet and return points of the hot water tank for monitoring purposes. In larger hot water tanks, time controlled recirculation pumps should be considered to prevent temperature variations in the stored water. Hot water distribution pipes should be insulated to prevent any impact on cold water pipes (EWGLI, 2005).

#### 3.2.2.4. Cold water systems

Cold water tanks should have inlet access points for cleaning, maintenance, and inspection of the inlet valve. Larger tanks may require multiple inlet access points. The volume of stored cold water should be minimized and should not exceed the typical daily water usage. The cold water storage tank should be placed in a cool location and protected from heat. Cold water pipes should be kept at a distance from hot water pipes to prevent temperature increases, with a maximum allowable temperature rise of no more than 2 °C. Cold water pipes should be designed to allow for easy monitoring of temperature insulation and placement (EWGLI, 2005).

#### 3.2.2.5. Management of water systems with temperature control

In managing hot water systems, the water temperature at the bottom and outlet sections of the water heater should be continuously measured throughout the day. The tank outlet temperature should not fall below 50 °C for more than 20 minutes in a day. If the hot water tank or any part of the hot water system has been out of service for more than one week, the water temperature should be raised to 60 °C for at least one hour before using the system. If circulation pumps are present in the hot water circuit, they should be operated at least once a week. If biocides are used for *Legionella* control, their concentration should be restored to normal levels before the system is put into use (EWGLI, 2005).

#### 3.2.2.6. cold water production

Cold water is typically supplied to buildings with a small amount of active chlorine disinfectant and in a consumable condition. However, users should not rely on this alone to process the hot water system. In areas where water is sourced from rivers, lakes, or other sources, pre-treatment is required. According to the EU Council directive (98/83/EC on The Quality of Water Intended for Human Consumption), water supplied to buildings for human consumption must not exceed 25 °C. In practice, it is preferred that the water temperature remains well below this maximum. However, during prolonged summer periods, incoming water may be warmer than expected in some locations. If the incoming water exceeds 20 °C, the cause of this high temperature should be investigated and addressed. If this is not possible, a risk assessment should be conducted, and the increased risks along with mitigation measures should be documented (EWGLI, 2005).

#### 3.2.2.7. Hot Water Production

Water in boilers can be heated by hot water, steam, or electric heaters. Generally, the temperature at the bottom of hot water tanks is lower than at the top. To balance this, the temperature at the bottom should be raised to at least

60 °C for one hour daily. Although this balancing process is not commonly applied, it can be performed by using a pump to circulate hot water from the top to the bottom of the tank, preferably during low-demand hours, such as early morning. In tanks with temperatures above 60 °C, calcium layering at the bottom can pose a risk. Therefore, it is recommended to install a control connection at the very bottom of the tank (McCoy and ASHRAE, 2006).

#### 3.2.2.8. Cleaning Faucets and Shower Heads

In seasonal operations, during the winter period, all showerheads and faucet taps are removed and soaked in a descaling chemical solution for at least one day. Once fully descaled, the showerheads and faucet taps are reinstalled in the rooms at the start of the season. If spares are available, they are replaced with cleaned ones every three months. As removing and reinstalling faucet taps can be labor-intensive and time-consuming, if showerheads are unavailable, descaling is instead done in place using spray concentrate solutions without disassembly. In rooms not used throughout the day, faucets should be flushed for at least two minutes (EWGLI, 2005).

### 3.3. Conditioning and Control Programs

System cleaning and disinfection should be achieved using both temperature control and biocide application. In facilities with cooling towers, the incoming water for cooling must be continuously disinfected with appropriate, long-lasting biocides, operating 24/7. Due to the air-cooling process and the lukewarm temperature of the incoming water, cooling towers are among the highest-risk elements. The amount of biocide used should be proportional to the expected microbial activity. Conditioning treatments applied to boiler water, potable water, and closed loop solar system water will ensure optimal and consistent flow in the piping, saving both time and money (Lucas et al., 2006).

### 3.4. Monitoring Temperature Condition

Hot water should be stored at 60 °C and should flow from the outlets at a minimum temperature of 50 °C, preferably 55 °C, within one minute. Higher temperatures should be avoided due to the risk of scalding. The temperature difference between the highest and lowest readings at the taps should be recorded. If this difference exceeds 10 °C after one minute, it indicates a significant insulation issue or possible mixing of cold water with the hot supply, warranting a thorough inspection of the system. In the fight against *Legionella* the addition of chemicals to the domestic water supply can help inhibit bacterial growth, complemented by controlling hot and cold water temperatures. This dual approach allows for greater reliability, ensuring that one method compensates for the other if an issue arises (Kayabek, 2002).

### 3.5. Cooling Systems

Cooling systems, much like the temperature control measures in *Legionella* prevention, are critical components of the cold chain for businesses providing goods and services in the tourism sector. Beyond ensuring guest room comfort, these systems are essential to prevent microbial activity in food served to guests. In travel-associated *Legionella* cases, risk assessments should begin at the point of departure whether an airport, bus station, or port and extend to all cooling-related equipment along the journey. This includes ventilation systems within the transportation, decorative fountains at the destination, air conditioning in transfer vehicles, and cooling systems at the hotel. Pools and other water features also pose a potential risk (Leoni et al., 2001).

#### 3.5.1. Cooling towers

Cooling towers are generally systems used in older facilities. With the construction of newer establishments and rising electricity costs, many operators have moved away from cooling tower-based systems. These systems are designed to dissipate the heat generated by large cooling machines, such as kitchen cold rooms or chillers, through a closed-circuit water system. Water, heated as it absorbs warmth from the motor, is pumped to the cooling tower. Here, the water flows down from a height and cools as it meets air forced by a large fan. The cooled water is then circulated back to the heated motors, preventing them from overheating. However, during the cooling process, *Legionella* bacteria can spread in the air through the fan. In contrast, newer cooling systems, often referred to as packaged cooling units, use more compact motors that cool through their own internal fans, minimizing this risk (Köksal et al., 2002; THSK, 2015).

### 3.5.2. Evaporators and condensers

Inside the indoor unit, as the refrigerant gas heated or cooled in the outdoor unit circulates through fine metal fins, the fan pushes room air over these fins, warming or cooling the air as needed. The filters located in front of the air conditioner's evaporator clean the air as it's drawn in. Ideally, these filters should be removed, cleaned, and replaced monthly, or at least every three months, to contribute to energy savings for the establishment. Using a concentrated aluminum cleaner to clean both the indoor unit's evaporators and the outdoor units condenser reduces the load on the motor, lowering electricity consumption and enhancing the air conditioner's performance. After this maintenance, surfaces should be disinfected appropriately, ensuring a clean start to the season. During the season, filter cleaning should be performed as needed without delay (EWGLI, 2005; THSK, 2015).

### 3.5.3. Air conditioning systems

Split air conditioners consist of two parts: an indoor and an outdoor unit. Systems known as VRF (Variable Refrigerant Flow) work on the same principle, allowing multiple indoor units (typically 6-8) connected to a single outdoor unit to operate in either heating or cooling mode independently. The outdoor unit adjusts the refrigerant's temperature, sending heated or cooled gas to the indoor unit as needed. When cooling, water droplets from the humid air condense on the thin coils of the evaporator due to the temperature difference and accumulate in a condensation tray inside the unit. This water is then drained via a plastic hose, usually directed to a balcony drain intended for rainwater. However, if *Legionella* bacteria proliferate in the standing water of the tray, they can spread into the room via the fan. In establishments that use centralized heating and cooling instead of split systems, fan coil units typically located on ceilings or near walls also have condensation trays. In fan coil systems, the central chiller provides cooling, while a boiler provides heating, whereas in split systems, the outdoor units contain condensers. To continuously disinfect the water collected in the condensation trays of both split and fan coil units, "*Legionella* Tablets" or "Bromine Tablets," with a six-month lifespan, are placed at the farthest point of the tray. This measure not only reduces the risk of *Legionella* infection from the tray but also prevents blockage in the drainage pipes. These tablets are odorless (THSK, 2015).

### 3.5.4. Air conditioning units

Air handling units (AHUs) are among the most commonly used systems for heating and cooling large public spaces. Ducts are installed at strategic points to handle the intake and supply of air. A high volume intake fan draws in air through the AHU, where it undergoes climate control before being distributed back into the space via a supply fan. Starting from the intake, an AHU typically consists of an intake fan, an exhaust damper with fresh air damper in the mixing chamber, a coarse filter, a bag filter, an activated carbon filter for odor control, a heating coil, a cooling coil, a droplet separator, and a supply fan. During cooling, condensation forms as humidity from the air collects on the droplet separator and drips into the tray beneath the AHU, creating a potential Legionella risk. To mitigate this, *Legionella* tablets similar to those placed in the trays of split air conditioners should be added to the AHU tray as a preventative measure (Leoni et al., 2001; THSK, 2015).

### 3.5.5. Jacuzzi and spa pools

Though models vary, a jacuzzi is typically a bath or small pool where warm water is continually circulated. The water is not changed after each use but is filtered and chemically treated. The temperature usually exceeds 30°C, and the bubbling action creates aerosol particles on the water's surface, which can contribute to the spread of *Legionella*. Maintenance of these pools requires regular operational checks, equipment cleaning, and continuous water conditioning. In contrast, plunge pools are emptied after each use, posing less of a risk than spa pools. Guests who have had diarrhea within the past 14 days, children under 4, and those wearing sunscreen or skin creams should avoid using the jacuzzi. It is also important not to spit into the water, avoid ingesting it, limit use to 15 minutes, and ensure the jacuzzi is not occupied beyond its maximum capacity. Diaper changes should not occur near the jacuzzi. Those with heart issues, blood pressure concerns, asthma, or who have recently eaten heavily should refrain from use. Pregnant individuals should use the jacuzzi only with a doctor's approval. The pH level should be maintained between 7.0 and 7.6 (Hsu et al., 2006; EWGLI, 2005; THSK, 2015).

### 3.5.6. Humidifiers

Atomic humidifiers, ultrasonic humidifiers, and air humidifiers can use water at temperatures above 20 °C in their tanks or reservoirs. Without regular maintenance and cleaning, these devices can become highly contaminated. Using non-spray humidifiers can help mitigate this risk (EWGLI, 2005).

### 3.5.7. Chemicals and application methods

In *Legionella* control, disinfection is carried out using both temperature regulation and chemical treatment of water. A Chemical Use Program encompasses guidelines for the storage, handling, and application of chemicals, as well as emergency procedures in case of accidents. It details control measurement values for chemical, biological, and physical parameters, including sampling methods, storage conditions, frequency, sampling points, and procedures for cases where results exceed control limits. The program also outlines communication protocols, cleaning and disinfection procedures, and methods for repair and maintenance, specifying whether the facility is occupied or unoccupied. Together, these elements form the guidelines for chemical use and application methods (EWGLI, 2005; THSK, 2015).

## 4. CONCLUSION

With advancements in technology, communication, information, culture, and economics, tourism and tourist health are becoming increasingly important. Tourists, despite being healthy in their home environments, may fall ill while traveling or upon returning home. Additionally, waterborne health issues are also observed in buildings with centralized cooling or hot water systems, such as schools, hospitals, barracks, and large complexes. Mortality rates from Legionnaires' disease, a bacterial respiratory illness, can reach up to 15 %, with cases and outbreaks more common in summer and autumn. Travel-associated Legionnaires' disease has been reported as both epidemic and sporadic cases across all continents and numerous countries. *Legionella* species are found widely across the globe, and water sample analyses from various regions in our country show similar distribution patterns to those in other countries. This issue holds significant importance for national tourism and is a critical public health concern. The true global scale of travel-associated Legionnaires' disease remains unknown, as many cases go undiagnosed. Today, many European countries report any travel-associated Legionnaires' cases to the source country, a measure intended to facilitate prompt preventive actions and control outbreaks.

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# CHAPTER IV

## SOLUTION METHODOLOGIES FOR THE *LEGIONELLA* PROBLEM IN TOURISM

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## INTRODUCTION

The *Legionella* bacteria settle in the human respiratory system, leading to Pontiac fever, which resembles flu-like symptoms (Vural, 2014; Fricke et al., 2020), and Legionnaires' disease, which is similar to pneumonia. The disease was first identified in 1976 during an outbreak at a hotel in Philadelphia, USA, where a Legionnaires' convention was taking place. Investigations linked the outbreak to the hotel's water systems. The bacteria isolated from the hotel's water were named *Legionella* (Joshi and Swanson, 1999), and the disease it caused was named Legionnaires' Disease (LD) (EWGLI, 2005; Felice et al., 2019; Scaturro et al., 2020). Due to its transmission through water, *Legionella* is recognized as a waterborne environmental pathogen (Vural, 2014; Zhan et al., 2014; Graham et al., 2020). Warm, stagnant waters with biofilm layers, where protozoa and amoebae are present, pose a potential risk for Legionnaires' disease (Tachibana et al., 2013). *Legionella* proliferates in water sources and distribution systems and spreads to humans through aerosols (Felice et al., 2019). Additionally, person-to-person transmission has also been reported (EWGLI, 2005; Swart et al., 2018). *Legionella* can exist freely in humid environments, soil, sludge, and natural and fresh water sources (Eisenreich and Heuner, 2016), as well as living as parasites within amoebae and protozoa (Tao et al., 2013; Felice et al., 2019). It forms colonies within biofilm layers found in water systems (Graham et al., 2020). The greatest threat to humans arises when it multiplies within biofilm structures (Fricke et al., 2020).

Legionnaires' disease causes life-threatening pneumonia worldwide, with a mortality rate of 15-20 % (Alli et al., 2003; EWGLI, 2005). Over the past 50 years, *Legionella* has become one of the microorganisms with increasing pathogenicity and virulence (Felice et al., 2019). Factors such as urban industrialization, the increased use of pools, spas, air conditioning, and shower systems, water source contamination, and the rise in communal living spaces like sports centers, elderly care facilities, and shelters have contributed to a higher incidence of Legionnaires' disease (Felice et al., 2019).

Aquatic environments with temperatures between 25-55 °C, such as spa baths, air conditioning systems, and water systems in buildings that are infrequently disinfected and accumulate biofilm layers, provide ideal conditions for *Legionella* to thrive and lead to outbreaks (Buse and Ashbolt, 2011; Eisenreich and Heuner, 2016). The environments where *Legionella* is most frequently found include hospital and hotel water systems, dental centers, medical units with dialysis and respiratory devices, air conditioning systems, and decorative fountains, all of which present high risks for disease transmission (Sikora et al., 2015).

In the transmission of *Legionella*, both potable water sources, such as faucets, and non-potable sources, including showers, spas, cooling towers, and condensers, play a significant role. *L. pneumophila* has adapted to survive in air conditioning systems, cooling towers, fountains, spas, sprinklers, ice machines, plant misters, dental equipment, and showerheads. Inhaling contaminated aerosols from these environments can lead to Legionnaires' disease, which may result in severe pneumonia, especially in immunocompromised individuals, the elderly, and those who are otherwise vulnerable (Oliva et al., 2018; Talapko et al., 2022).

## 1. *LEGIONELLA* PROTECTION METHODS

### 1.1. Hot Water Systems and Chemical Application Methods in Hot Water Systems

National water regulations may set a maximum allowable biocide level for potable water sources. Water conditioning system installers must be aware of these regulations and maintain biocide levels within acceptable limits (EWGLI, 2005). For both emergency and routine disinfection of systems, thermal shock treatment involves maintaining water at 70-80 °C in the hot water tank and circulating it throughout the system for three days. During this time, each faucet is run for at least five minutes to ensure the water temperature reaches at least 65 °C. Effective insulation of the water system is crucial for this process. Some experts also recommend draining, cleaning, and chlorinating the hot water tank, though this may cause corrosion. Circulating hot water raises temperatures in distant outlets to at least 65 °C. After treatment, water and sediment samples should be taken from distant points in the system to check for *Legionella* growth, and disinfection should be repeated if bacterial growth is detected. However, due to the high energy and labor required, this method is impractical for large buildings. Thermostatic mixing valves prevent effective disinfection downstream, and unless combined with other methods, biological activity can quickly return to the water system. Keeping hot water at a constant temperature 24/7, supplemented with chemicals, is a safer approach. At 60 °C, 90 % of *Legionella* bacteria die within approximately two minutes, and at 50 °C or above, they survive only for a few hours. Therefore, hot water temperatures should consistently reach at least 50 °C throughout the facility to minimize *Legionella* colonization (McCarter and Jacksonville, 2009). When chlorine is used in hot water system disinfection, its effectiveness depends on pH. Above pH 7.0, chlorine's effectiveness rapidly decreases, with an ideal pH of 6.9 for combating *Legionella* (EWGLI, 2005). Shock chlorination is performed when water temperature is below 30 °C, with chlorine added to reach levels of 2 to 5 ppm. When testing from the furthest point, a concentration of 2 ppm requires two hours, while 5 ppm needs one hour to ensure full distribution of chlorine throughout the system. Afterward, the chlorinated water is flushed and replaced with fresh water, maintaining 0.5-1 ppm of free chlorine. Continuous chlorination, typically with calcium hypochlorite or sodium hypochlorite, varies with water quality, flow, and biofilm presence, with a residual chlorine level between 1 and 2 mg/L being ideal. However, chlorine may be ineffective in “dead ends” of plumbing systems, and maintaining desired levels is difficult as it evaporates at high temperatures. Chlorine is also corrosive, with increased effects at higher temperatures (EWGLI, 2005; Mekkour et al., 2012). Unlike chlorine, chlorine dioxide is non-volatile at high temperatures and is more effective on biofilm. Hospitals that use water disinfected with monochloramine or Chloramine T experience lower risks of *Legionella* outbreaks (Flannery et al., 2006). Monochloramine disinfection of hot water systems may be more effective than chlorine but suitable dosing systems for buildings are not yet available. Monochloramine is slower-acting than chlorine, though both chlorine dioxide and monochloramine are more effective than chlorine in biofilm on iron pipes. Ionization, a water conditioning method using electrolytically generated copper and silver ions, is effective against bacteria by attacking cell walls and causing protein breakdown, resulting in cell death. When managed effectively, copper and silver ion concentrations of 400 μg/L and 40 μg/L can control *Legionella* within biofilms in hot water systems. In softened water, silver ion concentrations between 20-30 μg/L may be sufficient. Ionization is pH-sensitive and achieving sufficient silver ion concentration above pH 7.6 can be challenging. This method is easy to apply and unaffected by water temperature, but fluctuations in concentration require regular monitoring for proper maintenance (EWGLI, 2005). UV

radiation is also effective for water disinfection, using special fluorescent tubes made of quartz glass filled with mercury vapor to emit UV rays at a wavelength of 254 nm. Microorganisms in water passing through well-insulated UV lamps are rendered harmless as UV light disrupts their DNA and/or RNA structures (Lukas et al., 2006). UV radiation is commonly used in drinking water disinfection, proving effective when applied near the point of use. Thermal shock and chlorination can be combined with UV treatment. UV equipment is easy to install, has no impact on water taste or quality, and does not damage piping systems. However, due to its limited impact, UV treatment is unsuitable as a primary method for entire water systems or large buildings (EWGLI, 2005; Amemura-Maekawa et al., 2012).

### 1.1.1. Biocide applications

Biocides are chemical substances, such as bactericides, fungicides, and pesticides, that inhibit the growth of or kill living organisms, especially microorganisms. They are classified into two main groups: oxidizing and non-oxidizing biocides. Examples of non-oxidizing biocides include Sothiazolones and its derivatives, DBNPA, Glutaraldehyde and/or Quat, Carbamates, Tris-hydroxymethyl nitromethane, Bromo nitropropanediol, Bromo nitrostyrene, Methylene Bisthiocyanate, and Quaternary Phosphonium. For oxidizing biocides, examples include Bromo-chloro-dimethyl Hydantoin, Sodium Hypochlorite, Catalyzed Hydroperoxide, Chlorine Dioxide, Iodine, and Isocyanurates (Kayabek, 2002). Since hot water systems are supplied from cold water, they retain the disinfectants used in cold water for sanitization. When chlorine is used as a disinfectant in hot water systems, it can penetrate the skin through pores opened by the hot water, potentially causing skin and hair dryness, skin conditions, and eye irritation and redness. Chlorine may also be absorbed into the lungs through steam from hot water, which can lead to serious long-term health issues, such as asthma and allergies (Burak and Zeybek, 2011).

### 1.1.2. Monitoring of oxidizing biocides

Regular maintenance and inspections will be sufficient if the following items are monitored regularly (EWGLI, 2005):

- The amount of chemicals in the reservoir

- The proportion of active substances added to the water source
- Monthly measurement of active substance concentration
- Annual measurement of active substance concentration at a representative number of outlet points throughout the building

### 1.1.3. Monitoring ionization

Ionization refers to the electrolytic generation of copper and silver ions as a water conditioning method. Metals such as copper and silver are effective against bacteria, as they disrupt the cell walls of microorganisms. Regular maintenance and monitoring of the system will be sufficient if the following parameters are routinely checked (EWGLI, 2005):

- Free ion concentration in the water source
- Quarterly monitoring of silver ion concentration at representative outlet points
- Cleaning of installed electrodes if non-fireproof electrodes are used
- pH level of the water source should be kept under control.

## 1.2. Cold Water Systems and Chemical Application Methods in Cold Water Systems

Cold water distribution pipes should be cleaned and disinfected if routine inspections indicate a need, if the system has been out of use for more than a month, if the system (in whole or part) has undergone maintenance that could introduce contaminants, or if there is a suspected outbreak. Disinfection can be carried out chemically or through thermal disinfection, with a preference for chemical disinfection (EWGLI, 2005; Mekkour et al., 2012). Oxidizing biocides are commonly used in cold water systems, with a maximum allowed concentration of 0.5 mg/L. If the water is intended for drinking, national drinking water regulations must be followed. An operating manual should be created for the cold water system, detailing operational-maintenance procedures and water conditioning programs. For systems with automatic dosing units, a device to measure the amount of biocide should be available. If automatic measurements are not possible, daily biocide measurements should be taken from various points using calibrated equipment, and results should be recorded. Regardless of the dosing method, the quantity and frequency of chemical applications, monitoring needs, corrective actions, and disinfection procedures should be documented alongside normal control parameters. The operating manual should also include a detailed maintenance schedule, with staff updating records after each task (EWGLI, 2005; Buse et al., 2020). For tourist accommodations and recreational areas with circulating decorative fountains, rest areas, airports, and other travel-related facilities, water systems should be analyzed to prevent *Legionella* risks. Structurally, water sources should meet official standards for “Water for Human Consumption.” Measures should be taken to prevent contamination of suitable water sources. Businesses should restrict or enforce policies to prevent activities that could contaminate water sources, such as livestock farming, proximity to septic tanks, or industrial activities. Ideally, water pipes from sources to the facility, as well as internal plumbing, should be made of plastic rather than iron. In older facilities where room and technical service lines are replaced, the main lines are often overlooked. If iron piping remains, chemical biodispersants should be used, and Teflon tape should replace flax in repairs. If filters are used on faucet spouts, they should be avoided where possible or cleaned regularly. Both indoor and outdoor water storage tanks should have floors, walls, and ceilings made from hard, smooth materials. Ceramic or tile bases should be fully cemented, with epoxy or other hard, smooth coatings. Storage tanks should be accessible for easy cleaning and have adequate ventilation shafts or windows with steel screens. If necessary, electrical wiring should be installed to provide full visibility of the tank’s interior when filled. In outdoor setups, water storage tank lids should be kept secured, and the door to indoor storage tanks should be locked to ensure security. Daily random measurements of cold and hot water temperatures, pH, and free chlorine levels should be taken and recorded, with cold water ideally not exceeding 25 °C when biocides are used, or 20 °C if they are not. In cases where cold water exceeds 26 °C, the insulation of both external and internal plumbing should be reviewed. Artesian systems on the ground or dark-colored plastic tanks exposed to sunlight can increase cold water temperature. The cold water pH level should average around 7.6, with a residual free chlorine level not exceeding 0.5 mg/L in samples taken from endpoints 24/7. If pH levels are too high or low, pH regulators should be activated until the appropriate level is reached. Automatic dosing machines are commonly linked to water pumps to maintain chlorine levels, or slow-release chlorine tablets may be placed in water tanks. Biocide should be applied to water in decorative fountains, and measurements recorded weekly. Regular weekly water replacement can help prevent environmental contamination. In large pools or streams containing fish within hospitality facilities, biocides that do not harm aquatic life should be used.

If the cold water system has been out of use for over a month but is maintained with a management/monitoring system, it should remain filled with conditioned water. If this is not feasible, the system should be drained and corrosion controlled by a desiccant. Non-continuous cooling systems require special biocide application monitoring (EWGLI, 2005).

### 1.3. Chemical Application Methods in Cooling Towers

Cooling towers are generally categorized into two main types: mechanical draft and natural draft. Mechanical draft towers employ fans to expel air, with fans positioned to push air out from the top of the tower. In natural draft towers, the warm return water heats the internal air. Open-circuit cooling towers are widely used in commercial settings, with the chosen system tailored to its specific cooling purpose. A cooling system may consist of a cooling tower, evaporative condenser, or other cooling components, forming the core of management and control systems. A comprehensive conditioning program should be established based on the operating parameters of the cooling system, ensuring the program’s components are environmentally acceptable. Factors that may impact the program’s effectiveness include contamination, microbiological activity, and corrosion. The operational conditions of cooling systems can facilitate microbial growth. Factors such as water temperature, pH, nutrient levels, $CO_2$, and sunlight influence the living conditions of organisms, including *Legionella*, protozoa, algae, fungi, and bacteria. Both surface-adhered and free-floating bacteria must be managed through conditioning programs. Routine monitoring of cooling water ensures the continuous efficacy of the conditioning program, with weekly monitoring recommended, though the frequency and scope may vary depending on system characteristics (EWGLI, 2005; Chang et al., 2010).

Studies on *Legionella* cases indicate that cooling towers are more likely to harbor the bacteria than other water systems (Mavridou et al., 2008; Chang et al., 2010). Closed-loop circulation, rather than open-circuit systems, is recommended for cooling tower water to manage energy consumption; each degree Celsius increase in temperature may raise energy usage by 1-2%. Thus, through effective water conditioning, *Legionella* risk in cooling towers can be efficiently managed, potentially achieving around 20% energy savings (Billiard, 2004). In facilities with central cooling, the main cooling machine operates in tandem with the cooling groups of refrigerated areas, producing heat. This heat is transferred to circulating water within a closed-loop, which flows to external cooling towers, reducing motor temperatures. If cooling tower water becomes contaminated with dust and debris, it can form a biofilm layer on tower surfaces, providing an ideal environment for Legionella bacteria, which can spread through the tower fan (Chang et al., 2010). For cooling tower maintenance, the system water should be completely drained, and all components, including sprinklers, mist eliminators, dirt-trapping filters, and equipment, must be disassembled and cleaned of scale and deposits. Cleaning involves an acidic solution prepared with the recommended dose and may include acid baths for thorough scale removal, especially in condenser lines. Following acid treatment, the system is refilled with an inhibitor-infused solution for circulation, and then neutralized and flushed. Fresh water is then introduced with a suitable biocide and corrosion inhibitor (Kayabek et al., 2005). Cooling towers and systems benefit from regular operation. In cases of intermittent use, weekly dosing with water conditioning chemicals and water quality monitoring are advised. If a cooling system is offline for over a month, conditioned water should ideally fill the system to maintain management standards. If this is not feasible, the system should be drained and dehumidified to minimize corrosion. Operating guides for cooling towers should include maintenance procedures and water conditioning programs. When automatic dosing units are active, tools should verify biocide quantities. Regardless of dosing method, the amounts and frequency of chemical applications, monitoring outcomes, control parameters, corrective actions, cleaning, and disinfection procedures should be documented. A detailed maintenance schedule and record-keeping of completed tasks by responsible personnel are also essential (EWGLI, 2005).

The monitoring program should encompass general oversight and include sampling and testing specifically for *Legionella* bacteria. In addition to aerobic bacteria sampling, *Legionella* sampling should be a part of the monitoring routine, conducted at least quarterly. If a routine sample tests positive, further sampling is required to reassess the Risk Management System. Sampling and analysis methods should comply with ISO 11731, and samples should be taken as close as possible to the heat source (EWGLI, 2005). System maintenance disrupts microbial conditions, minimizing biological contamination. Cooling towers should be cleaned and disinfected at least twice annually, though environmental factors, like exposure to polluted air, may necessitate more frequent cleaning. Systems with brief operating cycles may require cleaning only at the start and end of each cycle. Chlorine or other oxidizing biocides are effective for cooling tower disinfection. In addition to routine disinfection, cooling towers should be cleaned and disinfected before reactivation. Cleaning and disinfection should also occur immediately before initial system startup, after a shutdown lasting over a month, when parts of the system or tower are replaced, or if microbiological monitoring indicates an issue (EWGLI, 2005; Kirschner, 2006). For initial cleaning, the system water should be disinfected with an oxidizing biocide, such as chlorine, to minimize health risks to personnel. This can be achieved by adding sodium hypochlorite or chloroisocyanurate derivatives to provide a free chlorine level of 5 mg/L. Sodium hypochlorite solutions typically contain 10-12 % chlorine, and rapid-release tablets contain 50-55% chlorine. These products must be used according to supplier instructions, with a biodispersant added to enhance chlorination efficacy. Water containing 5 mg/L of free chlorine should be circulated for five hours. If the pH exceeds 8.0, chlorine levels should be raised to 15-20 mg/L to ensure effective disinfection. Cleaning should follow the guidelines for all accessible areas of the tower, and reachable surfaces should be thoroughly rinsed with water. High-pressure washing methods that may leave excessive chemical residue should be avoided. If necessary, cleaning should occur while the building is unoccupied. Cleaning personnel should wear protective equipment, including gas masks, and receive appropriate training on equipment usage and maintenance. Residues in the tower and distribution system that cannot be removed by these methods may be dissolved with selected chemicals. Finally, water should be drained from the system until it runs clear (EWGLI, 2006; Kirschner, 2006). For post-cleaning disinfection, the system should be refilled and chlorinated to maintain a free chlorine level of at least 5 mg/L for five hours. Hourly checks should be performed to ensure this level is sustained. A biodispersant will further enhance the effectiveness of this process. If the system capacity exceeds 5 cubic meters, it should be re-chlorinated, drained, rinsed with pressurized water, refilled with fresh water, and treated with appropriate conditioning chemicals. In situations where the five-hour protocol is impractical, alternative chlorination levels can be applied: 50 mg/L for one hour or 25 mg/L for two hours. Personnel executing these steps must be trained to avoid damage to the system. Afterward, the system should again be chlorinated, drained, rinsed with pressurized water, refilled with fresh water, and dosed with suitable conditioning chemicals. High-chlorine wastewater may require re-chlorination to meet local environmental standards before disposal (EWGLI, 2005). The industrial application of filtration in cooling tower construction prevents the entry of thousands of kilograms of airborne solid matter into the cooling water over the year, as millions of cubic meters of air pass through the tower. These solids contribute to scaling, clog condensers, erode the system, and promote *Legionella* growth (Burkut, 1999; Kirschner, 2006).

### 1.4. Chemical Application Methods in Evaporators and Condensers

Evaporative condensers are employed in air conditioning and commercial refrigeration applications, combining the functions of both cooling towers and traditional condensers. These systems present a relatively lower risk of *Legionella* proliferation. In some cases, alternative cooling systems may also be considered. Cooling systems should be designed to control particle drift and allow for safe operation, cleaning, and disinfection (EWGLI, 2006).

### 1.5. Chemical Application Methods in Air Conditioning Systems

The filters of indoor and outdoor units of air conditioners, or fan coil filters in room units of central systems (often located above entrance corridor ceilings), should be cleaned, and condensers should be cleared of oil and dirt. This maintenance should be performed before the operating season for seasonal establishments, and at both the beginning and end of the season for year-round hotels. For split air conditioners or central systems, "*Legionella* Tablets" or "Bromine Tablets" with a lifespan of six months should be placed at the farthest point of the condensation trays to ensure continuous disinfection of water that accumulates there. This placement reduces the risk of Legionnaires' disease that can arise from condensation water and buildup of dirt and grease layers on filters or evaporators. Additionally, the tablets prevent blockage of the drainage pipe and do not produce odors (EWGLI, 2005). It is possible to clean surfaces without damage using aluminum cleaning concentrate. While cleaning and disinfection are typically performed during the winter season, they should also be conducted as needed throughout the operating season. During chemical cleaning and disinfection, protective measures must be taken. After cleaning aluminum surfaces with a degreaser, they should be rinsed with warm water, allowed to dry, and then disinfected with surface disinfectants. This process should also be applied to the outdoor unit. Thorough cleaning of even the smallest components of air conditioning units every three months, along with general maintenance, will reduce energy consumption. The fresh air intake of the air conditioner should not be located near a source of contaminated or low-quality air. The air circulation capacity of air conditioners should be monitored regularly, and disinfection should be performed every six months. Additionally, the damp interior surfaces and filters of the air conditioner should be inspected and cleaned monthly (EWGLI, 2005; Llewellyn et al., 2017).

### 1.6. Protection Methods in Jacuzzis and Spa Pools

Jacuzzis, also known as hot tubs, are typically small pools or baths in which warm water is continuously circulated. The water is generally not changed after each user but is filtered and chemically conditioned. The water temperature is usually above 30°C, and the agitation of the water produces aerosol particles on the surface, which can contribute to the risk of Legionnaires' disease. Proper maintenance, operation, equipment cleaning, and continuous water conditioning are essential for these pools. Draining the water after each use would further reduce the risk (EWGLI, 2005). Thermal spas also pose significant health risks. High water temperatures not only provide favorable conditions for microbial growth but also increase skin sensitivity, creating an environment conducive to infections (Ceylan, 2005; Llewellyn et al., 2017). In spa pools filled with thermal water, at least half of the water should be replaced daily. Thermal pools should be equipped with sand filters, similar to standard pools, and thermal water should be filtered at least daily or as needed. The water turnover time should not exceed 6 minutes, and paper or polyester filters should be avoided. An oxidizing biocide should be automatically dosed into the thermal pool continuously via the filtration system;

manual dosing should only be used in emergencies. The pool water should contain 3-5 mg/L of free chlorine, and pumps and disinfection systems should operate 24 hours a day. Disinfectant concentration and pH should be measured every two hours during use and before operation. Like other pools, thermal pools should undergo monthly chemical and microbiological testing. Colony counts at 37°C should be below 100 CFU/mL, ideally under 10 CFU/mL (EWGLI, 2005; Chang et al., 2010).

### 1.7. Other Risk Protection Methods

The assumption that the source of travel-related Legionnaires' disease must be exclusively hotel-based is unfounded. Since travel involves physical movement across various environments, identifying where and how the bacterium was contracted becomes crucial. Potential sources of exposure that should be considered in risk assessments include spray humidifiers, air humidifiers, water softeners, emergency eyewash and shower sprays, sprinklers and hose systems, spa baths, dental water systems, vehicle wash water, decorative fountains, artificial ponds, aircraft ventilation systems, tour bus ventilation systems, and similar possible sources (EWGLI, 2005; Chang et al., 2010; Buse et al., 2020).

## 2. WATER AND DISINFECTION

The "Regulation on Water Intended for Human Consumption" was enacted within the framework of EU harmonization policies, published in the Official Gazette dated 17/2/2005 and numbered 25730. It establishes the minimum requirements for regulatory and follow-up monitoring of drinking and utility water. According to Article 10 of this regulation, if chlorine is used for disinfection, the residual free chlorine concentration measured at the farthest point in the system must not exceed 0.5 ppm. Article 36 specifies that only methods such as ozonation, ultraviolet treatment, and similar processes may be used for disinfecting drinking water. The regulation also outlines the microbiological and chemical parameters for drinking and utility water. In practice, the requirement that hotels or tourism-related establishments, which source water from the municipal network, should demand water that complies with the "Regulation on Water Intended for Human Consumption" and pay only if this standard is met, proves challenging. Due to supply issues and costs, tourism-oriented businesses (particularly hotels) often seek alternatives, given their high water consumption. One of the most common methods is sourcing "artesian" water. It has been observed that groundwater extracted from wells, despite being technically public property, is frequently used without conditioning or chemical and microbiological analysis and monitoring.

### 2.1. Hot Water Conditioning Systems

The quantity and frequency of biocide use depend on microbial activity, while the success of conditioning relies on the compatibility of all chemicals used, along with monitoring and control procedures (EWGLI, 2005). Key water disinfection systems include thermal shock, chlorination, chlorine dioxide, monochloramine, ionization, hydrogen peroxide-silver, and ultraviolet treatment (EWGLI, 2006).

#### 2.1.1.Thermal shock

For both emergency and routine disinfection, systems are treated at 70-80 °C over relatively short periods. During this process, water circulates in the system for three days, ensuring that the temperature at each tap remains above 65 °C. Each tap and fixture should be operated sequentially at full temperature for at least five minutes. To maximize effectiveness, the water system must be well-insulated. Some experts recommend first draining, cleaning, and disinfecting the hot water tank with chlorine (50 mg/L for one hour), though this may lead to corrosion. At distal points, water temperatures should reach or exceed 65 °C. At the end of the procedure, water and sediment samples from remote areas of the plumbing system should be collected for *Legionella* testing. If results are unsatisfactory, the disinfection procedure should be repeated until successful. This process is energy-intensive, labor-intensive, and impractical for large buildings. Additionally, thermostatic mixing valves downstream will not ensure disinfection, and if not combined with other methods, biological regrowth in the water system may quickly recur. Maintaining a constant temperature between 55-60 °C can also be effective, as keeping water at 60 °C halts *Legionella* growth by 90 % within two minutes. Systems maintained above 50°C show significantly reduced *Legionella* colonization (EWGLI, 2005; Schwake et al., 2021).

#### 2.1.2. Chlorination

Until the 1900s, large-scale epidemics were often caused by waterborne pathogens. However, from the 1900s onward, the chlorination of drinking water led to a decline in waterborne infectious diseases. For example, in the United States, the number of typhoid cases decreased from approximately 25.000 in 1900 to 8.000 by 1920 and below 1.000 by 1945, following the implementation of chlorination across the country. Chlorine was first discovered by the Swedish chemist Scheele in 1774, and by the late 1700s in France, potassium hypochlorite was already being used as a deodorizer and disinfectant. In 1810, Humphry Davy confirmed chlorine as a distinct element, naming it “chloron” after the Greek word for “green.” Chlorine saw its first application as a disinfectant in 1846 at Vienna General Hospital. Initially, it was used in sanitation efforts, such as in sewers. Following a typhoid epidemic in 1897, Sims Woodhead in England began disinfecting drinking water with milk of lime, and after another typhoid outbreak in 1905, Lincoln initiated regular chlorination of drinking water at 1 ppm active chlorine using 10 % sodium hypochlorite. Chlorine’s role in water disinfection is vital due to its bactericidal efficacy, which, however, decreases rapidly above a pH of 7. Chlorination can be applied as shock or continuous treatment (EWGLI, 2005). Its accessibility, affordability, ease of application, effectiveness against *Escherichia coli*, and its ability to eliminate iron- and sulfate-reducing bacteria make chlorine a highly advantageous disinfectant (Akçay et al., 2007; Chang et al., 2010). In Turkey, chlorine was first introduced in 1932 at the Kağıthane treatment plant for Terkos drinking and utility water in Istanbul, using milk of lime. In Ankara, water sourced from the Çubuk Dam was systematically chlorinated with chlorine gas in 1936 at a treatment facility behind the Faculty of Agriculture. Chlorination subsequently spread across Turkey after 1940. In certain countries in Latin America and Africa, where water systems are not chlorinated, cholera and typhoid related fatalities remain common, whereas in countries with effective chlorination, newborn mortality rates significantly decline, and waterborne diseases are virtually eliminated. Thus, chlorine can be regarded as the chemical that has made the most profound contribution to public health in history. Chlorine exerts a bactericidal effect by inhibiting glucose oxidation in bacteria and also by reducing the activity of enzymes with sulfhydryl groups. To eradicate spore-forming bacteria, viruses, protozoa, and primitive organisms in water, higher chlorine doses and longer exposure times are required compared to ordinary bacteria. Free chlorine is significantly more bactericidal than chloramines, and both free and combined chlorine's bactericidal effectiveness increases with temperature; however, a high pH combined with low temperature can diminish this effect. One of chlorine's major advantages is its ability to disinfect recreational water, in addition to drinking water, setting it apart from other disinfection methods. Common health issues linked to such waters include bacterial gastroenteritis, Legionnaires' disease, ear infections, and skin diseases. Today, chlorine is used for sanitation in approximately 90 % of private and public pools worldwide due to its primary and residual disinfecting effects, versatility, and cost-effectiveness. Odors and eye irritation, often attributed to chlorine use in pools, generally arise from high-dose copper-based algaecides used to control algae, rather than chlorine itself (Oğur and Güler, 2008). Pool filtration systems are required to operate at least four times daily (Ceylan, 2008). Each disinfectant has a primary active component and specific contact time. In Turkey, disinfectants are manufactured and marketed under the supervision and approval of the Ministry of Health, which also oversees their production and sale (Schwake et al., 2021).

Chlorine is marketed in liquid gas form or as sodium and calcium hypochlorites, with sodium hypochlorite being the most commonly used form in Turkey. It is a potent oxidizing disinfectant that can cause corrosion, a risk that increases notably with higher doses. For this reason, high doses may be harmful when used in iron plumbing systems. The rate at which microorganisms are eliminated by chlorine depends on factors such as chlorine concentration, whether it is free or combined, the chemical composition of the water, temperature, pH, and contact time. In drinking water disinfection, it is generally applied at doses of 0.4-0.8 mg/L. Chlorine compounds lose their activity over time when stored. At concentrations above 1 mg/L, chlorine may impart an undesirable taste and odor, and at higher doses (3 mg/L), it can cause bleaching of clothing, as well as skin irritation and lesions (Kayabek, 2002; Chang et al., 2010; Schwake et al., 2021). Chlorine dissolves readily in water and can be applied in controlled amounts. When chlorine ions dissolve in water, they react to form hypochlorous acid and hydrochloric acid ($Cl_2 + H_2O \rightarrow HOCl + HCl$). These acids further dissociate into hydrogen and hypochlorite ions ($H^+ + OCl^-$), forming what is known as "free chlorine." The concentrations of hypochlorous acid (HOCl) and hypochlorite ions ($OCl^-$) are determined mainly by pH. If the pH is above 3, chlorine does not exist in molecular form ($Cl_2$); at pH levels between 6 and 8.5, hypochlorous acid fully dissociates. When the pH is exactly 6, chlorine is predominantly in the form of hypochlorous acid, while at a pH above 7.5, hypochlorite ions ($OCl^-$) are dominant, and at a pH above 9.5, chlorine exists almost entirely as hypochlorite ions ($OCl^-$). Water disinfection typically occurs at a pH range of 7.0-8.0 in which HOCl transforms into $OCl^-$, with HOCl exhibiting higher biocidal activity than $OCl^-$. These reactions are continuous and reach equilibrium once the reactions stabilize. Chlorine ions also react with substances in the environment such as phenols and ammonia, resulting in compounds like chlorophenol, monochloramine, dichloramine, nitrogen trichloride, and HCl. Collectively, all compounds except HCl are referred to as combined residual chlorine. The demand for chlorine in water is determined by inorganic and organic molecules, suspended particles, and microorganisms present, referred to as "chlorine demand." When this demand is fully satisfied, the concentration at which any additional chlorine remains as "free chlorine" is termed the "breakpoint." From this point on, any added chlorine exists as free chlorine, and the time that free chlorine remains in the water is known as the "contact time," which indicates the extent of the disinfection achieved (Oğur and Güler, 2008).

When chlorine comes into contact with water, it produces various by-products due to its chemical reactivity. The most notable of these are THMs (Total Trihalomethanes), HAAs (Total Haloacetic Acids), Total Haloacetonitriles, Total Haloketones, Total Aldehydes, Chloropicrin, Chloral Hydrate, and Cyanogen Chloride. Studies have shown that prolonged exposure to low levels of THMs and HAAs in drinking water may significantly increase the risk of colorectal and bladder cancers, with carcinogenic effects documented. Research on populations consuming chlorinated drinking water has indicated statistically significant increases in congenital anomalies, brain cancers, and gastrointestinal cancers. In light of these adverse effects, many developed countries have implemented legal limits on Disinfection By-Products (DBPs) (Akçay et al., 2007). In drinking water disinfection, chlorine is typically added just before filtration. This approach, known as prechlorination or pre-disinfection, serves multiple purposes: it utilizes sand filters as contact basins for disinfection, prevents the formation of biological films in pipes and tanks, addresses potential issues with unpleasant taste and odor in water, oxidizes iron or manganese, and ensures sufficient contact time for disinfection (Oğur and Güler, 2008; Schwake et al., 2021).

#### 2.1.2.1. Shock chlorination

In water below 30 °C and in plumbing systems, chlorination should be done by adding only chlorine to achieve 20-50 mg/L of free residual chlorine. The water should be held for at least 2 hours at 20 mg/L or for at least 1 hour at 50 mg/L, after which it is flushed out. Fresh water is then added until a residual chlorine concentration of 0.5-1 mg/L is achieved (EWGLI, 2005). Chlorine compounds and other halogens have strong oxidizing activity, disrupting essential enzyme functions in microorganisms and ultimately killing them. The *Legionella* bacterium, however, exhibits greater resistance to typical drinking water concentrations of chlorine (~ 0.5 ppm) than other pathogens and can even tolerate higher concentrations (Akbaş, 2007).

#### 2.1.2.2. Continuous chlorination

Continuous chlorination of the system can be achieved using calcium hypochlorite or sodium hypochlorite. The residual chlorine level may vary depending on water quality, flow, and the level of biofilm, but it should be maintained between 1 and 2 mg/L. In stagnant areas within the plumbing system, chlorine alone may not prevent *Legionella* growth. If iron piping is present, biodispersants should be used. In these systems, it can be challenging to maintain the desired chlorine levels in hot water, as chlorine tends to evaporate, and its corrosive effect, which intensifies with temperature, can cause further complications (EWGLI, 2005; EWGLI, 2006).

#### 2.1.2.3. KlorinDioxide

Chlorine dioxide is a disinfectant highly effective in *Legionella* control, particularly in hot water systems. Unlike chlorine, it is not volatile at higher temperatures and has a greater impact on biofilm (EWGLI, 2005). Among its advantages are its high virucidal efficacy, the absence of chlorinated amine and trihalomethane formation, its ability to break down phenols that cause taste and odor issues, minimal production of disinfection by-products, and remarkable effectiveness against *Giardia* and *Cryptosporidium*. Additionally, it quickly oxidizes iron and manganese, removes them from the environment, does not react with bromide, and, under suitable conditions, can reduce water turbidity. However, it also has certain drawbacks: it can produce inorganic by-products through interactions with natural organic matter, requires specialized equipment for preparation, and may occasionally cause unique taste and odor issues not typically associated with other disinfectants (Oğur and Güler, 2008).

#### 2.1.2.4. Monochloramine

Hospitals that use monochloramine-treated water have been shown to experience lower risks of *Legionella* outbreaks. Disinfecting hot water systems with monochloramine may be more effective than chlorine; however, suitable dosing systems for buildings are not yet widely available. Monochloramine acts more slowly compared to chlorine (EWGLI, 2005). In waters containing chloramines, the use of free chlorine as a disinfectant can lead to the formation of NDMA (Nitrosodimethylamine), a disinfection by-product with known carcinogenic effects. NDMA, one of the most potent carcinogens among nitrosamines, can form during the disinfection of drinking and wastewater, posing a cancer risk significantly higher than that associated with trihalomethanes (Akçay et al., 2007). Monochloramine offers several advantages, including residual protection, making it a safe disinfectant option for water distribution systems in developing countries, where system security and potential cross contamination risks are concerns. It also helps control taste and odor issues, produces lower levels of trihalomethanes and haloacetic acids, and reduces biofilm accumulation in distribution systems. However, its disadvantages include a lower oxidizing capacity than free chlorine, the formation of disinfection by-products with unclear health effects, potential eye irritation at high doses, longer required contact times, limited research on its efficacy against viruses and parasites, and possible algae growth in distribution systems due to ammonia formation (Oğur and Güler, 2008).

### 2.1.3. Ionization

Ionization refers to the electrolytic generation of copper and silver ions for use as a water conditioning agent. Metals such as copper and silver are effective against bacteria, disrupting microbial cell walls. Copper and silver ions are produced electrolytically, and concentrations maintained at 400 µg/L for copper and 40 µg/L for silver can effectively control *Legionella* bacteria within biofilms in hot water systems if properly managed. In softened water, silver ion concentrations between 20-30 μg/L may be effective. The ionization process is pH sensitive in both hard and soft water, making it challenging to maintain adequate silver ion concentrations at a pH above 7.6. This method is easy to apply and is unaffected by water temperature. However, without automatic control, concentration fluctuations may occur, necessitating regular monitoring of the two metals concentrations (EWGLI, 2005).

#### 2.1.4. Hydrogen peroxide and silver

Disinfection can be achieved using stabilized solutions of hydrogen peroxide and silver. This technique is relatively new and requires further experimental research to validate its effectiveness (EWGLI, 2005).

#### 2.1.5. UV radiation

Ultraviolet (UV) radiation offers an alternative method for drinking water disinfection, particularly effective when applied close to the point of use. Techniques like thermal shock and chlorination can be employed prior to UV application to enhance effectiveness. UV systems are easy to install, do not affect the taste or potability of water, and cause no harm to piping systems. However, due to its limited impact, UV disinfection is not suitable as the sole or primary method for an entire water system or building (EWGLI, 2005). UV disinfection does not alter the physical or chemical properties of water, does not cause taste or odor issues, and remains unaffected by other chemical substances. It requires minimal contact time and provides localized treatment but is ineffective against biofilms in the system. This method demands significant electrical energy and costly equipment (Kayabek, 2002).

#### 2.1.6. Ozonation

When ozone is used as a disinfection agent, it can increase the amount of biodegradable organic matter in the distribution system, potentially leading to bacterial growth issues. Therefore, to prevent bacterial growth in the distribution system, it is recommended to reduce the simple organic compounds transformed by ozonation in a biofilter and to perform final chlorination. Additionally, ozone production is an expensive process due to its requirement for electrical energy. During power outages in emergencies, the system ceases to function. The proven carcinogenic risk of chlorine during disinfection and the inefficacy of chlorine, chlorine dioxide, and chloramines in removing dangerous pathogens such as *Giardia* and *Cryptosporidium* have led to the increased adoption of ozone as an alternative disinfectant. As a strong oxidant that generates hydroxyl radicals, ozone is far superior to chlorine in inactivating protozoa like *Giardia* and *Cryptosporidium*, which are resistant to other disinfectants. It also excels in oxidizing iron, sulfur, and manganese, facilitating their precipitation and subsequent filtration from water, as well as in providing effective taste and odor control (Akçay et al., 2007).

### 2.2. Cold Water Treatment Systems

In cold water conditioning systems, oxidizing biocides are commonly used. The maximum allowable concentration should be 0.5 mg/L. If the water is intended for drinking purposes, national drinking water regulations must also be followed. The permissible maximum concentration is 0.5 mg/L. Chlorine, monochloramine, and chlorine dioxide are also frequently used (EWGLI, 2005; EWGLI, 2006).

### 2.3. Spa Pool Conditioning Systems

Spa pools need to be carefully maintained. The water should be continuously filtered and conditioned with 1-2 mg/L of chlorine or 2-3 mg/L of bromine. These levels should be measured several times a day (EWGLI, 2005; Llewellyn et al., 2017).

### 2.4. Reducing Risk in Accommodation Establishments

The EWGLI (European Working Group for *Legionella* Infections) states that implementing the following 14 key measures can help reduce the risk of Legionnaires' disease in hospitality establishments (EWGLI, 2005; EWGLI, 2006; Llewellyn et al., 2017; Schwake et al., 2021):

1. Assign a Responsible Person: A designated person with authority and training in *Legionella* management should be appointed to oversee *Legionella* control measures and ensure compliance.
2. Train Staff on *Legionella* Control: Ensure all staff working on *Legionella* prevention are trained to understand the importance of their tasks.
3. Hot Water Temperature: Maintain the return temperature of hot water at a minimum of 50 °C.

4. Cold Water Temperature: Ensure that cold water does not exceed 25 °C.
5. Flush Unoccupied Rooms: In vacant rooms, flush taps for at least 2 minutes daily, especially before guest arrival.
6. Clean Shower Heads and Faucets: Regularly clean and disinfect all shower heads and faucet heads.
7. Cooling Towers and Pipes: Clean and disinfect cooling towers and connected pipework.
8. Clean Split Air Conditioners: Ensure that split air conditioners and their drip trays are cleaned and disinfected.
9. Clean Water Heaters: Clean and disinfect water heaters.
10. Hot Water System Disinfection: Disinfect the hot water system with 50 mg/L of chlorine for 2 to 4 hours.
11. Clean Water Filters: Clean and disinfect water filters at least every three months.
12. Inspect Storage Tanks and Cooling Towers: Visually inspect storage tanks, cooling towers, and connected pipelines monthly for leaks, cleanliness, and potential tampering.
13. Cold Water Tank Disinfection: Annually, or after contamination or repairs, clean and disinfect cold water tanks with 50 mg/L of chlorine before use.
14. Spa Pools and Jacuzzis: If there is a jacuzzi or spa pool maintain disinfection with 2-3 mg/L of chlorine or bromine for 24 hours measure levels three times daily replace at least half of the water daily, backwash once daily and keep daily records of chlorine/bromine levels and cleanliness.
15. Maintain Daily Records: Keep daily records of water disinfection and temperature checks.

## CONCLUSION

In our country, research on Legionnaires' disease and travel-associated legionellosis began considerably after the emergence of the issue on the global stage. Even looking solely at foreign-sourced data over time, it is clear that travel-associated legionellosis could be a significant medical, economic, and social concern for our country. Furthermore, travel-associated legionellosis is not only a concern for foreign tourists visiting Turkey but also for domestic tourism. The lack of focused attention on this issue has led to significant deficiencies in identifying cases. From 1989 to 1996, 100 cases were identified in Europe, suggesting that local cases could theoretically exist, affecting domestic tourists in the same hotels during the same periods. However, travel-associated Legionnaires' disease among local residents was first identified by our laboratory in 1996. This implies that many travel-related Legionnaires' disease cases in Turkey likely go undiagnosed each year or are treated under non-specific diagnoses. The primary goal of our ongoing research is to lead the development of a surveillance system to improve the epidemiology and control of Legionnaires' disease in Turkey. From a tourism perspective, our aim is to motivate businesses to implement necessary precautions and provide scientific support. Increasing studies on this subject would also raise awareness in clinical settings, encouraging physicians to consider Legionnaires' disease as readily as other forms of pneumonia in suspected cases. Ultimately, diagnosing affected tourists before they return home would prevent potential medical and social complications, underscoring the importance of this work.

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# CHAPTER V

## SUSTAINABLE AGRICULTURE AND ECOTOURISM: NEW ECONOMIC MODELS IN ECOVILLAGES

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## INTRODUCTION

Ecovillages are community-driven living spaces that blend sustainable agriculture with ecotourism practices, providing notable environmental and social benefits (Lockyer and Veteto, 2013; Litfin, 2014). In a time when conventional agricultural and tourism practices frequently contribute to environmental damage and social inequities, ecovillages offer an alternative by promoting a lifestyle that aligns with nature and emphasizes responsibility (Bang, 2005). By adopting eco-friendly production methods and fostering innovative tourism activities, these communities strive for economic, ecological, and social sustainability. In doing so, they exemplify comprehensive approaches to sustainability and strengthen community resilience (Dawson, 2006; GEN, 2021).

Ecovillages aim to enhance soil fertility and ensure food security by minimizing chemical usage through sustainable agricultural practices (Bang, 2005; Lockyer and Veteto, 2013). Simultaneously, they promote ecotourism by offering visitors an immersive experience in nature and contributing to economic development in rural areas (Dawson, 2006; Litfin, 2014). In this context, ecovillages can be regarded as laboratories for implementing new economic models, showcasing innovative approaches to harmonizing ecological integrity with community well-being (Kunze and Avelino, 2015; GEN, 2021).

This book chapter aims to examine the integration of sustainable agriculture and ecotourism practices within ecovillages and explore their potential for creating new economic models. The chapter discusses the current practices of ecovillages, the challenges they face, and the opportunities they offer, providing recommendations for sustainable development.

## 1. METHODOLOGY

### 1.1 Data Collection Methods

This study adopted a comprehensive approach to understand sustainable agriculture and ecotourism practices. Academic articles, reports, and books at both national and international levels were reviewed to compile current and reliable information. Additionally, selected examples of ecovillages from Turkey and around the world were analyzed in detail, focusing on their economic models, sustainable farming practices, and ecotourism activities.

The collected data were evaluated using content analysis and categorized under thematic headings. Information from the literature was compared with field data and interpreted within the framework of sustainable development and economic models. The study also qualitatively discussed the economic, environmental, and social impacts of the strategies implemented in these ecovillages. This approach ensured a balanced perspective that combines both academic and practical insights, forming a robust dataset that underpins the study's recommendations.

## 2. SUSTAINABLE AGRICULTURE PRACTICES IN ECOVILLAGES

In ecovillages, sustainable agriculture is at the core of their mission to live harmoniously with nature. These practices are designed not only to be environmentally friendly but also to meet the social and economic needs of the community (Pretty et al., 2011; Altieri and Nicholls, 2017). By combining innovative techniques such as permaculture, agroecology, and organic farming with traditional agricultural knowledge, ecovillages establish food systems that are both resilient and self-sufficient. These systems focus on reducing the use of chemicals, encouraging biodiversity, and ensuring the sustainable management of natural resources (Gliessman, 2007; Litfin, 2014).

A defining feature of these practices is their strong emphasis on soil health and water conservation. Techniques such as crop rotation, composting, mulching, and the use of drought-resistant crops help to enhance soil fertility and improve water efficiency, contributing to the sustainability of agricultural systems in a variety of ecological contexts (UNEP, 2012; Kiper, 2013). Additionally, ecovillages frequently integrate renewable energy sources like solar and wind power into their agricultural activities, which not only reduces their environmental impact but also ensures long-term sustainability (Dawson, 2006; Honey, 2008).

The sustainable agriculture methods adopted by ecovillages not only ensure food security by growing crops that are both nutritious and well-suited to local conditions but also play a crucial role in maintaining the health of ecosystems by safeguarding biodiversity and improving ecological balance (Gliessman, 2007; Altieri and Nicholls, 2017;). These approaches are essential for proving that agriculture can be productive and, at the same time, restorative, offering an example for tackling global food security challenges while protecting nature. By putting these methods into practice, ecovillages help address broader sustainable development goals, such as combating climate change and encouraging rural development (Pretty et al., 2011; Litfin, 2014).

## 2.1. Key Practices

### 2.1.1. Permaculture Design

Permaculture is a widely practiced agricultural approach in ecovillages, emphasizing the design and management of agricultural systems to emulate natural ecosystems (Mollison and Holmgren, 1978; Ferguson and Lovell, 2014). Originating from the idea of creating permanent, sustainable agricultural systems, permaculture integrates ecological principles to develop self-sufficient and regenerative landscapes (Holmgren, 2002).

In ecovillages, ideas like water collection, energy saving, crop mixing, and soil care are seen as essential, though sometimes a bit challenging to implement consistently (Dawson, 2006; Macnamara, 2012). For instance, techniques such as swales and rain gardens are often used to capture and store water efficiently. This is especially useful-some might even say critical-in areas where water is scarce, like dry regions (Ferguson and Lovell, 2014). When it comes to energy, strategies like adding solar panels or windmills, or just designing buildings to use sunlight smartly, help cut down on fossil fuel use and shrink the overall footprint (Litfin, 2014). At the same time, planting methods such as companion planting or polyculture support biodiversity and control pests in a natural way, while also making crops a bit tougher against unpredictable weather (Macnamara, 2012). Finally, soil management practices like composting, mulching, and no-till farming ensure long-term fertility without the need for synthetic chemicals (Mollison and Holmgren, 1978). Although these methods are not perfect and sometimes need adjustments depending on local conditions, they seem to work quite well in many situations.

By sticking to these principles, ecovillages make agricultural practices more sustainable while also helping to keep natural cycles running smoothly and maintaining ecological balance. This kind of mixed approach gives useful ideas for dealing with big global problems like climate change, soil erosion, and water shortages. It shows how agriculture can fit together with taking care of the environment, finding a way to balance being productive with protecting the planet (Holmgren, 2002; Ferguson and Lovell, 2014).

### 2.1.2 Agroecology and Polyculture Systems

Ecovillages adopt agroecological methods and polyculture systems instead of traditional monoculture practices, aligning with principles that enhance both sustainability and biodiversity (Altieri and Nicholls, 2003; Reddy, 2017). Cultivating diverse plant species together provides natural pest resistance by disrupting pest populations and making it more challenging for them to target specific crops (Wezel et al., 2015). This approach reduces reliance on chemical pesticides, thereby minimizing environmental and health risks (Altieri and Nicholls, 2003). Additionally, diverse cropping systems improve soil fertility through complementary root structures and nutrient demands, which facilitate a more efficient nutrient cycling process (Yadav et al., 2021). The integration of agroecological practices within these systems promotes ecosystem services, such as soil health improvement and erosion prevention, while simultaneously supporting local biodiversity (Wezel et al., 2015; Erktan et al., 2024). By adopting such eco-friendly practices, ecovillages exemplify sustainable agricultural production models that prioritize environmental stewardship and long-term productivity.

### 2.1.3. Community-Supported Agriculture (CSA)

In ecovillages, sustainable agriculture is implemented in direct collaboration with local communities, fostering a participatory approach to food production (Erisman et al., 2016; Brown et al., 2018). Community-Supported Agriculture (CSA) systems play a significant role in this process by actively engaging consumers in food production, creating a direct connection between producers and consumers (Hinrichs, 2000). These systems not only shorten the distance between producers and consumers but also promote transparency and trust in local food networks (Schnell, 2013).

Moreover, CSA systems enhance the economic sustainability of producers by providing them with financial stability through pre-season investments from consumers, reducing the risks associated with market fluctuations (Galt et al., 2019). By strengthening local food supply chains, these practices contribute to the resilience of local economies and encourage sustainable agricultural practices that are less reliant on external inputs (Erisman et al., 2016; Brown et al., 2018). This integrated approach aligns with the principles of sustainability and self-reliance that define ecovillages as innovative models for community-based food systems.

### 2.1.4. Organic Farming Practices

Organic farming, which minimizes the use of chemical fertilizers and pesticides, is a prevalent production method in ecovillages, aligning with their focus on sustainability and ecological integrity (Altieri, 1995; Reganold and Wachter, 2016). By prioritizing organic fertilizers, such as compost and manure, and adopting natural pest control methods like crop rotation, companion planting, and biological controls, ecovillages protect soil health and enhance biodiversity (Pimentel et al., 2005; Pretty et al., 2005). Biological control practices, such as the use of beneficial insects or microorganisms, further contribute to maintaining natural ecosystem balance while reducing the need for synthetic inputs (Van Lenteren, 2012).

These methods not only improve the quality and nutritional value of agricultural products but also significantly reduce ecological footprints by minimizing energy-intensive chemical production and greenhouse gas emissions (Smith et al., 2019). Organic farming in ecovillages exemplifies an integrated approach to agriculture that prioritizes environmental preservation and sustainable resource management, providing a viable alternative to conventional farming systems with high ecological impacts (Pretty et al., 2005; Reganold and Wachter, 2016).

### 2.1.5. Water Management and Rainwater Harvesting

Agriculture in ecovillages is closely linked to the sustainable management of water resources, reflecting a commitment to conserving this critical natural asset (Falkenmark and Rockström, 2004; Pretty et al., 2006). Innovative techniques such as rainwater harvesting, which captures and stores rainwater for agricultural use, play a pivotal role in ensuring water availability in regions facing scarcity (Malesu et al., 2006). Drip irrigation systems, which deliver water directly to plant roots with minimal waste, further enhance water use efficiency and reduce evaporation losses (Postel et al., 2001).

In addition, greywater recycling, which involves treating and reusing household waste water for irrigation, supports sustainable water management by reducing reliance on freshwater resources and lowering overall water consumption (Misra et al., 2010). These practices not only conserve water but also contribute to agricultural productivity by maintaining consistent moisture levels for crops, even in arid conditions (Rockström et al., 2010). By integrating these methods, ecovillages exemplify a holistic approach to water resource management that aligns with principles of sustainability and resilience in agriculture (Falkenmark and Rockström, 2004; Pretty et al., 2006).

### 2.1.6. Composting and Soil Fertility Management

Composting organic waste enhances the natural fertility of soil in ecovillages by recycling nutrients back into the ecosystem, a process that exemplifies the principles of the circular economy (Hargreaves et al., 2008; Kirchherr et al., 2017). By transforming organic waste into nutrient-rich compost, this practice reduces reliance on chemical fertilizers, thereby lowering environmental risks associated with their production and use, such as water contamination and greenhouse gas emissions (Edwards and Arancon, 2004; Pimentel et al., 2005).

Moreover, composting contributes to the accumulation of organic matter in the soil, which improves soil structure, enhances its water retention capacity, and supports the activity of beneficial microorganisms (Lal, 2004; Zaller, 2007). These benefits make composting a cornerstone of sustainable agricultural practices, promoting long-term soil health and productivity. The adoption of composting in ecovillages not only reduces waste but also aligns with sustainability goals by closing nutrient loops and minimizing ecological footprints (Hargreaves et al., 2008; Kirchherr et al., 2017).

### 2.1.7. Use of Local and Heirloom Seeds

The use of local and heirloom seeds in ecovillages is crucial for preserving biodiversity and ensuring production that is adapted to the region's specific climate and soil conditions (Altieri, 1999; FAO, 2010). These seeds, often passed down through generations, are rich in genetic diversity, making them more resilient to pests, diseases, and environmental stresses compared to the standardized varieties commonly used in industrial agriculture (van de Wouw et al., 2009; Ceccarelli et al., 2010). It's not just about plants; it's about preserving a kind of farming culture that holds so much wisdom from the past. The loss of this knowledge would be like erasing part of our identity.

Heirloom seeds also play a strategic role in sustainable production by maintaining the ecological balance of local agricultural systems and reducing dependency on commercial seed companies and synthetic inputs (Shiva, 2012; Lammerts van Bueren et al., 2002). Their adaptation to specific soil and climate conditions enhances productivity while promoting a self-reliant and ecologically integrated approach to farming (Altieri, 1999; Ceccarelli et al., 2010). The idea of farming in harmony with the environment, without needing to depend on some faceless corporation's 'magic beans,' is incredibly empowering. The preservation and use of these seeds in ecovillages contribute not only to sustainability but also to the cultural heritage and food sovereignty of communities, ensuring the long-term viability of local agriculture (FAO, 2010; Shiva, 2012).

## 2.2. Social and Economic Impacts

Sustainable agricultural practices in ecovillages offer more than just environmental benefits-they serve as a lifeline for local communities, strengthening their economic resilience in an ever-changing world (Altieri and Nicholls, 2000; Gliessman, 2007). These practices do more than sustain the land; they nourish local economies by creating jobs, supporting small-scale farms, and reducing dependency on the industrial agricultural systems that often erode local autonomy (FAO, 2017; Shiva, 2012). Rooted in the principles of agroecology, these practices ensure the wise use of resources and promise long-term productivity, all while preserving the fragile balance of nature (Pretty et al., 2011; Lamine, 2015).

Yet, the impact of these practices goes beyond economics and the environment. In ecovillages, agriculture is a social bond—one that weaves together community members in a shared vision of sustainability and mutual care (Hinrichs, 2000; Macias, 2008). It is through this collective effort that a deep sense of solidarity emerges, where everyone carries the responsibility for nurturing the earth. This isn't just farming-it's a way of life, a shared commitment to a future where the land and the people thrive together (Shiva, 2012; Lamine, 2015).

Sustainable agriculture in ecovillages is not just about feeding the community; it is about connecting deeply to the land, to each other, and to the values that make us human (Altieri and Nicholls, 2000; Gliessman, 2007). By intertwining agriculture with natural ecosystems, these communities offer a powerful example of how environmental and social sustainability can coexist-standing as a beacon of hope and a model for addressing the challenges of global agriculture and food systems (Pretty et al., 2011; FAO, 2017).

# 3. ECOTOURISM AND NEW ECONOMIC MODELS IN ECOVILLAGES

Ecovillages have really become shining examples of economic sustainability, merging sustainable agriculture with ecotourism in a way that feels more holistic and connected to the land (Dawson, 2006; Litfin, 2014). They offer a lifestyle that's deeply intertwined with nature, aiming to minimize the harmful effects of traditional tourism, while trying to create economic models that, somehow, don't stray too far from ecological values (Honey, 2008; UNEP, 2012). These models aren't just about tourism; they're about trying to live in a way that respects resources, protects biodiversity, and reduces carbon footprints. It's a small but significant step toward reimagining what tourism could be, and should be (Goodwin, 2011; Buckley, 2012).

However, it is not only about the environment. The ecotourism activities in these villages are also a way of giving back to local communities-creating jobs and offering income, which can make a real difference in tackling rural poverty and fostering a sense of fairness (UNEP, 2012; Kiper, 2013). Ecovillages also have this powerful role in education-helping people understand the importance of sustainable practices, and encouraging visitors to carry those lessons with them, into their own lives, which is crucial for the long-term impact (Dawson, 2006; Honey, 2008). There's something so deeply valuable in how this balance of tourism and nature is showing us that alternative economic models don't just protect the environment-they can also improve the quality of life for people in these communities, offering a path to a more just and sustainable future (Goodwin, 2011; Litfin, 2014).

## 3.1. Key Aspects

### 3.1.1. The Role of Ecotourism in Ecovillages

Ecotourism in ecovillages plays a vital role in promoting economic sustainability while safeguarding the unique cultural and environmental values of these communities (Honey, 2008; UNEP, 2012). Visitors who have the chance to engage with sustainable farming practices and immerse themselves in nature not only learn about ecological principles but also gain a deeper respect for local traditions (Dawson, 2006; Kiper, 2013). These experiences help to strengthen the community's cultural identity, underlining the importance of preserving what makes them special (Weaver, 2001; Goodwin, 2011).

One of the most rewarding aspects of ecotourism in these villages is its ability to help market local products, such as organic produce and handmade crafts, which in turn boosts the local economy (Honey, 2008; Buckley, 2012). By generating income from within, these activities help reduce reliance on outside markets, giving ecovillages greater economic resilience and creating sustainable livelihoods for the people who live there (UNEP, 2012; Kiper, 2013). In addition, ecotourism supports the diversification of rural economies, allowing local communities to blend their economic activities with efforts to protect the environment and preserve their cultural heritage (Goodwin, 2011; Dawson, 2006).

### 3.1.2. Nature-Based Tourism Activities

Tourism activities in ecovillages are fundamentally centered around nature-based experiences, offering visitors opportunities to engage in activities such as nature walks, volunteering on organic farms, participating in permaculture workshops, and exploring traditional crafts (Weaver, 2001;Honey, 2008). These activities are carefully designed not only to deepen participants' connection with nature but also to teach sustainable living practices in ways that are both practical and meaningful (Dawson, 2006; Kiper, 2013). By involving visitors in hands-on experiences-whether through farming or learning traditional skills-ecovillages create immersive opportunities that highlight the significance of preserving both ecological balance and cultural heritage (Goodwin, 2011; Litfin, 2014).

Furthermore, these activities foster local community participation in the development and management of tourism ventures, allowing residents to take an active role in shaping their own economic future. This sense of ownership and responsibility is crucial, not just for the success of tourism but for the long-term sustainability of the community (UNEP, 2012; Kiper, 2013). The approach strengthens community bonds while also generating an additional source of income for residents, which enhances their economic resilience (Weaver, 2001; Honey, 2008). The distinct, interactive experiences offered by ecovillages thus serve as a meaningful example of sustainable tourism, emphasizing environmental stewardship and the preservation of cultural values (Dawson, 2006; Litfin, 2014).

### 3.1.3. Cultural and Educational Tourism

Ecovillages also stand out for their cultural and educational tourism activities, offering visitors opportunities to explore local culture, learn traditional cooking methods, and gain insights into sustainable living practices (Honey, 2008; Kiper, 2013). These activities allow visitors to engage with the unique heritage of the region, fostering a deeper appreciation for cultural diversity and traditional knowledge (Weaver, 2001; Dawson, 2006). By integrating hands-on experiences with cultural education, ecovillages bridge the gap between tourism and sustainable development, emphasizing the importance of preserving intangible cultural assets (Goodwin, 2011; UNEP, 2012).

These practices underline ecotourism's vital role in promoting social and cultural sustainability within ecovillages. By connecting visitors with the traditions and lifestyles of local communities, ecovillages help sustain cultural practices that might otherwise be lost in the face of globalization (Shiva, 2012; Litfin, 2014). Additionally, the participatory nature of these activities strengthens community involvement in tourism, empowering residents to become custodians of their cultural heritage while benefiting economically and socially (Honey, 2008; Kiper, 2013).

### 3.1.4. Circular Economy and Local Production

Ecotourism activities in ecovillages are deeply integrated with local production systems that follow circular economy principles, offering a sustainable model for both tourism and community development (UNEP, 2012; Kirchherr et al., 2017). Foods, beverages, and souvenirs provided to tourists are primarily sourced from organic, locally produced goods within the ecovillages, which aligns with the broader goals of reducing environmental impact and promoting resource efficiency (Hargreaves et al., 2008; Honey, 2008). Through local production, ecovillages establish closed-loop systems that aim to minimize waste-employing practices like composting, upcycling, and the reuse of materials-while maintaining ecological balance (Dawson, 2006; Pretty et al., 2006).

This model also helps revitalize local economies by creating income opportunities for residents and promoting the unique cultural and artisanal products specific to the region (Goodwin, 2011; Kiper, 2013). By focusing on locally sourced goods, reliance on external supply chains is reduced, enhancing economic resilience and fostering a sense of self-sufficiency (Shiva, 2012; UNEP, 2012). In combining ecotourism with sustainable production practices, ecovillages provide a clear example of how tourism can align with both environmental conservation and economic sustainability, creating a replicable model that could inspire other communities (Honey, 2008; Kirchherr et al., 2017).

### 3.1.5. Sustainable Accommodations and Ecological Structures

Ecotourism in ecovillages is often supported by sustainable accommodation options that align with principles of ecological design and energy efficiency (Goodwin, 2011; UNEP, 2012). Lodging spaces are typically constructed using natural and locally sourced materials, such as wood, adobe, or bamboo, minimizing the carbon footprint associated with construction while harmonizing with the surrounding environment (Honey, 2008; Kibert, 2016). These accommodations are further enhanced with energy-efficient systems and renewable energy technologies, such as solar panels and biomass heating, providing visitors with eco-friendly and comfortable lodging experiences (Dawson, 2006; Buckley, 2012).

This approach not only reduces the environmental impact of tourism activities in ecovillages but also serves as an educational tool, encouraging visitors to adopt sustainable practices in their own lives (Weaver, 2001; Kiper, 2013). By experiencing sustainability firsthand, visitors gain a deeper appreciation for the integration of renewable energy and green building methods, reinforcing the ecological values promoted by ecovillages (Honey, 2008; UNEP, 2012). Sustainable accommodations thus play a crucial role in ecotourism by demonstrating the viability of low-impact living and promoting long-term environmental stewardship (Goodwin, 2011; Kibert, 2016).

### 3.1.6. Economic Participation of Local Communities

Ecotourism activities in ecovillages actively encourage economic participation from local communities, creating inclusive opportunities that contribute to rural development and sustainability (Honey, 2008; Kiper, 2013). Activities such as volunteering on farms, producing crafts, providing guide services, and preparing local foods enable community members to directly benefit from tourism while showcasing their unique cultural and agricultural heritage (Goodwin, 2011; UNEP, 2012). This active involvement ensures that the economic benefits of ecotourism are distributed within the local population, reducing economic inequalities and fostering community empowerment (Weaver, 2001; Kiper, 2013).

By integrating local participation into tourism activities, ecovillages enhance the resilience of rural economies and provide sustainable livelihoods for residents (Dawson, 2006; Buckley, 2012). This approach aligns with the principles of sustainable development, emphasizing the importance of community-based tourism models that prioritize social equity and environmental conservation (Honey, 2008; UNEP, 2012). Through such initiatives, ecotourism in ecovillages not only supports economic growth but also strengthens the social fabric and promotes a shared responsibility for sustainability (Dawson, 2006; Goodwin, 2011).

### 3.1.7. Environmental and Social Impacts of Ecotourism

Ecotourism in ecovillages not only provides significant economic benefits but also serves as a powerful tool for raising environmental awareness among visitors (Honey, 2008; UNEP, 2012). By observing eco-friendly agricultural practices, such as organic farming and permaculture, as well as energy-saving methods and innovative waste management systems, tourists gain firsthand knowledge of sustainable living techniques (Dawson, 2006; Kiper, 2013). These immersive experiences inspire visitors to adopt similar practices in their own lives, promoting a broader cultural shift toward sustainability (Weaver, 2001; Goodwin, 2011).

In addition to environmental education, ecotourism fosters meaningful interactions between tourists and local residents, creating opportunities for cultural exchange and mutual learning (Kiper, 2013; Litfin, 2014). These interactions enhance cultural understanding, strengthen social ties, and encourage a sense of global citizenship, making ecotourism in ecovillages a socially enriching experience (Honey, 2008; UNEP, 2012). Through this dual focus on environmental education and community engagement, ecotourism in ecovillages serves as a comprehensive model for sustainable tourism that integrates ecological, economic, and social dimensions (Dawson, 2006; Goodwin, 2011).

### 3.1.8. Challenges of Ecotourism in Ecovillages

Expanding ecotourism activities in ecovillages presents several challenges, some of which can feel overwhelming, such as infrastructure gaps, marketing difficulties, and tourism demands that often fail to prioritize sustainability (Honey, 2008; Kiper, 2013). Infrastructure, often lacking in key areas such as transportation and adequate lodging, frequently limits ecovillages' ability to both attract and accommodate visitors in a sustainable manner (Goodwin, 2011; UNEP, 2012). Marketing these spaces to eco-conscious travelers is another struggle; the lack of visibility in highly competitive tourism markets leaves many ecovillages hidden from those who would benefit the most from their offerings (Weaver, 2001; Buckley, 2012). Moreover, the very heart of ecotourism-the sustainability-can be threatened by the growing demand for amenities that just don't fit the ecological principles these communities strive to uphold (Dawson, 2006; Honey, 2008).

However, despite these challenges, there's hope. Support from local governments and non-governmental organizations (NGOs) can make a significant difference (UNEP, 2012; Kiper, 2013). Investments in sustainable infrastructure-eco-friendly transportation, renewable energy-could allow ecovillages to host visitors without straying from their core values (Goodwin, 2011; Litfin, 2014). NGOs and government-led initiatives also have a role in helping ecovillages stand out in the marketplace through well-crafted marketing campaigns and by providing both financial and technical support (Honey, 2008; Buckley, 2012). With such partnerships and investments, ecovillages can tackle their obstacles head-on and continue to lead the way in promoting sustainable tourism practices.

### 3.1.9. Building New Economic Models

The integration of ecotourism and sustainable agriculture in ecovillages creates innovative approaches that go beyond traditional economic models, emphasizing environmental and social sustainability over mere profit orientation (Dawson, 2006; Litfin, 2014). These models are built upon sharing economies, local collaborations, and community-supported initiatives, fostering economic systems that prioritize collective well-being and ecological balance (Kiper, 2013; Kirchherr et al., 2017). By shifting the focus from profit-driven practices to holistic sustainability, ecovillages demonstrate the viability of alternative economic frameworks that support both community resilience and environmental conservation (Honey, 2008; UNEP, 2012).

The holistic integration of ecotourism and sustainable agriculture in ecovillages enhances local welfare by creating employment opportunities, supporting local production, and strengthening social bonds within communities (Goodwin, 2011; Pretty et al., 2011). Simultaneously, this model minimizes the environmental impacts of tourism by adopting eco-friendly practices such as organic farming, renewable energy use, and waste reduction strategies (Buckley, 2012; Kiper, 2013). These integrated approaches lay the groundwork for future economic sustainability in ecovillages, serving as a model for achieving broader sustainable development goals while addressing global challenges such as climate change and social inequality (Dawson, 2006; Litfin, 2014).

## 4. SUCCESS STORIES: EXEMPLARY ECOVILLAGES

Ecovillages are, in many ways, revolutionary communities that bring together sustainable living, agriculture, and ecotourism to address urgent environmental and social challenges (Litfin, 2014; Dawson, 2006). They represent a beacon of hope, showing that it is possible to harmonize ecological principles with economic and social needs. They offer alternatives to conventional systems, which too often prioritize profit at the cost of the environment and social equality (Honey, 2008; UNEP, 2012). Around the world, and particularly in Turkey, these villages have managed to succeed by adapting to the unique ecological and cultural landscapes they occupy (Goodwin, 2011; Kiper, 2013).

In this section, we look at the success stories of ecovillages, focusing on how they’ve developed innovative economic models that integrate sustainable agriculture and ecotourism. These models are rooted in local production, resource efficiency, and community-led initiatives-pillars that not only strengthen economic resilience but also promote a deep sense of environmental responsibility (Pretty et al., 2011; Kirchherr et al., 2017). By merging eco-friendly practices with governance that encourages participation, ecovillages provide a glimpse into how sustainability can be achieved in a variety of contexts, offering valuable lessons that contribute to the global goal of sustainable development (Dawson, 2006; Litfin, 2014).

### 4.1. Global Ecovillage Network (GEN): Success Stories

The Ecovillage Network serves as a global platform connecting ecovillages worldwide to foster knowledge sharing and sustainable development. Through global collaboration, it facilitates joint projects and knowledge exchange, organizes educational events such as seminars and workshops to raise awareness about sustainable living, and promotes economic solidarity by marketing local products globally. Prominent examples of successful ecovillages include Findhorn Ecovillage in Scotland, known for its innovative agricultural techniques combining organic and biodynamic farming methods, as well as its ecotourism and educational programs that offer sustainable living workshops. Its community-supported economy thrives on local food production and eco-friendly product marketing. Similarly, Auroville in India exemplifies sustainable living by integrating agroforestry, polyculture systems, and renewable energy technologies like solar and wind power. Auroville also emphasizes ecotourism and cultural exchange, with tourism revenues supporting the community's sustainability efforts.

In Portugal, Tamera Ecovillage, founded in 1995, operates as a peace research village aiming for sustainable and self-sufficient community models. It integrates ecological, social, and spiritual dimensions to promote nonviolent cooperation between humans and nature. The village is noted for holistic research, sustainable architecture such as straw bale buildings, and educational initiatives that attract international participants. Lastly, Colombia's Gaviotas Ecovillage, established in 1971, specializes in sustainable technologies tailored to tropical environments. It has developed low-cost technologies like windmills and water pumps, reforested over 10,000 hectares with Caribbean pine trees, and revitalized local ecosystems. Additionally, Gaviotas provides essential community services, including education and healthcare, significantly enhancing residents' quality of life.

Turning to Turkey, several ecovillages showcase impressive examples of how sustainable living can be achieved in harmony with local contexts and values. TATUTA (Turkish Alternative Energy and Rural Development Foundation), established to promote sustainable rural development, supports the creation of ecovillages across Turkey. The foundation aims to empower rural communities, primarily by integrating renewable energy systems, organic farming, and sustainable tourism practices. It also facilitates the development of community-based projects focused on ecological preservation and social well-being.

Other prominent Turkish ecovillages include Narköy Ecovillage, located near Izmir, which is committed to biodiversity conservation through heirloom seeds and sustainable farming practices. Narköy serves as a popular destination for those interested in organic farming methods, offering workshops and farm tours, and markets organic produce regionally. Belentepe Permaculture Farm in Bursa focuses on creating eco-friendly, self-sufficient systems that integrate agriculture with sustainable living. Kapor Farm in Nevşehir is dedicated to permaculture and organic farming, providing an opportunity for visitors to learn about eco-agriculture in central Turkey. Pastoral Vadi in Fethiye operates as an agricultural farm and ecotourism destination, offering organic food and a tranquil environment for visitors to explore sustainable living. Gağgı Farm in Izmir emphasizes a balanced life with nature through organic farming and community-based projects. İmece Evi in Izmir Menemen aims to create a harmonious community that combines sustainable farming and natural living.

What ties these ecovillages together is not only their success but the hope they offer for a better future. The very idea that alternative lifestyles grounded in sustainability can bring real change is something that many are beginning to embrace. These communities are living proof that it is possible to reimagine food production, energy solutions, and the way people interact with the world around them.

## 4.2. Common Success Factors

The success of ecovillages can be attributed to several key factors that make them effective models for sustainable development. These include practices that minimize environmental impacts by maintaining harmony with nature, ensuring that agricultural and lifestyle choices align with ecological principles. Active community participation, where local populations are directly involved and collaborate in decision-making, strengthens the social fabric and enhances resilience. Revenues generated from ecotourism and educational activities play a crucial role in supporting the economic sustainability of these communities, while also raising awareness about sustainable living practices among visitors. Furthermore, the adoption of innovative approaches, including new agricultural techniques and alternative economic models, fosters adaptability and long-term viability. Collectively, these success stories highlight the significant role ecovillages play both locally and globally in advancing sustainable development goals (Litfin, 2014).

## 5. CHALLENGES AND SOLUTIONS IN ECOVILLAGES

While ecovillages offer numerous benefits in terms of sustainable living, agriculture, and ecotourism, they also face various challenges. These include infrastructure deficiencies, financial barriers, regulatory obstacles, and social resistance. This section explores the main challenges ecovillages encounter and proposes solutions.

### 5.1. Infrastructure and Technology Deficiencies

One of the major challenges facing ecovillages is the lack of adequate infrastructure for eco-friendly energy, water management, and transportation. The absence of advanced infrastructure can really hold back the effective implementation of sustainable agriculture and ecotourism practices, limiting the potential of these communities to achieve their sustainability goals (UNEP, 2012). Without reliable renewable energy systems, efficient water management solutions, and sustainable transportation networks, ecovillages may really struggle to balance ecological conservation with the demands of modern living and tourism (Dawson, 2006; Buckley, 2012). It's frustrating to see how these limitations keep communities from reaching their full potential.

To overcome these obstacles, several solutions have been suggested. Government incentives and grants could provide much-needed financial support for developing infrastructure projects in ecovillages, encouraging the adoption of sustainable technologies (UNEP, 2012). The introduction of innovative and cost-effective technologies, such as affordable solar panels, greywater recycling systems, and eco-friendly public transportation, could drastically reduce implementation costs and make things more accessible (Kirchherr et al., 2017). Additionally, fostering local and international funding opportunities, along with partnerships with NGOs and private sector stakeholders, can provide the resources and expertise needed to establish sustainable infrastructure in ecovillages.

### 5.2. Financial Constraints

Establishing and operating ecovillages sustainably is often a costly endeavor, presenting a significant obstacle, especially for smaller projects. The expenses tied to setting up renewable energy systems, managing water resources, and adopting sustainable agricultural practices can be overwhelming for many communities (Kirchherr et al., 2017). This financial pressure restricts the growth of ecovillages and their potential as models for sustainable living. However, several solutions have been suggested to overcome these financial hurdles. One approach is to establish community-driven funding options, like crowdfunding, which can rally support from a broad base of people who share the vision for a more sustainable future (Goodwin, 2011). Another possibility is securing low-interest loans through collaborations with banks or private sector partnerships, which can relieve some of the financial strain and allow ecovillages to invest in the necessary infrastructure.

In addition, creating revenue streams by marketing locally produced goods, such as organic products or handmade crafts, can help ensure the financial stability of ecovillages in the long term (Litfin, 2014). These solutions, while practical, offer hope for overcoming financial barriers and empowering ecovillages to thrive, fostering sustainability in the communities that need it most.

### 5.3. Regulatory Barriers and Bureaucratic Challenges

Ecovillage projects often face delays due to complicated regulations and bureaucratic challenges, especially regarding land use and permits. These barriers can increase costs and make it harder for ecovillages to establish themselves as models of sustainability (Dawson, 2006; UNEP, 2012). Traditional legal frameworks, built with urban or rural development in mind, don’t always align with the unique needs of ecovillages, making the process even more frustrating. To overcome this, creating specific legal structures that recognize the distinct nature of ecovillages and simplify the bureaucratic process could be a key step in making the process smoother (Goodwin, 2011). Working closely with local governments to make zoning and permits easier to navigate would also help build a regulatory environment that supports ecovillages (Kiper, 2013). A broader legal recognition of ecovillages and their contributions to sustainability could further encourage support, making it clear how essential they are to reaching long-term global goals (Litfin, 2014). These changes could reduce the administrative burden and allow ecovillages to develop more freely, paving the way for them to become powerful examples of what’s possible when we rethink how we live with nature.

### 5.4. Social Resistance and Lack of Awareness

Ecovillage projects often face resistance, especially in rural areas, where people's deep attachment to traditional practices can make them wary of new lifestyles. It is understandable change can feel daunting, and it is not always easy to let go of the familiar, even when new ways of living offer hope for a more sustainable future. Local communities may hesitate to accept ideas that seem to challenge what has always been done or threaten to disrupt cultural norms, making it difficult for ecovillage initiatives to take root (Dawson, 2006; Kiper, 2013). This kind of resistance can create roadblocks, hindering collaboration and limiting the potential of these projects to meet their sustainability goals.

Demonstrating how ecovillages can boost the local economy—creating jobs, fostering community resilience, and enhancing the overall quality of life-underscores their value (Goodwin, 2011; Pretty et al., 2011). Sharing success stories from pilot projects serves as compelling proof that ecovillages do not need to disrupt local traditions but can instead integrate with them, offering sustainable solutions that respect the community's way of life (Litfin, 2014; Dawson, 2006). These examples are more than just proof of concept; they have the power to ease doubts, build trust, and inspire communities to see ecovillage principles as a hopeful and achievable path toward a sustainable future.

### 5.5. Educational and Expertise Gaps

Managing ecovillages sustainably takes a lot of technical know-how, especially in areas like community management, sustainable farming, and renewable energy. Unfortunately, these specialized skills are not always easy to find, which can be a big challenge for ecovillages trying to operate successfully (Dawson, 2006; UNEP, 2012). Without the right expertise, it becomes harder to put innovative ideas into practice and deal with the complexities of community life.

Building the capacity of ecovillage residents is essential for ensuring long-term sustainability and resilience. To overcome these challenges, it is important to establish training programs that emphasize sustainable agriculture, energy management, and community leadership. These programs would help ecovillage residents gain the practical skills they need to keep things running smoothly (Honey, 2008; Kiper, 2013). Collaborating with universities and research institutions could bring in fresh knowledge and expert guidance, making sure the latest research is translated into actionable solutions (Pretty et al., 2011; Litfin, 2014). Volunteer programs and internships within ecovillages are also a great way to attract people with diverse skills, spark innovation, and give a helping hand in daily tasks (Goodwin, 2011; UNEP, 2012).

These approaches not only build the skills and expertise necessary for long-term sustainability but also remind us that when communities come together with a common purpose, they can overcome any obstacle, no matter how tough it might seem. It's empowering to think that with the right support, ecovillages can truly thrive and lead the way in sustainable living.

### 5.6. Community Management and Conflict Resolution

Ecovillages, being made up of communities, often struggle with decision-making because members might have different ideas and priorities. When those differences aren't managed well, they can cause conflicts that disrupt the unity of the community and slow down progress toward shared sustainability goals (Dawson, 2006; Honey, 2008). Without a solid way of governing, these conflicts can escalate and make it harder for the ecovillage to run smoothly.

As a solution to these issues, management models that are both participatory and transparent ensures that everyone gets a say in decisions, creating a sense of ownership and responsibility (Goodwin, 2011; Kiper, 2013). Providing training in conflict resolution and collaborative problem-solving could give the community the tools they need to handle disagreements in a productive way (UNEP, 2012; Litfin, 2014). And just having regular meetings and open forums to discuss ideas can make a big difference in strengthening trust and teamwork (Dawson, 2006; Pretty et al., 2011).

### 5.7. Marketing and Economic Sustainability

Promoting locally made products and ecotourism in ecovillages isn't always easy. Many communities struggle to reach bigger markets, and without proper marketing for ecotourism, they often miss out on income opportunities that could help keep them financially stable (Honey, 2008; Goodwin, 2011). This is especially challenging for smaller initiatives that may lack the resources or expertise to compete in such competitive markets. But with the right tools, digital platforms can offer a real solution. By using social media and ecommerce websites, ecovillages can expand their reach, attracting environmentally conscious consumers from all over the globe.

Promoting organic products, handmade crafts, and sustainable tourism can be much easier with these tools (UNEP, 2012; Kiper, 2013). Another useful strategy is forming regional cooperatives, which can combine resources and expertise to strengthen marketing efforts. This can help ecovillages access bigger markets and secure better deals with buyers (Dawson, 2006; Pretty et al., 2011). Additionally, developing strategies to promote ecotourism at both national and international levels-such as forming partnerships with travel agencies, participating in eco-tourism events, and running online campaigns-can significantly increase visibility and bring in more visitors (Honey, 2008; Litfin, 2014).

## 5.8. Climate Change and Environmental Risks

Climate change brings serious environmental challenges to ecovillages, including droughts, floods, and other natural disasters that jeopardize agricultural production and residential areas. These climate-driven risks can severely disrupt the sustainability of ecovillages by damaging vital infrastructure, lowering crop yields, and increasing their vulnerability to extreme weather events (Pretty et al., 2011; UNEP, 2012). If these challenges are not addressed proactively, they could erode the very ecological and economic foundations upon which ecovillages are built.

To address these challenges, it is crucial to adopt climate-resilient agricultural practices and plant varieties. Approaches like agroforestry, permaculture, and the cultivation of drought-resistant crops can improve the ability of agricultural systems to adapt to shifting climatic patterns (Dawson, 2006; Altieri and Nicholls, 2017). In addition, fortifying infrastructure to better endure natural disasters-such as flood-proof housing and effective drainage systems-along with creating thorough risk management plans, can provide much-needed protection against climate threats (Honey, 2008; Goodwin, 2011). Transitioning to renewable energy systems like solar, wind, and biomass not only ensures dependable and eco-friendly energy sources but also helps reduce greenhouse gas emissions, keeping ecovillages aligned with larger climate action goals (Kiper, 2013; Litfin, 2014).

It is devastating to think that the very ecosystems ecovillages aim to protect could crumble under the weight of climate change. If nothing is done, the dream of living in harmony with nature may become just that-a distant dream. These solutions offer a glimmer of hope, but the stakes couldn't be higher. Ecovillages must prepare themselves to weather these storms-literally and metaphorically-while staying true to their vision of sustainable living.

## CONCLUSION AND RECOMMENDATIONS

Ecovillages stand as inspiring examples of how humans can live in harmony with nature, providing practical ways to achieve environmental sustainability while offering a space for experimenting with alternative economic systems that emphasize ecological balance and community well-being. The way they integrate ecotourism and sustainable agriculture shows immense promise for developing creative economic models that balance environmental and social benefits, while also building resilience and self-sufficiency.

What makes ecovillages so special is their ability to give people hope-a glimpse of a world where humans and nature thrive together without harming future generations. They are living proof that a better, kinder world is possible if we prioritize the right values and work together.

Research going forward should focus on finding ways to make ecovillage models work in different kinds of environments. Long-term studies are really needed to look at their economic, environmental, and social impacts, while also figuring out how to boost community participation and push for better policy support. These steps can help unlock more of their potential to contribute to global sustainability goals.

Through innovative policies, cooperative approaches, and living practices that truly fit with nature, ecovillages play an important role in achieving sustainable development goals. If more people adopt this model, it could offer a powerful solution to some of the world's biggest environmental challenges while making life better for communities everywhere.

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# CHAPTER VI

## THE ROLE OF AGRICULTURAL COOPERATIVES IN SUSTAINABLE DEVELOPMENT GOALS

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## INTRODUCTION

In 2015, the United Nations (UN) introduced the Sustainable Development Goals (SDGs), a set of 17 global objectives that came into effect on January 1, 2016 (UN, 2015). In addition, it also addresses critical global challenges such as poverty, hunger, health and well-being, gender equality, sustainability, and climate change, among others by 2030. The SDGs and their intention are to improve the lives of people, the planet and the environment. They were developed to inspire nations to take action toward eliminating poverty, protecting the environment, and fostering peace and prosperity for everyone (ILO and ICA, 2015). According to the Food and Agriculture Organization, food and agriculture are core issues of the 17 SDGs (FAO, 2016). Smallholder farms are vital for achieving the SDGs, and they are poised to play a significant role in shaping sustainable food systems in the future (Hong, 2015; Terlau et al., 2019). Investing socially and financially in smallholder farmers accelerates progress toward multiple SDGs simultaneously.

Because of their principles and values, cooperatives play a crucial role in achieving the proposed SDGs (COPAC 2015; Díaz de León et al., 2021). These entities aim to deliver both social and economic benefits to their members and the communities they serve. Their nature allows them to solve problems environmental issues. However, despite the extensive research highlighting their societal benefits, there is limited understanding of how cooperatives specifically contribute to achieving the SDGs (Díaz de León et al., 2021). Cooperatives have the ability to solve the poverty and health problems faced by the population today (Bassi and Vincenti 2015; Amonarriz et al. 2017; ILO 2018). Moreover, their ability to solve the problems faced by people has made them organizations with the capacity to contribute to the achievement of the SDGs.

UN has declared 2025 as the International Year of Cooperatives (IYC2025). The corresponding logo highlights the cooperative model as a vital solution to address numerous global challenges and underlines the critical role of cooperatives in achieving the SDGs by 2030. The IYC2025 logo depicts people from around the globe connecting with together to create a better world. It features three colors inspired by the graphic identity of the SDGs: red symbolizing society, blue representing the economy, and green reflecting the environment. Collectively, these elements highlight the vital role cooperatives play in promoting sustainable development (ICA, 2024a).

Globally, approximately one billion people are engaged with cooperatives. Cooperatives provide employment for over 280 million individuals worldwide, and it is estimated that nearly half the global population relies on cooperative enterprises for their livelihoods. The vast majority of employment provided by cooperatives is in agricultural cooperatives. The profits of the three hundred largest cooperatives in the world are four times the gross domestic product of Belgium, and 35% of these cooperatives are agricultural cooperatives. (ICA, 2024b). Cooperatives strive to address evolving consumer needs by offering products and services that go beyond meeting consumption demands, focusing on improving health (Amonarriz et al., 2017). By fostering democratic practices and social inclusion, cooperatives are uniquely positioned to contribute to sustainable development. Furthermore, they have demonstrated remarkable resilience during economic crises. Cooperatives seen as a key contributor to achieving the SDGs (ICA, 2015; Díaz de León et al., 2021).

## 1. THE PROGRESS OF THE SDGs

In 2024, a progress assessment was conducted and it was determined that the world was significantly behind on the path to achieving the 2030 Agenda. Among the measurable targets, only 17% show progress adequate to meet the 2030 goals. Nearly half (48%) are moderately to severely off track, with 30% demonstrating only minimal progress and 18% showing moderate progress. Alarmingly, 18% of targets have stagnated, and 17% have fallen below the 2015 baseline, highlighting the UN's urgent call for intensified efforts to realign with the SDGs (UN, 2024).

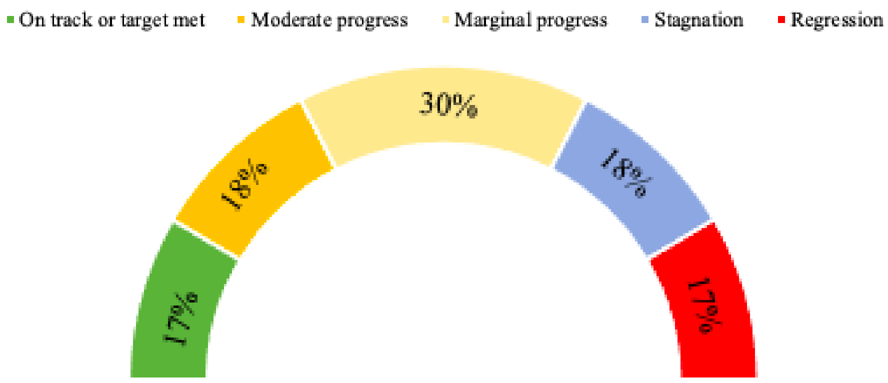


**Figure 1.** The progress of the SDGs between 2015 and 2024

When examining the progress of the SDGs from 2015 to 2024 (Figure 2), significant gaps are evident, particularly significant gaps in key development priorities such as gender equality (Goal 5), climate action (Goal 13), and peace, justice, and strong institutions (Goal 16). Among the assessable targets for Goal 1, 35% show moderate progress, while 65% demonstrate marginal progress, indicating insufficient advancement to achieve the 2030 targets. Alarmingly, for Goal 2 and Goal 14, 47% and 40% of targets, respectively, have regressed below the 2015 baseline levels.

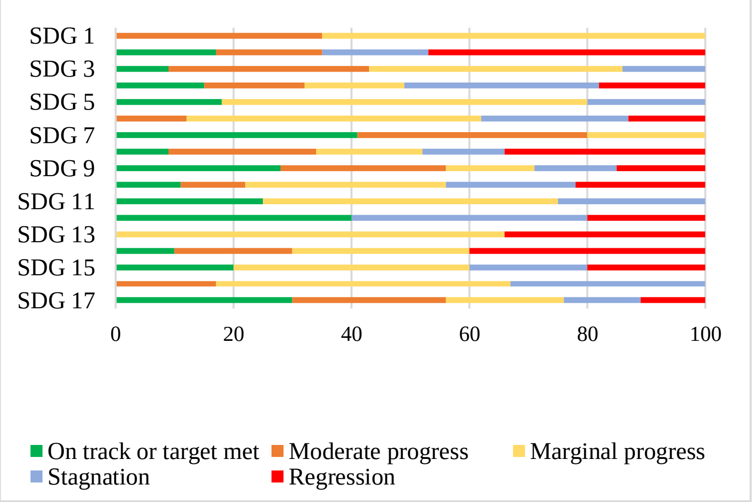


**Figure 2.** The progress of the SDGs according to the 17 Goals (%)

## 2. THE ROLE OF AGRICULTURAL COOPERATIVES IN SDGs

### 2.1. SDG 1: No Poverty

In 2022, 712 million people, corresponding to 10.9% of the world population, were living in extreme poverty, an increase of 23 million in the last 3 years. Forecasts show that if current trends continue, by 2030, 590 million people, equivalent to 6.9% of the world's population, may be living in extreme poverty (UN, 2024).

There is widespread agreement among various stakeholders such as UN, ILO, and International Cooperative Alliance (ICA), cooperative enterprises are the most suited to address multiple aspects of poverty reduction and social inclusion. Cooperatives contribute to poverty alleviation by identifying economic opportunities for their members, empowering marginalized individuals to advocate for their rights, providing security by transforming individual risks into shared risks, and facilitating access to assets that enable members to generate income.

Agricultural cooperatives, in particular, have made significant contributions to reducing poverty. Gava et al. (2021) found that agricultural cooperatives contributed to rural poverty alleviation in Bosnia and Herzegovina. In Egypt, approximately 4 million farmers earn their livelihoods by selling their produce through agricultural marketing cooperatives (Aal, 2008). In Ethiopia, around 900,000 individuals in the agricultural sector rely on cooperatives for most of their income (Lemma, 2008). Cooperatives also contribute to reducing poverty by creating employment opportunities, supporting livelihoods, and offering a diverse range of services.

A study conducted on co-operatives in Sri Lanka and Tanzania revealed that most cooperatives played a significant role in reducing poverty (Birchall and Simmons, 2009).

In addition, agricultural cooperatives assist farmers by supplying inputs, processing goods, and supporting the transport and marketing of their products. Similarly, consumer cooperatives enable members and the broader community to purchase essential goods, such as food and clothing, at reasonable prices, thereby improving quality of life and helping lift members out of poverty (ICA, 2015).

## 2.2. SDG 2: Zero Hunger

According to the UN report, over the past four years, the number living in extreme poverty has increased by 23 million, reaching 733 million in 2023, and 2.33 billion people are food insecure. The COVID-19 pandemic has had a major impact on this increase, and global hunger remains high. Despite some progress, 148 million children under 5 were stunted in 2022. If current trends continue, one in five children under 5 will be stunted by 2030. Around 60% of countries worldwide faced high food prices in 2022, driven by disrupted supply chains. To achieve zero hunger, countries must work hard to make their food systems sustainable, resilient and equitable. The outbreak of war in Ukraine caused significant disruptions to logistics and food supply chains, leading to increased food and energy prices, particularly in the first half of 2022. Additionally, the war drove fertilizer prices sharply higher, creating uncertainty around farmers' planting decisions (UN, 2024).

Cooperatives contribute to food security by supporting small-scale farmers, fishers, livestock farmers, forest owners, and other producers in overcoming the various challenges they face in food production.

According to the ICA, agricultural cooperatives are the most common globally, with 1.2 million cooperatives and 570 million members active in the sector out of 2.5 million cooperatives and over one billion members worldwide. Agricultural cooperatives dominate the global cooperative sector, accounting for 35% of the top 300 cooperatives and holding significant market share (ICA, 2024b). Small agricultural producers face challenges like limited market information, fluctuating input costs, and poor infrastructure. Agricultural cooperatives help address these issues by offering services such as group purchasing, shared credit access, and marketing support. They also enhance producers' skills, provide knowledge, and empower farmers through participation in decision-making and policy influence.

According to Veerakumaran (2005), cooperatives are considered the most effective institutional mechanism for achieving food security in any nation and they play a pivotal role in ensuring food security at the household level. Developed countries such as the most European nations, Canada, United States, Australia, and as well as socialist countries like China, have achieved food self-sufficiency and improved their social well-being largely through the efforts of cooperative societies (Chambo, 2009).

Dairy cooperatives have proven to enhance both diversify food supply and income of household. In western Cameroon, agricultural cooperative members improved family nutrition by increasing fresh milk consumption, increased income by marketing milk through cooperatives, and increased crop yields by using cow dung. Between 2008 and 2012, annual household income rose from $430 to $3,000. Over the same period, the percentage of households with year-round access to quality food increased dramatically, from 14% to 76% (Heifer, 2012).

### 2.3. SDG 5: Gender Equality

Cooperatives provide benefits to a certain segment of the agricultural population in rural areas. Cooperatives are very important in social development as they provide full or part time employment opportunities to local women who are completely deprived of job opportunities in rural areas (Lyberaki and Paraskevopoulos, 2002).

Cooperatives play a significant role in promoting gender equality by increasing women's opportunities to engage in local economies and communities worldwide. For instance, in Japan's consumer cooperatives, women make up 95 % of the membership and have secured positions within the governance structures of these organizations (Suzuki, 2010). In Uganda, women's participation in agricultural cooperatives is rising at a faster pace than that of men (Majurin, 2012). Similarly, Surendran Padmaja et al. (2023) found that women’s participation in agricultural cooperatives has increased their role in decision making in agriculture by 8–13%. In India, women’s cooperatives provide employment opportunities. Similarly, in the Arab states, these cooperatives enhance women’s access to economic opportunities and participation in public life. Through cooperatives, women in Tanzania and Sri Lanka have been empowered to assume leadership positions, form management committees, and organize welfare initiatives (ICA, 2015).

The establishment of cooperatives played a key role in promoting women's entrepreneurship in rural tourism in Greece. This movement began in 1983 in the small village of Petra on the island of Lesvos and grew gradually over time. Women were included many European projects and incentives such as NOW, EQUAL and LEADER for their activities (Koutsou et al., 2003). Women's cooperatives operating in Greece are reported to provide full- or part-time employment opportunities for a significant number of women, with 79.2% of women's cooperatives subsidised by national programmes and 36% by LEADER. The number of women employed by women's cooperatives in rural areas is much higher than private enterprises. In fact, approximately 40% of women's cooperatives employ more than ten women (Koutsou et al., 2009). Women's cooperatives in Türkiye are reported to have a positive but limited impact on regional development through creation employment, empowering women, building partnerships, implementing projects and increasing social capital (Kılıç Topuz and Ege, 2024).

### 2.4. SDG 7: Affordable and Clean Energy

Ensuring access to clean energy by 2030 requires strong policies to accelerate electrification, improve energy efficiency and boost investments in renewable energy. Encouraging innovation, establishing supportive regulatory frameworks, and advancing these efforts are essential to achieving Goal 7 and meeting global climate targets (UN, 2024).

Rural cooperatives In the United States own 42% of the nation's electric distribution lines. Additionally, 66 generation and transmission cooperatives have been established to collectively enhance purchasing power for wholesale electricity (ILO, 2013).

Energy cooperatives have been implemented as a tool in both developed and developing countries around the world since the 1930s. Following the global “Great Depression” of 1929, energy cooperatives in the United States were viewed as a means of promoting development. Through these cooperatives, electricity was delivered to rural areas that previously had no access to it. Energy cooperatives now serve 56% of the U.S. landscape, powering 22 million entities across 48 states and supporting 42 million Americans, including 92% of persistent poverty counties. They are reducing emissions by adopting natural gas, renewables, and other measures, while returning over $1 billion annually. They reduced sulphur dioxide emissions, nitrogen oxide emissions and carbon dioxide emissions 83%, 68% and 14% from 2005 to 2022, respectively (NRECA, 2024).

Downing et al (2005) underlined that new generation agricultural cooperatives have played a particularly strong role in the proposed new crop rotations, the inclusion of perennial crops in these rotations, and the development of renewable energy and agribusinesses.

## 2.5. SDG 8: Decent Work and Economic Growth

Progress toward Goal 8 is hindered by challenges such as the lingering effects of COVID-19, trade disputes, increasing debt burdens in developing nations, conflicts, and geopolitical tensions-factors that collectively pose risks to global economic growth. Unemployment rates are disproportionately higher among women and youth. Global GDP per capita declined sharply by 3.9% in 2020 due to global disruptions. By 2022, growth had slowed again to 2.2% (UN, 2024).

Cooperatives are instrumental in generating employment opportunities and supporting income generation. Cooperatives provide direct employment while also fostering indirect job opportunities and self-employment by enhancing marketing conditions and creating new avenues for market access (Develtere et al., 2008).

According to the World Cooperative Monitor (WCM), cooperatives support sustainable economic growth and provide stable, quality employment, offering jobs or work opportunities to 280 million people worldwide, which accounts for 10% of the global workforce. The 300 largest cooperatives $2.41 trillion in turnover while delivering essential services and infrastructure to support societal well-being (WCM, 2024). Considering that this number was 100 million in 2011 (ICA, 2011), the impact of cooperatives on the world economy is remarkable. The majority of the population employed in cooperatives is also in the agricultural sector (ICA, 2017). Alongside small and medium-sized enterprises, cooperatives are the most important sources of new employment opportunities (ILO, 2007). Although global data on cooperatives' role in job creation requires further development, existing evidence from various countries is quite persuasive.

## 2.6. SDG 9: Industry, Innovation and Infrastructure

While the intensity of carbon dioxide (CO2) emissions has decreased, global emissions have reached an all-time high. Progress in reducing emissions intensity has been insufficient. Advancing low-carbon energy solutions and green manufacturing requires collaborative strategies tailored to the specific strengths and circumstances of each country. Advancing progress toward Goal 9 requires a unified effort to boost innovation through greater investment in research and development, prioritize the green transition, and enhance access to information and communication technology. Small enterprises are the foundation of economies worldwide, creating jobs and sustaining livelihoods in communities. Despite their critical role, they continue to face significant challenges such as rising operational costs. This burden is particularly severe in lower-income nations, where small enterprises are more vulnerable to economic shocks. Access to credit, essential for their survival and growth, remains limited. Implementing inclusive industrial policies is vital to enhance the growth, competitiveness, and resilience of small enterprises (UN, 2024).

Research on family farms in China found that agricultural cooperative membership increases the adoption of new technologies by 7.5–9.1%. The study also showed that farms with lower incomes and smaller sizes are more likely to adopt new technologies through cooperatives (Wu et al., 2023).

## 2.7. SDG 10: Reduced Inequalities

While social assistance programs have reduced the proportion of people living below half the median income, 2023 saw record fatalities on migration routes and an unprecedented global refugee population. Developing countries remain underrepresented in global economic decisions, emphasizing the need for inclusivity. Addressing inequality requires fair resource distribution, education investments, robust social protection, anti-discrimination measures, support for marginalized groups, and international cooperation for equitable trade and financial systems (UN, 2024). Blanco and Domínguez (2019) highlight that the cooperative approach model plays a role in promoting women's empowerment and gender equality, contributing to the achievement of SDG 10. However, the limited scale of these organizations and specific contextual challenges may hinder these efforts. Greater support and financial assistance during the early stages of such projects could significantly enhance their impact. Research by Pakawanich et al. (2022) suggests that crop production schedule is needed to reduce income inequality among small-scale farmers in an agricultural cooperative. In the study by Anigbogu and Uzondu (2019) on income inequality among cooperative farmers in Anambra State found that productivity, technology, credit, farm size, soil fertility, crop type, input supply and agricultural extension services contribute significantly to farmers' income. The study recommends that the government should undertake a public awareness campaign on the potential of agricultural cooperatives as a sustainable approach to reduce income inequality and place more emphasis on cooperative education as a tool for growth and development. In addition, agricultural cooperatives should be adequately funded to help increase farmers' income and reduce income inequality.

## 2.8. SDG 11: Sustainable Cities and Communities

More than half of the world's population now lives in cities. Although air pollution levels have decreased in most regions, they remain well above recommended guidelines for safeguarding public health. Between 2000 and 2020, urban sprawl occurred 3.7 times faster than the rate of intensification, adversely affecting the natural environment and land use. As urbanisation continues to increase and nearly 70 per cent of the global population is expected to live in cities by 2050 (UN, 2024).

Cooperatives play a vital role in the sustainable management of natural resources in several ways. They help prevent resource depletion by providing a platform for local communities to address environmental challenges. Through this, cooperatives assist in defining property and user rights, managing natural resources effectively, and diversifying economic activities to include green and sustainable ventures (ICA, 2015). The Netherlands is home to over 125 environmental agricultural cooperatives. These cooperatives enable Dutch conservation agencies to establish environmental management contracts with groups of land managers, facilitating the management of entire landscapes rather than fragmented areas. For instance, in the Fryslan Woodlands during the early 1990s, farmers faced challenges such as the viability of small-scale farming under the pressures of low-cost dairy production, shrinking farm sizes, and stricter environmental regulations on soil pollution. Environmental cooperatives emerged as a solution, allowing farmers to self-regulate and implement locally tailored strategies to achieve environmental goals within their farming practices (Renting and Van der Ploeg, 2001).

Sustainable agricultural cooperatives expand their activities to encompass areas such as water management, tourism, organic farming, and the production of high-quality regional foods. Agricultural cooperatives in the

Netherland address challenges posed by high-tech agriculture and stringent environmental regulations. Italian green social cooperatives, which are non-profit democratic organizations specializing in the provision of environmental services, are described as a tangible initiative aimed at integrating the three pillars of sustainability. The social cooperative, the primary empirical expression of social enterprise in Italy, as seen the departure point. They contribute to environmental sustainability by maintaining public green spaces, managing urban waste collection and sanitation, installing solar panels, and promoting waste prevention and reuse initiatives (Osti, 2012). In developing countries, thousands of waste-pickers work under challenging conditions, playing a crucial contribute in environmental cleanup. However, they often lose a significant portion of their earnings to intermediaries who sell recyclables to industries. To address this, waste-pickers in countries such as Colombia, Brazil, Argentina, Mexico, the Philippines, India, and Indonesia have formed cooperatives. These cooperatives aim to enhance their incomes and elevate the dignity of their work (Medina, 2005).

### 2.9. SDG 12: Responsible Consumption and Production

Responsible consumption and production aim to minimize negative environmental impacts. Cooperatives in Mexico City actively work to preserve protected areas while promoting innovative recycling methods and eco-friendly practices (Díaz de León et al., 2021).

Yang and Wang examined how participation in farmer organizations influences dairy farmers' adoption of good management practices (GMPs), such as nutrient management, winter off-cows, soil testing, and riparian planting, in New Zealand. Their findings indicate that involvement in farmer organizations significantly increases the likelihood of dairy farmers adopting GMPs (Yang and Wang, 2023). Neupane et al. (2023) report that goat farmers who are members of cooperatives are more likely to use cooperatives as their primary market channel. Additionally, farmers selling their goats through cooperatives earned significantly higher prices compared to those selling in local markets or to independent goat collectors.

## 2.10. SDG 13: Climate Action

This goal means that take urgent action to combat climate change and its impacts. Climate records were broken in 2023 as the climate crisis intensified at an alarming pace. Global temperatures continue to rise, and greenhouse gas emissions show no signs of slowing. Communities around the world are grappling with extreme weather events and increasingly frequent, severe disasters that devastate lives and livelihoods daily. At the same time, fossil fuel subsidies reached an unprecedented high. The global community stands at a critical crossroads. Swift and comprehensive low-carbon transformations across all sectors are essential to avoid mounting economic and social consequences. Countries must align their efforts with the goal of limiting global warming to 1.5°C. There is no room for delays or partial measures. Global greenhouse gas emissions must see drastic reductions by 2030 and achieve net-zero levels by 2050 to avert further climate chaos. Limiting global warming to 1.5°C requires a 42% reduction in greenhouse gas emissions by 2030, necessitating an annual decline of 8.7% (UN, 2024).

In recent years, people's increasing awareness of environmental degradation and the benefits of healthy, organic food has driven a shift in consumer preferences toward organic products (Bernal-Jurado et al., 2019). This change has resulted in a higher intention to purchase these products (Kong et al., 2014) and a greater willingness to pay premium prices for them (Meliá-Martí et al., 2020). The rising significance of organic production is also highlighted in the SDGs, particularly its alignment with SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land) (UN, 2019).

Providing greater support to smallholder farmers is crucial for addressing the climate and development challenges in agriculture such as mitigating the adverse effects of climate change, ensuring global food security, reducing greenhouse gas emissions, and conserving natural resources. Kopytko (2018) underlined that Ukrainian cooperatives take a significant role adapt and/or mitigate climate change.

Adaptation to climate change is an urgent task not just at the national level but for all nations globally. Vu et al. (2023) noted that within Vietnam, agricultural cooperatives in Son La province play a crucial role in promoting green and safe production, significantly contributing to reducing harmful practices that damage agricultural ecosystems. Furthermore, cooperatives effectively bridge the gap between officials and farmers in implementing environmental protection measures and are at the forefront of applying solutions for climate change mitigation and adaptation in rural areas and agricultural production.

### 2.11. SDG 15: Life on Land

Alarmingly, species are quietly disappearing and biodiversity is declining. In the last two decades, nearly 100 million hectares of forested areas have been lost. Countries' efforts to conserve biodiversity are ongoing. However, tackling urgent environmental challenges such as climate change, biodiversity decline, deforestation, desertification and pollution requires an intensive, rapid and comprehensive approach not only at local and national levels but also at global levels (UN, 2024). According to the Bijman and Wijers (2019), most farmers cooperatives are focused on the exploitation of land. In addition, Lafont et al. (2023) found that producer cooperatives were found to be linked to the SDG 15. Producer cooperatives face the challenge of managing resources sustainably. They can also provide opportunities to efficient use the resource by increasing production and consumption, decreasing poverty and hunger, and protecting the environment.

### 2.12. SDG 16: Peace, Justice and Strong Institutions

Achieving all SDGs relies on establishing lasting peace and preventing violent conflict (UN, 2024). Cooperatives often serve as positive social capital, fostering community cohesion, participation, empowerment, and inclusion among members while helping to rebuild interpersonal relationships and promote peace. Historically, cooperatives have frequently emerged as collective responses to crises, such as the economic hardships in the UK during the 1840s, the Great Depression of 1929–1930 in the US, the agricultural depression in Germany in the 1860s, and the unemployment crisis in Europe during the 1970s. However, this does not imply that cooperatives thrive only during periods of crisis (ICA, 2015).

In times of crisis, when the need to establish more resilient economic and financial systems becomes urgent, cooperative enterprises often re-emerge as timely and durable solutions. They possess transformative potential to revitalize struggling sectors, aid the recovery of crisis-affected local economies, increasing returns for producers and service providers along value chains, formalize informal employment, and create job opportunities for women and youth in both rural and urban areas. New forms of cooperatives are also emerging to address specific crises. Women's cooperatives, in particular, have played a pivotal role as agents of peace and development. Cooperatives have played a significant role in rebuilding societies after conflicts. For example, a women's cooperative in Lebanon helped revive local and traditional products that were on the verge of extinction following the heavy shelling in 2006, while also contributing to the restoration of the village's cultural memory (Esim and Omeira, 2009). In rural Iraq, cooperatives became mandatory after the 1958 land reform for individuals receiving land. These cooperatives often served as distribution hubs for government-supplied agricultural inputs, such as fertilizers and seeds. They were primarily viewed as mechanisms to promote collaboration among agricultural producers, enabling them to achieve economies of scale by purchasing in bulk at reduced prices. This, in turn, lowered input costs and increased profit margins for farmers (USAID, 2005).

## CONCLUSION

The progress assessment carried out in 2024 highlights that the world is significantly off track in achieving the 2030 Agenda and urgent action is needed. Among the measurable targets, only 17% show progress adequate to meet the 2030 goals. Agriculture are core issues of the 17 SDGs and so, smallholder farms are vital for achieving the SDGs. Agricultural cooperatives are the most important tool for the sustainability of small farmers and for solving their problems. This study examines the role of agricultural cooperatives towards achieving the SDGs. In fact, because their nature, principles and values are based on the people, on the integration and well-being of its members and their communities, cooperatives play a vital role contributing to the fulfillment of the SDGs. Cooperatives empower individuals by providing opportunities for even the poorest segments of society to actively participate in economic progress. Cooperatives are essential to ensure that the benefits of development are equitably distributed and remain sustainable over time.

Agricultural cooperatives have significantly contributed to reducing poverty and achieving zero hunger. They have increased farmers' incomes by facilitating crop marketing, improving crop yields, and reducing production costs. Additionally, as women join cooperatives, their participation in decision-making processes grows, enabling them to play a more active role in employment and increasing their incomes. This underscores the importance of women's involvement and agricultural cooperatives in eliminating gender inequality. Globally, 10% of the employed population works in cooperatives, with agricultural cooperatives accounting for the largest share. Furthermore, the gross profit of the world's largest 300 cooperatives is several times greater than the gross domestic product of some developed countries, highlighting the critical role of agricultural cooperatives in driving economic growth. The tendency of lower-income and smaller-scale farms to adopt new technologies through agricultural cooperatives emphasizes their importance in fostering innovation.

According to the research results, agricultural cooperatives have a significant impact on the majority of sustainable development goals. Agricultural cooperatives have a significant contribution to achieving in particular the goals of SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). However, it was determined that agricultural cooperatives do not contribute to SDG 3 (Good Health and Well-Being), SDG 4 (Quality Education), SDG 6 (Clean Water and Sanitation), SDG 14 (Life Below Water) and SDG 17 (Partnerships for the Goals).

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# CHAPTER VII

## INSUFFICIENTLY REGULATED GREENHOUSE EXPANSION IN TURKEY'S MEDITERRANEAN REGION: ENVIRONMENTAL, TOURISM, AND SOCIO-ECONOMIC IMPACTS WITH SUSTAINABLE SOLUTIONS

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## INTRODUCTION

Greenhouse farming has rapidly expanded across the Mediterranean climate zones, driven by the region's favorable climate, increasing demand for fresh produce, and economic incentives for farmers (Saraive et al., 2023; Argento et al., 2024; Sturiale et al., 2024). This form of agriculture, which involves the cultivation of crops in controlled environments, has been instrumental in boosting agricultural productivity and meeting market demands year-round. However, the unchecked and often unregulated expansion of greenhouses has given rise to a host of environmental and human health concerns that warrant closer examination (Food Agricultural Organization [FAO] 2013; Castro et al., 2019; Pearce, 2024; Sturiale et al., 2024).

The Mediterranean region, known for its rich biodiversity and delicate ecosystems, is particularly vulnerable to the negative impacts of uncontrolled greenhouse expansion. The construction and operation of greenhouses, often without proper planning and regulation, can lead to significant ecological disruptions, including soil degradation, water resource depletion, and loss of biodiversity (Bojaca, 2013; Torellas et al. 2013; Chen et al. 2014; Fang et al. 2015; Sun et al. 2018). Furthermore, the intensive use of agrochemicals in greenhouse farming-such as fertilizers (Zikeli et al. 2017; Dhankhar and Kumar 2023; Zhang et al. 2024), pesticides (Bapayeva et al 2017; Amoatey et al. 2020; Shah 2021; Boye et al., 2022), and growth regulators (Ramírez et al., 2016) poses serious risks to human health, affecting not only agricultural workers but also surrounding communities through the contamination of air, water, and soil (Yu et al. 2010; Majsztrik et al. 2017; Li et al. 2018; Canaj 2019; Wang et al. 2020; Boye et al. 2022)

Turkey's Mediterranean region exemplifies these challenges and opportunities. As one of the most active areas for greenhouse agriculture within the country, it highlights both the economic benefits and environmental risks associated with this type of farming (Tuzel et al., 2017; Sturiale et al. 2024). The region's mild winters and long growing season make it an ideal location for year-round cultivation, which has led to significant agricultural development. Yet, this rapid expansion (Turkish Statistical Institute [TÜİK] 2019a) has also strained local water supplies and led to overuse of chemical inputs, prompting concerns about sustainable practices and regulatory oversight.

As greenhouse farming continues to expand, these challenges underscore the need for sustainable practices and effective regulatory frameworks. This chapter aims to explore the environmental and health risks associated with uncontrolled greenhouse expansion in the Mediterranean, discuss strategies for mitigating these risks, and examine global procedures that could serve as models for sustainable greenhouse management in the region.

By examining these issues, we seek to provide a comprehensive understanding of the implications of greenhouse farming in the Mediterranean and to offer practical solutions that can help balance agricultural productivity with environmental and human health considerations. The insights gained from this analysis will be crucial for policymakers, researchers, and practitioners working towards a more sustainable agricultural future in the Mediterranean region.

## 1. PROBLEMS ARISING FROM UNCONTROLLED GREENHOUSE EXPANSION

Uncontrolled greenhouse expansion has become a significant concern in recent years, particularly in regions with intensive agricultural activities. While greenhouses contribute to increased food production and economic growth, their unregulated proliferation can lead to serious environmental, social, economic, and health challenges. This section explores the key problems associated with the uncontrolled expansion of greenhouses, emphasizing their impacts on ecosystems, natural resources, and local communities.

### 1.1.Environmental Risks

The unchecked expansion of greenhouse farming in the Mediterranean region presents a series of environmental risks that threaten the sustainability of local ecosystems and natural resources. These risks, driven by the high intensity of agricultural activity in confined spaces, can have profound and lasting impacts on soil quality, water availability, biodiversity, and waste management (Castro et al., 2019; Alonso 2021; Argento et al. 2024; Sturiale et al. 2024).

### 1.1.1. Soil Degradation

One of the most significant environmental risks is soil degradation. Intensive agricultural practices within greenhouses, particularly those involving monocropping and the heavy use of chemical fertilizers, can lead to the exhaustion of soil nutrients. Over time, this reduces soil fertility, making it increasingly difficult to sustain productive agriculture without escalating inputs of fertilizers and soil amendments (Li et al., 2022; Shaheb et al. 2024). Additionally, frequent tilling and soil compaction within greenhouse environments disrupt the natural soil structure, leading to increased erosion and loss of organic matter (Hill et al., 1995; Morgan et al. 2020). As organic matter declines, soil's ability to retain moisture and nutrients diminishes, exacerbating the cycle of degradation (Wu et al., 2020; Pahalvi et al. 2021; FoodPrint, 2024)

### 1.1.2. Water Scarcity

Greenhouse farming in the Mediterranean, a region already facing significant water scarcity, places tremendous pressure on local water resources (Argento et al., 2024; Claro et al., 2024; Sturiale et al. 2024). Greenhouses often require substantial quantities of water for irrigation, especially in the arid and semi-arid areas characteristic of the region. This high demand for water can lead to over-extraction of groundwater, which is the primary source of irrigation water in many Mediterranean countries. Over time, excessive groundwater extraction can lower water tables, dry up wells, and cause the salinization of aquifers, further diminishing freshwater availability for both agricultural and domestic use. Salinization poses a severe threat to the long-term viability of agriculture, rendering soil less productive and potentially leading to the abandonment of previously fertile land (Greene et al. 2016; Pulido-Bosch, 2018; Acero Triana, 2020; Sturiale et al. 2024).

### 1.1.3. Habitat Destruction and Loss Of Biodiversity

The conversion of natural landscapes into greenhouse farms directly contributes to habitat destruction and loss of biodiversity (Tilman and Williams, 2021; Wudu et al, 2023). In the Mediterranean region, recognized as one of the world's biodiversity hotspots, this is of particular concern (Blondel, 2010). The expansion of greenhouses often involves the clearing of native vegetation, which serves as critical habitat for a wide range of plant and animal species. As these habitats are destroyed, the species that depend on them face the risk of extinction (Tilman and Williams, 2021; WWF, 2024). Additionally, the introduction of non-native plant species within greenhouses can lead to the spread of invasive species, further threatening local biodiversity by outcompeting native flora and fauna (Messelink et al., 2021; Hanberry, 2023; Sharma and Birman, 2024). The cumulative impact of these changes can disrupt local ecosystems, reducing their resilience and altering the ecological balance

### 1.1.4. Waste Management Challange

Waste management is another significant concern. The operation of greenhouses generates considerable amounts of plastic waste, including greenhouse covers, drip irrigation tubes, and mulch films. If not properly recycled or disposed of, these materials can accumulate in the environment, contributing to land and marine pollution (Sayadi-Gmada et al., 2019). Additionally, the intensive use of fertilizers and pesticides results in chemical runoff that can contaminate nearby water bodies, leading to the eutrophication of rivers, lakes, and coastal areas (Dorais and Dubé, 2009). Excessive nutrient loading stimulates the growth of algae, depleting oxygen levels in the water and harming aquatic life. Moreover, the leaching of agrochemicals into groundwater poses long-term risks to drinking water quality and public health (Withers et al., 2014; Xia et al., 2020).

### 1.1.5. Effect of Greenhouse Coverings

The materials used to cover greenhouses play a crucial role in regulating the internal climate and ensuring optimal growth conditions for plants. However, these materials, primarily composed of various plastics (Maraveas, 2020) and glasses, also bring significant environmental challenges (Monterao et al., 2013). Over time, the degradation of these materials can lead to substantial ecological and operational issues, affecting everything from local soil and water quality to the broader sustainability of agricultural practices (Maraveas, 2019; Muñoz-Liesa et al., 2022).

Research has shown that different materials used for greenhouse coverings, such as polycarbonate and glass, have distinct environmental footprints during their lifecycle (Maraveas, 2019; Ashok and Sujitha, 2021). For instance, polycarbonate sheets have a lower carbon footprint compared to glass in terms of $CO_2$ emissions per square meter per year (Nassif, 2021). However, the degradation of plastic films used in greenhouses can lead to environmental pollution if not managed properly (Maraveas, 2020). Studies highlight the use of fluoropolymeric materials to reduce the environmental impact of these plastics by enhancing their durability and recyclability (Stefani et al., 2007; Gudkov et al., 2020; 2019; Simakin et al., 2020; Améduri, 2023). Additionally, closed-loop recycling systems are being explored to minimize waste and restore the quality of recycled plastics to a state comparable to virgin materials (Ozgener and Ozgener, 2011; Ozgener et al., 2011; Xu et al., 2019; Recyclinginside, 2024).

### 1.1.6. Heat Island Effect

Beyond the internal effects, greenhouse coverings can significantly impact the surrounding environment. Greenhouses can reflect substantial amounts of sunlight, altering the temperature of nearby areas. This reflected light can lead to localized warming, especially on surfaces that absorb the light, such as nearby soil or vegetation. Consequently, the warming effect can change the microclimate, potentially leading to shifts in local weather patterns, such as increased evaporation rates and changes in soil moisture levels (Yue et al., 2021).

In regions with dense greenhouse coverage, this reflection and the heat generated inside the greenhouses can contribute to a "heat island effect”, similar to what is observed in urban areas (Edmonsdson et al., 2016). The increased temperature can affect local flora and fauna, potentially leading to changes in plant growth patterns or the behavior of animal species. Additionally, the increased temperature can stress local plant species, especially those not adapted to warmer conditions, and alter soil conditions by increasing evaporation rates, leading to drier soils that may require more irrigation or other interventions (Chaudhry and Sidhu, 2022).

### 1.1.7. Microclatate Changes

Microclimate changes induced by greenhouses can also influence local biodiversity (Tilman and Williams, 2021; Wudu et al, 2023). Some species may thrive under the new conditions, while others may be forced to migrate or could face population declines (WWF, 2024). For instance, insects and other small animals sensitive to temperature changes may be particularly affected, potentially leading to shifts in local ecological balances. Moreover, the altered microclimate can affect the prevalence of pests and diseases in surrounding areas, creating favorable conditions for certain pests or pathogens and potentially leading to increased outbreaks that could impact both greenhouse crops and nearby agricultural areas (Messelink et al., 2021; Hanberry, 2023; Sharma and Birman, 2024).

### 1.1.8. Light Pollution

Greenhouses that operate with artificial lighting during night hours can contribute to light pollution, disrupting the natural behaviors of nocturnal animals, including their feeding, mating, and migration patterns (Irwin, 2018). The increased light levels can also interfere with the circadian rhythms (Brüning et al., 2015; Domioni , 2015; Smolensky et al., 2015) of both plants and animals, leading to broader ecological disruptions (Gaston et al., 2012; Beterridge, 2023). Light pollution from greenhouses can attract insects, which may disrupt local food webs by concentrating insect populations around the greenhouses and away from their natural habitats, affecting species that depend on these insects for food (Grubisic et al., 2018; Owens et al., 2020; DarkSky, 2023).

### 1.1.9. Greenhouse Gas (GHGS) Emission

Greenhouse expansion also contributes to climate change through the emission of greenhouse gases (GHGs). The production and transportation of agricultural inputs, such as fertilizers and plastic materials, generate significant carbon emissions (Israel et al., 2020). The reliance on fossil fuels for heating and powering greenhouses further exacerbates this carbon footprint. In regions where renewable energy sources are not widely adopted (Paris et al., 2022), the cumulative effect of these emissions can contribute to global climate change, impacting the very agricultural systems that greenhouses are intended to support (Campra et al. 2008; Torsu et al., 2024).

## 1.2. Human Health Risks

Uncontrolled greenhouse expansion in the Mediterranean region presents several health risks, largely due to the intensive agricultural practices employed within these operations. These risks not only affect the workers directly involved but also extend to local communities and consumers.

Workers in greenhouses are regularly exposed to high concentrations of pesticides and fertilizers (Jurewicz et al., 2007),essential for pest control and promoting plant growth in densely planted environments. However, this exposure can lead to acute poisoning and long-term health issues, including respiratory problems (Nigatu, 2017; Liu et al., 2019), skin conditions (Adibelli and Sümen, 2023) and neurological disorders (de Graaf et al., 2022). Chronic exposure has been linked to serious conditions such as cancer, reproductive issues (Sallmén et al., 2003; Bretveld et al., 2008), and endocrine disruption (Yan et al., 2022). Furthermore, some of these chemicals emit Volatile Organic Compounds (VOCs), which can compromise air quality within the enclosed greenhouse environment, exacerbating respiratory illnesses among workers (Copeland, 2010; UMass Amherst Center for Agriculture, 2024).

The chemicals used in greenhouses can also leach into groundwater or run off into nearby streams and rivers, leading to the contamination of drinking water sources (U.S. Geological Survey, 2018; Shi et al., 2022; Singh et al., 2022). This contamination not only affects human health through direct consumption but also impacts aquatic life, thereby influencing community health through the food chain. Consumption of water tainted with agricultural chemicals can cause gastrointestinal (Gatto et al., 2009; Gleason and Fagliano, 2017; Masciopinto et al., 2019) and neurological symptoms (Bondy and Campbell, 2018), disrupt hormonal functions (Standley et al., 2008; Wee and Aris, 2017), and increase the risk of developmental disorders (Ahmed et al., 2019; Itarte et al., 2024).

Additionally, the operation of greenhouses often involves the release of significant amounts of greenhouse gases, particularly when fossil fuels are used for heating and powering equipment (Campra et al. 2008; Israel et al., 2020; Paris et al., 2022; Torsu et al., 2024) Particulate matter from soil, pesticides, and other sources further degrades air quality, leading to respiratory conditions (D'Amato et al. 2014) and other health problems in communities surrounding these operations (West et. al., 2013; Kiehbadroudinezhad et al., 2024). The altered local climate, characterized by increased humidity and heat from greenhouse clusters, can indirectly impact health by promoting the proliferation of disease vectors such as mosquitoes (Nosrat et al., 2021).

The physically demanding nature of greenhouse work, which often involves repetitive tasks and exposure to extreme tempera, tures, can lead to a range of musculoskeletal disorders (Nuraydın et al., 2018; López-Aragón et al., 2018; Xiaojun et al., 2021) from temporary discomfort to long-term disabilities. High temperatures, particularly during warmer months, pose severe health risks, including heat stress and heatstroke (Okushima et al. 2000; Greenhouse, 2023; Tiwari et al., 2023; Gibb et al., 2024) especially if workers do not have adequate hydration and cooling breaks. Moreover, working in high-pressure, chemically intensive environments can increase stress levels and associated mental health issues, with the isolation often experienced by agricultural workers exacerbating conditions like depression and anxiety (Esechie and Ibitayo, 2011; Montoya-García et al. 2013; Pérez-Alonso et al. 2021).

Communities living near large greenhouse operations may experience indirect health effects due to pesticide drift (Harrison, 2011), water contamination (Shi et al, 2009), and changes in local microclimates. These factors can contribute to broader community health issues that may not be immediately traced back to their environmental causes. Additionally, there is the risk of chemical residues on greenhouse produce, which can pose health risks to consumers. Persistent organic pollutants and heavy metals that accumulate on fruits and vegetables can lead to long-term health effects when ingested regularly (Lou et al., 2012; Fan et al., 2017; Chen et al., 2021a).

## 2. STRATEGIES FOR LIMITING UNCONTROLLED GREENHOUSE EXPANSION

To address the environmental and health challenges posed by uncontrolled greenhouse expansion, particularly in regions like the Mediterranean, comprehensive strategies need to be implemented. These strategies encompass regulatory measures, sustainable practices, education, and international cooperation.

Governments can play a crucial role by implementing strict zoning laws that restrict where greenhouses can be built, ensuring these structures are located away from sensitive ecosystems and residential areas (Popp, 1989). Land use regulations help maintain a balance between agricultural development and the conservation of natural habitats. Introducing a permitting system for new greenhouses can regulate the number and size of these structures, often requiring environmental impact assessments (EIAs) before construction is approved (Dutta and Bandyopadhyay, 2010; Joseph et al., 2019).

To further minimize environmental damage, specific building codes (Listokin and Hattis, 2005) for greenhouses should be enforced, focusing on reducing energy consumption and enhancing sustainability. A comprehensive EIA, evaluating the potential impacts on local water resources, soil health, biodiversity, and air quality, should be mandatory before any greenhouse project is approved. Including community input in the EIA process can also address public concerns and increase transparency during planning and implementation (Aroonruengsawat et al., 2012; Simpson et al., 2019).

Sustainable agricultural practices are vital in reducing the negative impacts of greenhouse farming. Encouraging the use of Integrated Pest Management (IPM) (Al-Zyoud, 2014; Van Lenteren and Nicot, 2020) can decrease reliance on chemical pesticides by incorporating biological pest controls (Pilkington, 2010), crop rotation (Ouda, 2018; Boincean et al., 2019), and other ecological methods. Additionally, implementing water-efficient irrigation systems, such as drip irrigation (Dasberg and Or, 2013; Wu et al, 2022), and promoting rainwater harvesting (Tzortzakis et al., 2020) or the use of treated wastewater can conserve freshwater resources. Utilizing renewable energy sources, like solar panels (Gorjian et al., 2021) or wind turbines, to power greenhouse operations can also significantly reduce the carbon footprint associated with traditional energy sources (Chel and Kaushik, 2011; Mostefaoui and Amara, 2019).

Education and awareness are key components in promoting sustainable practices (Sterling and Huckle, 2014). Educating greenhouse operators and workers about sustainable methods, the risks of pesticide use, and alternative techniques can lead to more environmentally friendly farming. Moreover, raising awareness among local communities about the impacts of greenhouse expansion and their role in regulatory processes can empower residents and encourage responsible development (Kavga et al., 2021).

To ensure compliance with environmental standards, regular inspections by environmental agencies are essential (U.S. Environmental Protection Agency, 2019). These inspections can help detect non-compliance early and prevent environmental degradation. Establishing a system of penalties for non-compliance, along with incentives for those who adopt sustainable practices, can motivate greenhouse operators to adhere to best practices (Al-Qassim et al., 2022; Al-Sartawi, 2022; EHS Daily Advisor, 2024).

Innovation and research also play critical roles in advancing sustainable greenhouse farming. Supporting research into new technologies, such as advanced materials for greenhouse covers (Maraveas et al., 2021) that enhance energy efficiency or new agricultural techniques that reduce chemical inputs, can lead to significant improvements (Giacomelli et al., 2007, Marcelis et al., 2019; Kavga et al., 2021; Hoseinzadeh and Garcia, 2024). Encouraging partnerships between research institutions, government agencies, and the private sector can facilitate the development of best practices and technologies tailored to specific regional needs (Hoffman and Loeber, 2016).

International cooperation is crucial in harmonizing sustainable greenhouse farming practices across borders (FAO 2024). Countries can work together to adopt international standards (International Organization for Standarts [ISO] (2017) that promote global sustainability goals. Furthermore, international forums and workshops can be instrumental in sharing knowledge and experiences related to greenhouse management, helping regions new to this form of agriculture implement effective strategies from the start (Mekouar, 2021).

## 3. AN OVERVIEW OF GREENHOUSE FARMING AND REGULATIONS IN THE WORLD AND TURKEY

In light of all this information, let's take a look at the current state, procedures, and regulations regarding greenhouse expansion and construction both globally and in Turkey.

### 3.1. Europe

Countries like the Netherlands, Spain, and Italy are leaders in high-tech greenhouse technologies (DutchGreenhouses, 2024; Ravensbergen, 2024). These countries utilize advanced systems for climate control, irrigation, and automation to maximize productivity while minimizing environmental impacts (Ben-Lhachemi, 2024; HBS, 2024). European greenhouses often incorporate sustainability measures such as renewable energy sources, water recycling systems, and integrated pest management (European Commission [EC], 2020; Riudavets, 2020).

In the European Union, the process for obtaining permission to construct a greenhouse typically involves complying with both national and EU-wide environmental regulations (GOV.UK, 2024). These regulations focus on ensuring sustainable land use and minimizing environmental impacts. For large-scale greenhouse projects, an Environmental Impact Assessment (EIA) may be required to evaluate the potential environmental impacts, ensuring the project does not significantly harm the local ecosystem or biodiversity (Kleinschmidt and Wagner, 2013; EC, 2020; 2024)

Furthermore, EU countries must adhere to land use regulations under the broader EU climate and energy framework. These regulations ensure that any changes in land use, such as converting forested areas to agricultural use for greenhouses, are offset by equivalent $CO_2$ removals elsewhere. This is part of the EU's "no-debit rule," which requires that accounted greenhouse gas (GHG) emissions from land use changes are compensated by removals to maintain or enhance carbon sinks. These measures align with the EU's 2030 climate and energy framework and its commitment to sustainable land management and reducing net GHG emissions by 55% compared to 1990 levels by 2030 (EC, 2018/841; 2022).

In addition to these overarching rules, specific local building permits and zoning regulations apply. These can include restrictions on the size and location of greenhouses, with some areas limiting the footprint of agricultural structures to preserve natural landscapes and prevent urban sprawl. The construction of greenhouses must also align with EU sustainable development goals, including energy efficiency standards and the use of sustainable materials where possible. In particularly sensitive regions, additional restrictions might be imposed to protect specific habitats or species. These areas might have caps on the total area that can be developed or special requirements for managing runoff and waste (Von Elsner et al, 2000).

The actual process of obtaining these permissions usually begins with a planning application to the local municipality, followed by a review that considers both national and EU regulations. Public consultations may also be required, particularly for larger projects with significant environmental impacts. Overall, while there is no specific EU-wide law directly limiting the total area of land that can be used for greenhouses, the combination of local, national, and EU regulations ensures that greenhouse development is conducted in a sustainable and environmentally responsible manner (EC, 2018/841; 2020; 2022; 2024).

### 3.2. North America

In the United States and Canada, greenhouse farming spans from small-scale operations to large commercial ventures, with a significant emphasis on producing vegetables, flowers, and ornamental plants. Automation and advanced agricultural technologies are increasingly adopted to enhance efficiency and crop yields. The regulatory environment for greenhouse construction in North America varies significantly between the United States and Canada, reflecting their different governmental structures and policies (Bryant 2013) .

In the U.S., land use and construction permissions are primarily governed at the local and state levels. Each state or municipality establishes its zoning laws and building codes, which can vary widely across the country. There isn't a federal policy specifically for greenhouses, so regulations rely heavily on local land use policies. Although there is no overarching federal requirement like the EU's Environmental Impact Assessment (EIA), large projects that may affect federally protected lands or species might require environmental reviews under the National Environmental Policy Act (NEPA) (EPA, 2024a;b; c).

Many U.S. regions have specific zones designated for agricultural use, including greenhouses. These zones help manage where agricultural operations can occur, aiming to protect farmland from being overtaken by urban or non-agricultural development. Greenhouse constructors must obtain relevant building permits from local authorities, ensuring that the structures are safe, comply with local codes, and sometimes meet certain environmental sustainability criteria (Eraslan, 2023, Anadolu Agency, 2024).

Similarly, in Canada, control over land use and building regulations is largely at the provincial and territorial levels, with municipalities playing a significant role in zoning and permits. For large projects or those in sensitive areas, Canadian law may require a comprehensive environmental assessment process, which considers the impacts on local ecosystems and communities, analogous to the EU's EIA (Liu et al, 2018; Government of Canada, 2024)

In provinces like British Columbia, Agricultural Land Reserves (ALR) are specifically designated to protect and promote agricultural activities, including greenhouse farming. Land within these reserves is restricted primarily to agricultural uses. Additionally, Canadian municipalities and provinces may have various sustainability initiatives affecting greenhouse operations, such as regulations on water use, pesticide use, and energy efficiency (Fraser, 2002; 2004;Dring et al, 2023).

### 3.3. Comparison with EU Regulations

The EU has more centralized regulations, particularly regarding environmental impact assessments and sustainable land management, while the U.S. and Canada rely more on state or provincial and local regulations for managing greenhouse construction. This results in a more uniform standard across EU member states, especially under frameworks like the Land Use, Land-Use Change, and Forestry (LULUCF) regulations, whereas North America sees more variation in its approach. Both regions emphasize the protection of agricultural land, but the EU's methods are more closely integrated with environmental goals, contrasting with the more segmented approach seen in North America.

Overall, while the basic concerns around greenhouse construction-such as land use, environmental impacts, and zoning-are similar across the U.S., Canada, and the EU, the regulatory frameworks and the degree of centralization differ significantly. These differences generally help prevent completely unchecked development in all three regions.

### 3.4. Asia

Countries like China, Japan, and South Korea are rapidly expanding their greenhouse sectors, focusing on technological innovations to address space and resource challenges. Many Asian countries support greenhouse farming through subsidies and research, reflecting a commitment to boosting agricultural productivity (Wang et al., 2017, Guo et al, 2024).

Greenhouse regulations in Asia vary widely by country, shaped by different environmental policies and agricultural practices. Unlike the centralized approach in the European Union, Asia's regulations are more decentralized but still effectively manage greenhouse operations. In several countries, EIAs are required for large agricultural projects, including greenhouses. Local governments control greenhouse placement through zoning laws and building codes to minimize environmental and community impacts. Some countries also promote sustainable practices, such as water conservation and reduced chemical use, in greenhouse farming. In Southeast Asia, incentives encourage the adoption of environmentally friendly technologies like renewable energy and water recycling (Liu et al, 2022; Guo et al, 2024).

For countries that export agricultural products, international standards for sustainable production often guide greenhouse operations, ensuring they meet environmental and health requirements. Notable regulations include Singapore's Environmental Protection and Management Act (Singapore Status Online, 1999, Singapore Environmental Council, 2019), Vietnam's Law on Environmental Protection (Do and Thi, 2022), and Taiwan's Climate Change Response Act (Climate Change Laws of the World, 2015) . These laws focus on mitigating environmental impacts and protecting public health in agricultural development, including greenhouse farming.

### 3.5. Middle East

Due to arid conditions, countries like Israel and the United Arab Emirates focus on climate-adaptive technologies, including desalination and solar-powered greenhouses. These countries emphasize producing high-value crops for export markets, leveraging advanced water-saving technologies (Nielsen and Adriansen, 2005; Home, 2024).

In the Middle East, greenhouse construction and operation regulations prioritize best agricultural practices and environmental sustainability. The focus is on minimizing chemical use and promoting safe, efficient production methods to ensure high yields and quality while protecting the environment, workers, and consumers. Standards typically include guidelines on site selection, greenhouse design, and integrated pest management to comply with national and international regulations (Nielsen and Adriansen, 2005; Home, 2024).

In regions like Saudi Arabia, there is a strong emphasis on modernizing agricultural practices through technologies like vertical and greenhouse farming (Hadid & Ahmed, 2024). The Saudi government's initiatives and collaborations reflect a structured approach to integrating these advanced agricultural technologies within regulatory frameworks. These practices help manage greenhouse expansion, ensuring alignment with environmental and safety standards, and preventing unchecked growth that could have negative ecological or social impacts (Fiaz et al. 2018; Alotaibi et al., 2020).

### 3.6. Africa

While greenhouse farming is less developed in many African countries, there is significant potential for growth, particularly in regions with favorable climates like Kenya and Morocco. These initiatives often aim to boost local food production and improve food security, with support from local governments and international aid organizations (Sanzua et al., 2018; Musafiri et al., 2020). Regulations for greenhouse construction and operation in Africa vary widely, reflecting diverse environmental, economic, and social conditions. These regulatory frameworks are typically designed to address local agricultural needs, promote environmental conservation, and achieve sustainable development goals. In many African countries, EIAs are required for large agricultural projects, including greenhouses (Musyoka et al., 2019).

Countries like Kenya and South Africa have specific guidelines for greenhouse farming within their agricultural policies. These guidelines focus on improving production efficiency, promoting sustainable technologies, and reducing environmental impacts. Additionally, there are strict regulations regarding the use of genetically modified organisms (GMOs) in greenhouses, with guidelines to prevent cross-contamination with non-GMO environments (Mayet, 2007; Bohama et al., 2010; Muchiri et al., 2020).

### 3.7. Latin America

Countries like Mexico and Brazil use greenhouses to produce a variety of crops year-round, allowing them to overcome diverse climatic conditions (Elings et al., 2013). Greenhouse production in these countries is largely focused on exporting vegetables and flowers to North American and European markets (Victoria et al., 2011).

Greenhouse farming activities in Latin America are subject to Environmental Impact Assessment (EIA) processes due to their environmental effects. In Brazil, the Environmental Policy Act regulates the environmental impacts of greenhouse activities, while Mexico's National Water Act governs water usage and wastewater discharge. However, corruption and institutional weaknesses in many countries hinder the effective implementation of EIA processes, leading to issues such as deforestation and biodiversity loss. For instance, uncontrolled greenhouse activities in Brazil have caused significant damage to the Amazon Rainforest and reduced the living spaces of local communities. Additionally, the misuse of agricultural chemicals increases greenhouse gas emissions, contributing to climate change. Promoting sustainable agricultural practices and ensuring transparency in EIA processes are therefore of critical importance. Nevertheless, inconsistent enforcement of these regulations can result in uncontrolled greenhouse expansion. The effectiveness of these measures often depends on a country’s economic priorities, institutional capacity, and commitment to environmental sustainability (Gomez and Silva, 2005; Coze and Nava, 2009; Moeria, 2013; Nadal et al., 2019; Zepeda and Natarajan, 2020).

## 4. REGIONAL BREAKDOWN OF GREENHOUSE CULTIVATION IN TURKEY

Turkey is among the top four countries globally and ranks second in Europe, after Spain, in terms of protected cultivation (Republic of Turkey, Ministry of Agriculture and Forestry [RT MoAF], 2024a). Over the past decade, the average size of protected cultivation operations in Turkey has increased from 0.2 hectares to 0.4 hectares. Recently, due to the support, grants, and loans provided by the Ministry and other relevant institutions, the number of modern greenhouse operations has rapidly increased, with an average size of 2.7 hectares (RT MoAF, 2024b).

The total value of Turkey's protected vegetable production is approximately 10 billion TL. Antalya leads in greenhouse vegetable production, contributing 48% (3.8 million tons) of the total, followed by Mersin with 16% (1.2 million tons), Adana with 13% (1 million tons), and Muğla with 9% (690.000 tons). In terms of the land area covered by greenhouses, Antalya occupies 36% of the total 79.000 hectares, Mersin 25%, Adana 20%, Muğla 5%, İzmir 2%, Aydın %2, and Hatay 2% (RT MoAF, 2024b). Turkey's modern greenhouse area is approximately 2.200 hectares, where soilless farming methods are employed, primarily for export-oriented production (Öz, 2023).

According to Baytorun (2016), 84% of Turkey's protected cultivation area is located along the Mediterranean coast, which is favored due to its warm winter months, ideal for this type of agriculture. The favorable climate conditions, including mild winters, make it an optimal location for year-round cultivation, and this region is responsible for a large portion of Turkey's vegetable production in greenhouses. Following the Mediterranean, the Aegean region, particularly around İzmir and Muğla, also sees significant greenhouse activity. The availability of geothermal resources for heating and a conducive microclimate supports extensive greenhouse farming in this area. In the north, areas around Yalova in the Marmara Region benefit from a microclimate that supports the cultivation of various plants, including ornamental plants in greenhouses. In contrast, regions like the Black Sea are less dominant in greenhouse cultivation due to less favorable climatic conditions for year-round production. However, certain areas with suitable microclimates still support some greenhouse farming.

The primary crops cultivated in these greenhouses across Turkey are vegetables, with a growing trend towards modern and sustainable practices to improve productivity and reduce environmental impact. While Turkey has made significant strides in modernizing its greenhouse infrastructure, the journey towards comprehensive sustainability in this sector is still in its early stages (RT MoAF, 2024c).

### 4.1. Regulatory Framework for Controlling Greenhouse Expansion in Turkey

There is no specific law in Turkey that directly prevents the uncontrolled expansion of greenhouses; however, various regulations indirectly affect the construction and operation of greenhouses. Specifically, the Zoning Law No. 3194 and its associated regulations contain general provisions regarding the construction and use of structures. Additionally, the Soil Conservation and Land Use Law No. 5403 provides regulations aimed at protecting agricultural lands and preventing their misuse. These laws indirectly regulate the construction and operation of greenhouses to ensure compliance with certain criteria (TR Presidency Legislation Information System, 1985; 2005; Yücer, 2020). Some of the key regulations include:

#### 4.1.1. Environmental Impact Assessment (EIA) Regulation:

Large-scale agricultural projects, including greenhouses, are required to undergo an EIA. These assessments aim to evaluate the environmental impacts of greenhouse projects and identify necessary measures to minimize these effects. The EIA process is a step towards ensuring that greenhouses are constructed without causing significant harm to the environment (Tekayak, 2014; Elvan, 2018). The EIA Regulation regulates the administrative and technical procedures and principles of this process. Additionally, pursuant to Article 6 of the EIA Regulation, projects cannot be granted incentives, approvals, permits, construction, or occupancy licenses, nor can they commence before the EIA process is completed (Republic of Turkey, The Ministry of Environment, Urbanization, and Climate Change [RT MoEUCC], 2022)

#### 4.1.2. Soil Conservation and Land Use Law:

The conservation and sustainable use of agricultural land in Turkey is regulated by Law No. 5403 on Soil Conservation and Land Use (2005). This law covers matters such as the classification of agricultural land, the determination of minimum agricultural land sizes, and the prevention of land fragmentation.

Article 8 of the law stipulates the classification of agricultural land based on its natural characteristics and its importance to the country's agriculture. Additionally, minimum agricultural land sizes are established, and subdivision and partitioning below these sizes are restricted. These regulations aim to ensure the protection and sustainable use of agricultural land. Article 13 of the law restricts the non-agricultural use of agricultural land and makes it mandatory to obtain the Ministry's approval for such uses. This article supports the conservation and sustainable use of agricultural land.

The provisions of this law aim to ensure that agricultural structures such as greenhouses are built on appropriate land and to protect agricultural land.

#### 4.1.3. Zoning Laws and Local Regulations:

In Turkey, the construction and expansion of greenhouses are also regulated by zoning laws and local regulations. In particular, construction in protected areas and natural conservation sites is subject to specific restrictions.

According to Zoning Law No. 3194, settlements and constructions within these areas must comply with planning, technical, health, and environmental standards. In this context, the construction of greenhouses must also adhere to zoning plans and relevant legislation (RT MoEUCC, 1985) .

The conservation and use conditions determined for natural conservation sites limit construction activities in these areas. Based on the principles established by the Ministry of Environment, Urbanization, and Climate Change, natural conservation sites are classified as strictly protected sensitive areas, qualified natural conservation areas, and sustainable conservation and controlled use areas, with construction conditions regulated accordingly (RT MoEUCC 2024). Local governments and environmental organizations play a crucial role in preventing the uncontrolled spread of greenhouses. By considering urban planning principles and public interest during the preparation and implementation of zoning plans, they ensure that greenhouses are built in appropriate areas (Şimşek, 2024)

In summary, while there is no specific law directly aimed at preventing the uncontrolled expansion of greenhouses in Turkey, these regulations indirectly contribute to this goal. Therefore, the construction and expansion of greenhouses are controlled through zoning laws, regulations on natural conservation sites, and planning decisions by local authorities.

## 5. IMPACT OF THE UNCONTROLLED GREENHOUSE EXPANSION ON TOURISM IN THE MEDITERRANEAN REGION OF TURKEY

The rapid and uncontrolled expansion of greenhouse farming in the Mediterranean region of Turkey poses significant challenges to the tourism industry, as it threatens the natural landscapes, environmental quality, and cultural heritage that are central to the area's appeal to visitors (Sevgican, 1997; Mihalko and Ratz, 2007; Tuzel and Oztekin, 2016; Sturiale et al. 2024).

### 5.1.Landscape Degradation and Loss of Scenic Beauty

The Mediterranean region is renowned for its picturesque landscapes, including coastal views, traditional agricultural areas, and natural reserves. The uncontrolled spread of greenhouses can significantly alter these landscapes, replacing natural or historically cultivated lands with large, industrial-looking greenhouse structures. This transformation can diminish the region’s aesthetic appeal, which is a major attraction for tourists. Visitors seeking natural beauty, traditional villages, and authentic Mediterranean experiences may be deterred by the presence of extensive greenhouse farming (Kiper et al. 2011; Yang et al. 2021).

### 5.2. Environmental Pollution and Deterioration of Tourist Attractions

Greenhouse farming often involves the intensive use of fertilizers, pesticides, and plastic materials. If not properly managed, these can lead to environmental pollution, affecting both land and water resources. For example, chemical runoff from greenhouses can contaminate nearby rivers, lakes, and coastal waters, leading to water pollution that affects beaches, which are key tourist attractions (Breś and Trelka, 2005; Shi et al, 2009; Farvadin et al., 2024). Polluted beaches and waters can result in a decline in tourism, as visitors are likely to avoid areas with visible pollution or reports of environmental hazards.

### 5.3. Health Risks and Decreased Appeal

The use of chemicals in greenhouse farming can pose health risks not only to local residents but also to tourists. Air and water pollution, along with the improper disposal of agricultural waste, can lead to unpleasant odors and hazardous conditions, making the area less appealing to tourists (Breś and Trelka, 2005; Shi et al, 2009; Antón et al. 2019). Tourists are increasingly conscious of health and environmental quality when choosing destinations, and reports of pollution or health risks can lead to a decline in tourist numbers.

### 5.4. Resource Competition and Reduced Availability for Tourism

Tourism and agriculture, especially greenhouse farming, often compete for the same limited resources, such as water and land. In regions where water is scarce, the high water demand of greenhouses can lead to shortages that affect the availability of water for hotels, resorts, and other tourism-related facilities (Nikolaou et al. 2019; Farvadin et al. 2024). This competition can also lead to higher water prices, increasing operational costs for the tourism industry. In extreme cases, it may even result in water rationing, which can disrupt tourism activities and reduce the overall visitor experience.

### 5.5. Impact on Local Climate and Visitor Comfort:

Large concentrations of greenhouses can create localized warming, known as the heat island effect (Chaudhry and Sidhu, 2022). This effect can increase temperatures in the surrounding areas, making the local climate less comfortable for tourists, particularly during the hot summer months. Increased temperatures can also affect outdoor activities that are central to the tourist experience, such as hiking, sightseeing, and beach outings. If the region becomes less comfortable due to these localized climate changes, it may deter visitors and reduce the region’s appeal as a tourist destination.

### 5.6. Alteration of Traditional Cultural Landscapes:

The Mediterranean region is not only valued for its natural beauty but also for its cultural landscapes, which include traditional farming practices and rural heritage. Uncontrolled greenhouse expansion can lead to the erosion of these cultural landscapes, replacing small-scale, traditional agriculture with industrial-scale greenhouse operations. This shift can diminish the cultural authenticity of the region, which is a significant draw for cultural and heritage tourism (Judy, 2016). Tourists seeking authentic experiences, local traditions, and historical sites may find the region less attractive if these elements are overshadowed by modern agricultural developments.

## CONCLUSION

The rapid, unchecked growth of greenhouse farming along the Mediterranean coast of Turkey has undeniably boosted agricultural productivity and local economies. However, this expansion comes at a significant cost to the region's natural landscapes, environmental quality, and tourism sector. The extensive greenhouse operations alter scenic views, intensify competition for limited water resources, and contribute to pollution and habitat loss-factors that diminish the area's appeal to tourists seeking natural beauty and cultural heritage.

To balance agricultural development with tourism sustainability, a comprehensive regulatory framework is essential. Enforcing zoning laws, promoting sustainable agricultural practices, and requiring environmental impact assessments for greenhouse projects could mitigate the adverse effects on the local ecosystem. By fostering responsible growth, Turkey can protect its vital tourism assets while supporting its agricultural sector.

This chapter underscores the urgent need for collaborative efforts among government agencies, local communities, and industry stakeholders to implement sustainable practices. Only through such a holistic approach can Turkey preserve its Mediterranean coastline as an attractive destination, ensuring long-term economic benefits from both agriculture and tourism.

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# CHAPTER VIII

## THE DUAL IMPACT OF AGRICULTURAL INCENTIVES IN TURKEY: FROM ECONOMIC GROWTH TO ENVIRONMENTAL CHALLENGES, WITH A FOCUS ON THE MEDITERRANEAN BANANA GREENHOUSES

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## INTRODUCTION

Agricultural incentives have played a pivotal role in shaping Turkey's agricultural landscape since the foundation of the Republic. These incentives, designed to boost productivity and economic growth, have directed producers toward specific crops, leading to significant changes in the country's agricultural output. Over the decades, government support has been instrumental in popularizing certain crops among farmers, resulting in increased production and, in many cases, economic prosperity (Kızıl and Çürük, 2021; Oğul, 2022; Merdan, 2023).

However, the implementation of these incentives may not have been without consequences. While they have likely contributed to economic growth and increased agricultural productivity, they also appear to have the potential to lead to several unintended negative outcomes. The possible expansion of monoculture farming, depletion of soil fertility, environmental degradation, and economic vulnerabilities are some of the critical issues that might emerge as a result of these policies (Kızıl and Çürük, 2021).

This chapter aims to explore the dual impact of agricultural incentives in Turkey-highlighting both their positive contributions and the adverse effects they have had on the environment, economy, and society. The discussion will focus particularly on the Mediterranean region, where banana greenhouses have proliferated in recent years. While these greenhouses have boosted local production and reduced dependency on imports, they are also thought to raise significant concerns about their potential impact on the Mediterranean climate, soil quality, human health, and the region's tourism industry.

By examining the historical context of agricultural incentives in Turkey and their outcomes, this chapter will provide a comprehensive overview of the benefits and challenges associated with these policies. It will also propose potential solutions to mitigate the negative effects, with a particular focus on the current issues surrounding banana greenhouses in the Mediterranean region.

## 1. HISTORICAL DEVELOPMENT OF AGRICULTURAL INCENTIVES IN TURKEY

### 1.1. The Early Republican Period (1920s-1950s)

During the early years of the Turkish Republic, agricultural policy was a cornerstone of the new government's strategy to modernize the economy and ensure food security (Karpat, 2015; Keyder, 2020). The period from the 1920s to the 1950s witnessed significant efforts by the state to encourage the production of key staple crops, particularly wheat and sugar beet, through various incentives and institutional support. These policies were not just about increasing production but were deeply intertwined with the broader goals of nation-building and economic independence (Pamuk, 2012; Karpat, 2015; Keyder, 2020).

### 1.1.1. Wheat and Other Cereals:

Wheat, as a staple food and a symbol of self-sufficiency, was at the forefront of these efforts. The government recognized the importance of securing a stable food supply and reducing dependency on imports, which was particularly crucial in the early years of the Republic (Yahya et al., 2016; Akbaş, 2022). The establishment of the Turkish Grain Board (TMO) in 1938 marked a significant step in this direction (TMO, 2024). Tasked with purchasing, storing, and regulating the price of wheat, TMO provided farmers with a guaranteed market and stable prices, which not only stimulated wheat production but also helped stabilize the agricultural economy during times of fluctuation in global markets. This approach, as noted by agricultural historians, was instrumental in securing food stability during a period marked by global economic instability and war (Bacaksız and Uysal, 2019; Bulut, 2023; Giray, 2023).

### 1.1.2. Sugar Beet Production:

In parallel, the sugar industry saw significant growth due to state interventions. The early Republican era's focus on industrialization found expression in the establishment of sugar factories as part of a broader economic strategy. The first sugar factories, such as those in Uşak and Alpullu, were established in the mid-1920s and served as models for subsequent investments (Pamuk, 2012; Kopuz, 2017). By the 1930s, sugar beet production had become a priority, supported by the state's financial and logistical backing. This not only facilitated the establishment of a domestic sugar industry but also contributed to rural development by creating jobs and infrastructure in previously underdeveloped areas (Quataert, 2002). The success of these factories is a testament to the effective use of state resources in fostering industrial and agricultural growth simultaneously, a point underscored by scholars studying the period's economic policies (Karayaman, 2012; Yurtoğlu, 2024).

## 1.2. The 1960s-1980s: Industrialization and Agricultural Expansion

The period from the 1960s to the 1980s marked a significant shift in Turkey's economic strategy, with a strong focus on industrialization that was closely supported by agricultural expansion (Keyder, 2020; Pamuk, 2012; Ataseven and Sumelius, 2014). The introduction of the First Five-Year Development Plan (1963-1967) was pivotal in outlining the importance of agriculture as a foundational element for industrial growth. During this era, key crops such as cotton, tobacco, hazelnuts, and sunflowers were heavily incentivized by the state, leading to substantial changes in the agricultural landscape (Snyder, 1969; Öniş and Şenses, 2009; Durdag, 2012).

### 1.2.1. Cotton and Tobacco:

Cotton production, particularly in the Aegean and Southeast Anatolia regions, became a critical component of the state's strategy to support the burgeoning textile industry. The government provided direct subsidies, low-interest loans, and price supports to cotton farmers, leading to a significant increase in production (Boratav, 1982; Keskinkılıç, 2014). Similarly, tobacco, primarily cultivated in the Aegean and Black Sea regions, was bolstered by state incentives. The government's monopoly on tobacco through TEKEL ensured stable prices and a guaranteed market for producers, further stimulating production (Snyder, 1969; Pamuk, 2006; Durdag, 2012).

### 1.2.2. Hazelnuts:

In the Black Sea region, hazelnut production flourished due to strong state support, turning Turkey into the dominant player in the global hazelnut market. Government incentives focused on increasing production through subsidies, the establishment of cooperatives, and technical support for farmers (Snyder, 1969; Pamuk, 2006; Durdag, 2012; Topuz et al. 2019). By the 1980s, Turkey was supplying nearly 59% of the world's hazelnuts (Aktaş et al., 2009).

### 1.2.3. Sunflowers:

Sunflower cultivation, particularly in the Thrace region, was another success story driven by state incentives aimed at meeting the growing domestic demand for edible oils. The government provided price supports to encourage sunflower cultivation and promoted the establishment of cooperatives to organize producers. These policies contributed to better marketing of products and improved production processes for farmers. The Thrace Region holds a significant share in Turkey’s sunflower production. During the 1970s, the decline in the production of other oilseed crops and the restrictions on poppy cultivation increased the economic importance of sunflower farming. During this period, sunflower accounted for approximately 30% of Turkey’s total oilseed crop production. This led to a steady increase in production throughout the 1970s and 1980s (Erem Kaya et al. 2010).

### 1.3. The 1980s-2000s: Market Liberalization and Export-Oriented Growth

The period from the 1980s to the 2000s was marked by significant changes in Turkey's agricultural policies, driven by a broader shift towards market liberalization and integration with global markets (Aydın, 2010; Koçak 2010). The January 24 Decisions of 1980 brought significant changes to Turkey's economic structure. With these decisions, protectionist and interventionist state policies in the agricultural sector were replaced by market-oriented policies. In this context, steps were taken such as increasing fertilizer prices, removing subsidies for chemical fertilizers and other inputs, tightening the conditions for agricultural credit usage, and reducing agricultural supports (Öztürk et al., 2008; Kaya and Kalaycı, 2021). The transition to a free market economy initiated by the January 24 Decisions paved the way for the implementation of export-oriented growth policies in the agricultural sector. During this period, Turkey's initiation of a Customs Union with the European Union and the elimination of tariffs on agricultural products and some other goods made competitiveness even more significant .Key crops during this period included olives, citrus fruits, and bananas, which were increasingly promoted for their export potential (Hiç, 2020).

#### 1.3.1. Olives:

Olive production, particularly in the Aegean and Mediterranean regions, saw substantial growth during this period. The government's focus on export-oriented agriculture led to increased investment in olive cultivation and processing. Advances in agricultural techniques, combined with the natural suitability of the Mediterranean climate for olive trees, enabled Turkey to become one of the world's leading producers of olives and olive oil (Bilgilioğlu, 2021; Öztürk et al., 2021; Uzundumlu and Ateş, 2024). The suitability assessment for olive cultivation in regions like Mersin, using GIS and multi-criteria decision-making, has highlighted areas with optimal conditions for olive growth, further promoting production in these regions (Mercan & Acibuca, 2023).

#### 1.3.2. Citrus Fruits:

Citrus production, especially in the Mediterranean region, became a key focus of agricultural policy during this period. The introduction of improved irrigation systems and government incentives for citrus farming allowed for the expansion of citrus orchards, particularly in Mersin and Antalya. These regions benefited from their favorable climate, which is ideal for citrus cultivation. In total fruit production, citrus ranks third after grapes and apples. During this era, the expansion of citrus production areas and improvements in productivity were made possible through state-provided incentives and support (Aşık and Ellibeş, 2020). After 1980, Turkey adopted an export-oriented growth model and implemented various incentive methods to boost exports. In this context, citrus producers were provided with tax incentives, low-interest loans, and infrastructure investments. These incentives enabled producers to adopt modern agricultural techniques and increase their production capacity (Şaşmaz and Karamıklı, 2018).

### 1.4. The 2000s - 2020s: Towards Sustainability and Organic Agriculture

The period from the 2000s to the 2020s marked a significant transition in Turkey's agricultural policy, with an increasing emphasis on sustainability, organic farming, and the cultivation of medicinal and aromatic plants. This shift was driven by both domestic and international factors, including growing environmental concerns, consumer demand for organic products, and Turkey's alignment with European Union agricultural standards.

**1.4.1. Bananas:**

Banana production in Turkey began on a commercial scale in the 1930s. However, a significant increase in production, supported by government incentives, has been observed particularly since 2017. During this period, state-provided subsidies have led to substantial growth in banana cultivation areas and production volumes. For instance, in the province of Adana, banana cultivation expanded from 75 decares to 7,558 decares since 2017 due to government support (Gubbuk et al. 2017; TUİK, 2020; Baysal and Türkay, 2023; Karar, 2024).

**1.4.2. Medicinal and Aromatic Plants:**

The cultivation of medicinal and aromatic plants has become increasingly significant in Turkey, especially as global demand for these products has risen. The government has promoted the production of these plants through targeted incentives, recognizing their potential not only for export but also for supporting rural development in less industrialized areas. The Aegean, Mediterranean, and Southeastern Anatolia regions have become key centers for the cultivation of plants like thyme, sage, and lavender (Öztürk et al. 2012; Pakdemirli et al. 2021; Máthé and Turgut, 2023).

**1.4.3. Organic Farming and Sustainable Agriculture Initiatives:**

Organic agriculture in Turkey has seen substantial growth since the early 2000s, supported by a combination of government policies and market demand. The Turkish government introduced various incentives, including subsidies for organic certification, training programs for farmers, and support for organic inputs like seeds and fertilizers. These efforts have led to an increase in the area of land under organic cultivation, particularly in regions such as the Aegean and Mediterranean, where crops like olives, figs, and grapes are predominantly grown (Olhan et al. 2005). The area dedicated to organic farming increased threefold from 2007 to 2016, while the area under good agricultural practices grew by 88 times during the same period (Boz and Kaynakçı, 2019; Eryılmaz et al. 2019).

Alongside the push for organic farming and medicinal plants, Turkey has also implemented broader sustainable agriculture initiatives. These initiatives are designed to enhance the environmental performance of agriculture by promoting practices such as crop rotation, reduced tillage, and the use of renewable energy in farming operations. The TARSEY project, launched in the mid-2010s, is one such initiative that aims to integrate sustainable practices across all agricultural activities in the country (Çeker, 2016; Republic of Turkey Ministry of Agriculture and Forestry [RT MoAF], 2024a, b)

## 2. ECONOMIC AND PRODUCTIVE BENEFITS OF AGRICULTURAL INCENTIVES

### 2.1. Growth in Productivity and Efficiency Gains

Since the early 2000s, agricultural productivity in Turkey has seen significant growth, largely driven by government incentives designed to modernize the sector and improve efficiency. One of the most impactful outcomes of these incentives has been the increased investment in technology and the rapid modernization of agriculture. The use of advanced irrigation systems, precision farming tools, and modern agricultural machinery has not only boosted yields but also reduced labor costs (Ceylan, 2003; Hatunoğlu and Eldeniz, 2012; Yüceer and Semerci, 2020). Experts highlight that these technological advancements have been crucial in enhancing Turkey's agricultural competitiveness on the global stage, particularly in high-value crops.

The productivity improvements have also significantly contributed to the economic development of rural regions. In particular, regions like Eastern and Southeastern Anatolia, which have historically lagged in development, have benefited from these incentives, leading to increased agricultural output and economic revitalization (Özkök, 2009; Akyol, 2016; Yazgan and Kadanalı, 2019). The targeted support has played a vital role in reducing regional disparities and promoting more balanced economic growth across the country (Arslan, 2014).

### 2.2. Enhancement of Export Potential

Turkey's agricultural incentives, particularly since the early 2000s, have significantly bolstered the country's export potential (Hatunoğlu and Eldeniz, 2012; Merdan, 2023). The focus on enhancing agricultural productivity and aligning production with global market demands has resulted in notable increases in the export of key agricultural products. This expansion has not only contributed to the country's economic growth but has also positioned Turkey as a significant player in global agricultural markets (Şeker, 2020; Yüceer et al., 2020).

The aggressive pursuit of export-oriented policies, supported by government incentives, has led to substantial growth in Turkey's agricultural exports. In 2021, agricultural exports surged by over 22,2 %, reaching nearly $29.74 billion. This growth was driven by high demand for products such as hazelnuts, flour, and pasta, which collectively accounted for a significant portion of the country's total exports. The diversification of export markets, particularly in Europe and the Middle East, has also played a critical role in sustaining this growth (Sansarlıoğlu, 2022).

The Turkish government has actively pursued Free Trade Agreements (FTAs) and other trade policies to enhance market access for Turkish agricultural products. These agreements have facilitated the entry of Turkish goods into new markets and helped stabilize export revenues despite global economic fluctuations. For instance, revised FTAs with countries like Bosnia and Herzegovina and Montenegro, as well as ongoing negotiations with others, have been instrumental in expanding Turkey's export footprint (RT MoT, 2022a; b; c) .

### 2.3. Rural Development and Prevention of Migration

Agricultural incentives in Turkey have played a crucial role in promoting rural development and mitigating rural-to-urban migration, which has been a persistent challenge for the country. These incentives have been instrumental in improving the livelihoods of rural populations, supporting local economies, and stabilizing rural communities (Güreşçi, 2009; Yalçın and Kara, 2016; Güven, 2017; Mızırak & Ceylan, 2023; IFAD, 2023)

One of the primary objectives of agricultural incentives has been to enhance the economic viability of rural areas. By providing financial support, technical assistance, and infrastructure development, these incentives have helped boost agricultural productivity in rural regions. This, in turn, has created job opportunities and increased incomes for rural households, thereby reducing the economic pressures that often drive people to migrate to urban areas (Güreşci, 2009; Yalçın and Kara, 2016; Güven, 2017; Mızırak and Ceylan, 2023). For instance, programs such as the National Strategy for Rural Development (2014-2020) have focused on improving rural infrastructure, promoting sustainable agricultural practices, and supporting small-scale farmers (IFAD, 2023)

The rural-urban migration trend in Turkey has been a significant concern, particularly in regions where agriculture is the primary economic activity. Agricultural incentives have been strategically deployed to retain the rural workforce by making agriculture a more attractive and profitable livelihood. Investments in rural education, healthcare, and infrastructure, alongside direct agricultural subsidies, have contributed to slowing down the migration rate (Güreşci, 2009; Yalçın and Kara, 2016; Güven, 2017; Mızırak and Ceylan, 2023). This approach has not only helped preserve the rural population but also maintained the cultural and social fabric of these (IFAD, 2023).

### 2.4. Food Security and Reduction of Import Dependency

Agricultural incentives in Turkey have played a pivotal role in enhancing food security and reducing the country's dependency on food imports. This focus has become increasingly important in light of global supply chain disruptions, economic instability, and the pressing challenges posed by climate change. By boosting domestic agricultural production and implementing policies that encourage self-sufficiency, Turkey has made strides in securing its food supply while also addressing vulnerabilities related to import dependency (Eştürk and Ören, 2014; Karaman, 2018; Köse and Meral, 2021; Mızırak and Ceylan, 2023).

The Turkish government has prioritized the enhancement of domestic agricultural production as a means to achieve food security. Incentives have been directed toward increasing the production of essential crops like wheat, barley, and legumes, which are critical for the country's food supply (Kadakoğlu and Karlı, 2022). The implementation of subsidies, support for modern farming techniques, and the promotion of drought-resistant crop varieties have all contributed to a steady increase in the output of these staple crops. As a result, Turkey has been able to reduce its reliance on imported grains, particularly wheat, which is essential for bread production-a key component of the Turkish diet (Göçer, 2015; Tarsus Commodity Exchange, 2023; Agricultural Products Market, 2024).

One of the key goals of Turkey's agricultural policies has been to reduce the country's dependency on food imports, which has historically exposed the economy to global price fluctuations and supply chain disruptions (Köse & Meral, 2021; Mızırak and Ceylan, 2023). By investing in local agriculture, particularly in the production of strategic crops like wheat and pulses, Turkey has managed to curtail its import needs. For instance, policies encouraging the use of domestic seeds and fertilizers have reduced the need for imported agricultural inputs, thereby bolstering the overall self-sufficiency of the agricultural sector Tarsus Commodity Exchange, 2023; Agricultural Products Market, 2024).

## 3. THE NEGATIVE OUTCOMES OF AGRICULTURAL INCENTIVES

### 3.1. The Spread of Monoculture Farming

Since the early 2000s, agricultural incentives in Turkey have boosted production and economic growth but have also caused unintended negative effects, particularly the rise of monoculture farming. Incentives promoting high-yield crops like wheat, hazelnuts, and olives have increased production and exports but have also created environmental and economic challenges (Egemen, 1993; Korucu, 2004; Bengisu, 2011, Oğul, 2023).

Monoculture farming, where the same crop is grown repeatedly over large areas, has degraded soil quality. Continuous cultivation depletes soil nutrients, reducing fertility and increasing reliance on chemical fertilizers. This practice harms the environment by causing soil erosion and water pollution while raising farming costs due to the need for more inputs. Experts warn that without a shift to sustainable practices, the environmental damage could become irreversible, threatening the future of agriculture (Egemen, 1993; Stamp, 2004; Michaels, 2011).

The focus on monoculture has also reduced biodiversity. Traditional methods like crop rotation and mixed farming supported diverse plant and animal species, but monoculture has diminished habitats, leading to species decline. This loss not only affects ecosystems but also makes agriculture less resilient to pests and diseases, as diverse systems are better at natural pest control (Stamp, 2004; Michaels, 2011).

Monoculture farming has made Turkish agriculture more vulnerable to market and climate risks. Dependence on single crops exposes farmers to global price fluctuations and extreme weather. For example, a drop in hazelnut prices or droughts impacting olive production can severely affect entire regions (Çamoğlu, 2017; Yıldırım, 2019).

Experts advocate revising agricultural incentives to promote sustainable and diversified farming practices. Encouraging crop rotation, supporting a variety of crops, and incentivizing organic farming can enhance soil health, biodiversity, and economic resilience (Stamp, 2004; Michaels, 2011).

### 3.2. Soil Fertility and Erosion Issues

Agricultural incentives in Turkey, particularly those promoting intensive farming and monoculture, have significantly impacted soil fertility and exacerbated soil erosion, threatening the long-term sustainability of agriculture (Egemen, 1993).

The intensive use of chemical fertilizers and the continuous cultivation of high-yield crops, such as wheat (Uzun et al., 2022), maize (Yano et al., 2007; Gözener et al, 2016), hazelnuts (Kılıç et al. 2018; Aydemir, 2021), cotton (Bayhan et al, 2015; Çopur, 2018), and sugar beet, have depleted essential nutrients in the soil across many regions. This nutrient loss, particularly affecting nitrogen, phosphorus, and potassium levels in wheat and maize production, has led to declining soil fertility. To sustain yields, farmers have increasingly relied on chemical fertilizers, which have disrupted the soil's natural structure over time. Additionally, the excessive use of these inputs has caused environmental issues, including soil acidification, water pollution, and biodiversity loss. Experts emphasize the need for improved soil management practices, such as crop rotation, the use of organic fertilizers, and conservation tillage, to restore soil health and safeguard future agricultural productivity (Sönmez et al. 2008; Gözener et al. 2016; Yeni and Teoman, 2023).

Soil erosion is another major issue linked to government-incentivized agricultural practices. The removal of natural vegetation and expansion of farmland, often on slopes and vulnerable areas, have accelerated erosion in regions like Eastern and Southeastern Anatolia (Uzun et al. 2022). This loss of fertile topsoil also leads to sedimentation in rivers and reservoirs, reducing water capacity and increasing flood risks. Additionally, erosion decreases the soil's ability to retain water, worsening droughts and further impacting agriculture (Vurarak and Bilgili, 2015; Süzer, 2024; TEMA, 2024).

The promotion of monocultural farming has led to soil erosion, particularly on sloped terrains. In regions where crops like hazelnuts (Kılıç et al. 2018; Aydemir, 2021), olives Banias et al, 2017; Maesano et al., 2021), and tobacco (Geist, 1999) are intensively cultivated, the natural vegetation has been removed, exposing the topsoil to wind and water erosion. In the Black Sea region, extensive hazelnut cultivation has deprived large areas of their natural vegetation, causing rapid soil degradation (Kılıç et al. 2018; Aydemir, 2021).

Similarly, in the Aegean and Mediterranean regions, areas dedicated to olive production have experienced significant soil loss (Değerliyurt, 2013).

Sustainable agriculture experts recommend a holistic approach to soil management to address these challenges. Techniques like terracing, reforestation, and cover crops can help prevent erosion. Moreover, agricultural policies should prioritize soil health over short-term yields. Incentives for crop diversification, green manures, and reduced tillage could significantly mitigate the negative effects on soil fertility and erosion (Zuazo and Pleguezuelo, 2009; Wei et al. 2016; Tiwari et al., 2024).

### 3.3. Water Scarecity, Pollution, and Biodiversity Loss

Agricultural incentives in Turkey have driven growth and increased productivity but have also caused significant environmental challenges, particularly affecting water resources, pollution, and biodiversity. As agriculture expands, these issues have intensified, putting pressure on Turkey's natural resources (Egemen, 1993; Özkay et al. 2008; Çetin et al., 2020).

The expansion of agriculture, fueled by incentives, has strained water resources through over-extraction of groundwater and surface water, especially in water-scarce regions. Water-intensive crops like cotton and maize have worsened this problem (WWF, 2023; Muratoğlu, 2024). Additionally, the heavy use of chemical fertilizers and pesticides has contaminated water bodies, with nitrate pollution being a key concern. This not only harms freshwater ecosystems but also poses long-term risks to human health and agricultural productivity (Pahalvi et al. 2021; Sünal and Erşahin, 2012; Cüre, 2022).

To address these issues, the Turkish government has implemented initiatives such as the Nitrate Information System (NIBIS) and Nitrate Action Plans (NAPs) (to control pollution and protect water bodies (RT MoAF, 2021). While these EU-supported efforts are steps in the right direction, significant challenges remain in fully addressing the scale of the problem (EU, 2022).

Monoculture farming and agricultural expansion have significantly reduced biodiversity by clearing natural habitats for crop production. This habitat loss has caused declines in flora and fauna, weakening the natural resilience of agricultural ecosystems and making them more vulnerable to pests and diseases. For instance, in regions where cotton (Chakravarthy et al. 2016), wheat (Andow, 1983) and maize (Tümer et al., 2019; Ordu & Aşık, 2021) are intensively cultivated, the lack of crop diversity has negatively affected local insects, birds, and microorganisms, leading to increased reliance on pesticides and further environmental degradation (Quandahor et al., 2024). Experts emphasize the importance of integrating biodiversity conservation into agricultural development by promoting agroecological practices, incorporating biodiversity into agricultural planning, and restoring natural habitats to ensure sustainable agriculture and environmental health (Grant, 2007; Altieri et al., 2009; Wang et al., 2019).

### 3.4. Market Fluctuations and Economic Vulnerability

Agricultural incentives in Turkey have boosted production and economic growth in the sector but have also increased economic vulnerability due to reliance on a few key export crops and exposure to global market fluctuations (Burrell & Kurzweil, 2007). The emphasis on high-value crops like cotton, hazelnuts (Kayalak and Özçelik, 2012; Bayrak et al., 2023), and wheat (Özdemir, 1989; Eşlik et al., 2024) has tied the agricultural economy to volatile global markets, leaving farmers vulnerable to price changes. For example, a sudden drop in global cotton prices can severely impact farmers heavily invested in cotton production, creating economic instability, especially for small and medium-sized farmers without financial buffers (Narin, 2006).

The uneven distribution of incentives has widened economic disparities among farmers. Larger farms, better equipped to utilize these incentives, have strengthened their dominance, while smallholder farmers, lacking resources to adapt or scale up, face marginalization. This increases income inequality and jeopardizes the sustainability of small-scale farming, which is vital for rural livelihoods and food security (Burrell & Kurzweil, 2007; Kızıl and Çürük, 2021).

To address these challenges, experts recommend diversifying agriculture to reduce dependency on a few export crops. Promoting a wider range of crops, investing in value-added products, and strengthening domestic markets could provide more stable income opportunities (Sever, 2020). Policies such as agricultural insurance and improved financial services for smallholders are also essential to buffer farmers against market volatility and support the sector's long-term resilience (Burrell and Kurzweil, 2007; RT MoAF, 2017).

### 3.5. Regional Disparities and Socioeconomic Impacts

Agricultural incentives in Turkey have significantly boosted economic growth and agricultural production but have also widened regional disparities and created socioeconomic challenges, particularly between the developed western regions and the less developed eastern and southeastern areas (Oral and Uğur, 2013; Kaplan, 2019; Yoloğlu, 2021; Oğul, 2022).

In regions like the Aegean and Marmara, incentives have increased productivity, but their impact has been limited in underdeveloped regions due to poor infrastructure, limited market access, and scarce resources. This has widened the economic gap, with wealthier regions continuing to grow while poorer regions struggle to catch up, hindering balanced national development (Arslan, 2014; Bal, 2019; Şaşmaz and Özel, 2019).

The uneven distribution of incentives has also deepened socioeconomic inequalities (Kaplan, 2019; Sağdıç and Yıldız, 2019). In less developed areas, inadequate use of incentives has led to persistent poverty, unemployment, and outmigration (Şaşmaz and Özel, 2019). Small-scale farmers in these regions struggle to compete with larger, more capitalized farms, perpetuating economic stagnation and low living standards (Şen, 2024).

Experts suggest tailoring future agricultural policies to address these disparities by increasing investments in rural infrastructure, supporting small-scale farmers, and fostering local markets (Şahin and Kan, 2022). Encouraging diversification of agricultural activities in underdeveloped regions could also reduce economic vulnerability and support sustainable growth (Gillespie et al., 2007; Onumah et al., 2007).

## 4. THE MEDITERRANEAN REGION CASE: BANANA GREENHOUSES

### 4.1. Historical Development of Banana Production and Incentives

The development of banana production in Turkey, particularly in the Mediterranean region, has grown significantly due to government agricultural incentives. Concentrated in Anamur and Mersin, banana cultivation expanded rapidly, with greenhouse areas increasing from 3.000 hectares in 2018 to approximately 5.000 hectares by 2020 and further reaching 70.000 decares by 2024 (Uysal, 2021; Sağlam, 2024). These incentives aimed to boost domestic production and reduce dependency on imports.

Banana production has become a major economic activity in Mediterranean microclimates, which are ideal for this crop. The local variety, Anamur bananas, is popular for its unique taste and quality, enabling Turkey to meet nearly 85% of its domestic demand, up from just 13% in the 1990s. This growth is largely attributed to state incentives that have supported greenhouse expansion and improved production techniques (Özay, 2022).

However, this rapid expansion has posed challenges. The intensive use of greenhouses has raised environmental concerns, particularly regarding water usage and agricultural sustainability. Increased water demand for banana cultivation has pressured local resources, raising questions about long-term viability. Additionally, banana monoculture has decreased biodiversity and heightened vulnerability to pests and diseases, threatening the economic sustainability of farms (Adsal et al. 2020; Atılgan et al. 2021).

Researchers emphasize the need for a balanced approach that fosters economic growth while ensuring environmental sustainability. Recommendations include adopting efficient irrigation systems, diversifying crops to mitigate environmental impact, and implementing stricter regulations for sustainable water use. Integrating environmentally friendly farming practices could further address the negative impacts of the rapid expansion of banana greenhouses (Eryılmaz et al. 2019).

## 4.2. The Expansion of Banana Greenhouses and Their Impact

Driven by government incentives and market demand, greenhouse areas increased from 3,000 hectares in 2018 to 5,000 hectares by 2020 (Uysal, 2021; Sağlam, 2024). This rapid expansion has significantly transformed the region's agricultural landscape, positioning banana cultivation as a major economic activity. However, this growth has also brought about a range of environmental, social, and economic challenges that necessitate careful analysis and sustainable management strategies.

### 4.2.1. Agricultural Impact

The expansion of banana greenhouses in Turkey's Mediterranean region, particularly in Anamur and Mersin, has significantly transformed local agriculture. (Uysal, 2021; Sağlam, 2024). This growth has enabled Turkey to meet 85% of its domestic banana consumption, a sharp rise from just 13% in the 1990s. The region's favorable microclimate and advanced greenhouse technologies have been key to this success (SGB, 2020).

Banana cultivation, especially the Anamur variety, has become highly profitable due to its year-round harvests and strong market demand. Its preferred taste and quality over imported varieties have led to increased focus on banana farming, often replacing traditional crops. This profitability has attracted significant investment, further accelerating the conversion of agricultural lands into banana greenhouses (Uysal, 2021; Sağlam, 2024).

While boosting local economies, the rapid expansion has also brought challenges. Greenhouse farming demands significant water resources, raising concerns about sustainability. Additionally, banana monoculture increases risks of soil degradation and pest infestations. To address these issues, sustainable farming practices and crop diversification are needed to ensure long-term agricultural viability in the region (Ankara Ticaret Borsası, 2020; Baysal and Türkay, 2023).

#### 4.2.2. Environmental Impacts: Climate, Soil, and Water Resources

The rapid expansion of banana greenhouses in Turkey's Mediterranean region has brought significant environmental concerns despite its economic benefits. These challenges primarily affect climate, soil health, and water resources, threatening the long-term sustainability of agriculture in the region (Özüpekçe, 2021; Karar, 2023).

Large-scale conversion of land to banana greenhouses has influenced local climates. Greenhouses create microclimates that can intensify global warming effects. In a region where temperatures have already risen by 1.5°C over the past 50 years, this additional warming exacerbates energy consumption for cooling and stresses local ecosystems (IPCC, 2022). The use of plastic coverings in greenhouses contributes to the heat island effect, altering local weather patterns and increasing vulnerability to extreme weather events (UNEP, n.d.).

Intensive banana cultivation has also led to soil degradation. Continuous monoculture depletes essential soil nutrients, prompting reliance on chemical fertilizers, which degrade soil quality, reduce water retention, and exacerbate erosion. Fertilizer and pesticide use further contaminates soil and groundwater, harming surrounding ecosystems and reducing soil health over time (Bellamy, 2013; Stoorvogel and Mena, 2018; Nath et al., 2023; Khanyile et al., 2024; Pramanik et al. 2024).

Water demand for banana production has significantly strained local resources, particularly groundwater, which is being depleted unsustainably. Inefficient irrigation methods worsen water losses through evaporation and runoff. If current practices persist, severe water shortages could impact banana farming and other agricultural and domestic water needs (Carr, 2009; Cano, et. al. 2024; FAO, 2024).

To address these challenges, experts recommend adopting sustainable farming practices such as drip irrigation to conserve water and crop rotation with organic farming to restore soil health. Stricter regulations on greenhouse expansion and the use of plastics are also needed to mitigate environmental impacts. These measures can help Turkey balance the economic benefits of banana production with environmental sustainability (Eryılmaz and Kılıç, 2019; Kayan and Küçük, 2020; Kimya Mühendisleri Odası, 2021; Baysal and Türkay, 2023).

#### 4.2.3. Impacts on Human Health

The rapid expansion of banana greenhouses in Turkey's Mediterranean region has raised potential concerns about human health, particularly related to pesticide use, water contamination, and air pollution associated with intensive cultivation (Altıkat et al. 2009; Adsal et al. 2020; Atılgan et al. 2021).

Banana greenhouse farming often relies heavily on pesticides to manage pests and diseases, which could pose health risks to farmworkers and local communities if not properly regulated or applied without adequate safety measures (Bradman et al., 2009; Brennan et al. 2015; FAO 2024). Prolonged exposure to pesticides has been associated with various health issues, including respiratory problems, skin conditions, and long-term effects like cancer (Sheahan et. al., 2017; Curl et al. 2020; Poudel, et. al. 2020). However, the extent of these risks in Turkey's banana farming sector requires further investigation to fully understand their implications. Strengthening regulations and monitoring pesticide use could play a critical role in mitigating these potential risks.

Runoff from banana greenhouses may carry pesticides and fertilizers into local water supplies, which could impact both human health and the environment. In regions where groundwater serves as a primary drinking water source, chemical infiltration might increase the risk of waterborne illnesses. High nitrate levels from fertilizers, for example, could potentially lead to conditions such as methemoglobinemia ("blue baby syndrome") in vulnerable populations, though specific cases linked to banana farming in Turkey have not been extensively documented (Fan and Steinberg, 1996; Fewtrell, 2004; Brender, 2020).

Air quality in greenhouse regions might also be affected by emissions from diesel-powered machinery and volatile organic compounds (VOCs) released by pesticides. While there is evidence of similar impacts in other agricultural sectors globally, further research is needed to confirm the scale and significance of these effects in Turkey's banana-producing areas (Uzel, 2015; Çeşmeli and Pençe, 2020).

To address these potential risks, experts recommend adopting sustainable farming practices such as integrated pest management (IPM) to reduce reliance on chemical pesticides (Ehler, 2006; Koppert, 2020; Deguine et al., 2021). Improved regulations on pesticide use and air quality standards, along with better access to personal protective equipment (PPE) for workers, could enhance safety (Tian et al., 2020; Ammad et al., 2021). Monitoring water quality and implementing buffer zones around water bodies may also help protect drinking water sources (Norris, 1993; Merret and Horng, 2023). These measures, combined with ongoing research into the health and environmental impacts of greenhouse agriculture, are essential for ensuring the benefits of banana production are balanced with public health and sustainability.

### 4.2.4. Impacts on Tourism and Regional Development

The proliferation of banana greenhouses has significantly altered the landscape in Turkey's Mediterranean region coastal regions that were traditionally known for their natural beauty and touristic appeal. The transformation of these areas into intensive agricultural zones has led to concerns about the visual impact on the landscape, which is crucial for attracting tourists. The dense clusters of greenhouses, often covered in plastic, can detract from the scenic views that draw visitors to the Mediterranean coast.

This shift in land use has the potential to diminish the attractiveness of these regions as tourist destinations, particularly for eco-tourism and luxury tourism segments that prioritize pristine natural environments (Aşur and Alphan, 2018; Boyacı and Kartal, 2019).

While banana production has boosted local agricultural income, it may come at the cost of tourism revenue. Tourism is a major economic driver in the Mediterranean region, contributing significantly to local economies through spending on lodging, dining, and recreational activities. The decline in aesthetic and environmental quality due to the spread of greenhouses could lead to a reduction in tourist numbers and, consequently, in tourism-related income. This is particularly concerning given that tourism has historically provided a more sustainable and less environmentally intensive source of revenue for these regions.

Experts suggest that a balanced approach is necessary to ensure that both agriculture and tourism can coexist and thrive in the Mediterranean region. This could involve stricter regulations on the placement and management of greenhouses to minimize their visual and environmental impact. Additionally, integrating green tourism practices, such as promoting agricultural tourism (agritourism) where visitors can experience and learn about local farming practices, might offer a way to harmonize these two important sectors (Kaya et al., 2021; Taşkıran et al. 2023). Such strategies could help mitigate the negative effects of greenhouse expansion on tourism while still supporting agricultural growth.

## 5. SOLUTIONS FOR SUSTAINABLE DEVELOPMENT IN THE MEDITERRANEAN REGION'S BANANA GREENHOUSES

### 5.1. Implementing Sustainable Practices to Address Environmental Impacts

The expansion of banana greenhouses in Turkey's Mediterranean region highlights the necessity of sustainable agricultural practices due to their environmental and socio-economic impacts. Climate-Smart Agriculture (CSA) practices are essential for ensuring the long-term sustainability of banana production. CSA focuses on increasing productivity, reducing greenhouse gas emissions, and enhancing resilience to climate change. Methods such as drip irrigation, which improves water efficiency, can prevent the over-extraction of groundwater. Additionally, practices like using organic fertilizers and implementing crop rotation can enhance soil health, reduce dependency on chemical inputs, and minimize environmental harm (Gemtou et al., 2024; Li et al., 2024).

However, the adoption of sustainable practices faces challenges such as high initial costs and a lack of technical knowledge among farmers. Government support plays a critical role in overcoming these barriers. Subsidies, training programs, and incentives should be provided to encourage the transition. Moreover, the use of renewable energy sources, particularly solar panels in greenhouses, can reduce reliance on fossil fuels and lower greenhouse gas emissions. The World Bank's support for climate-smart technologies in Turkey underscores the potential for transformative change in this area (World Bank Group, 2022).

### 5.2. Policy Reforms and Incentive Adjustments

The sustainable development of banana greenhouses in Turkey's Mediterranean region requires significant policy reforms and adjustments to current incentives. Existing policies often focus on maximizing production while overlooking environmental and socio-economic challenges. Agricultural policies must be restructured to promote environmentally friendly practices and ensure the fair distribution of economic benefits Sustainability criteria should be integrated into current agricultural policies. For instance, subsidies should be provided for practices such as organic farming, renewable energy use, and water-efficient irrigation systems. Incentives should also support the use of organic fertilizers as alternatives to chemical inputs, encouraging practices that reduce environmental harm (Demir and Guzel, 2024).

Financial support for sustainable technologies, such as solar-powered greenhouses, can help lower water consumption and reduce carbon emissions Policy reforms must shift from prioritizing short-term gains to achieving long-term sustainability by balancing economic growth with environmental protection. Aligning agricultural policies with environmental and social objectives will preserve natural resources while enhancing competitiveness (Aslan and Özdil, 2024)

### 5.3. Long-Term Development Strategies and Regional Planning

The expansion of banana greenhouses in Turkey's Mediterranean region requires urgent actions and long-term strategies that integrate sustainable agricultural practices with regional planning. Economic growth should not come at the expense of environmental degradation and social inequality. Strategic regional planning must include clear land-use policies that align agricultural expansion with sustainable development goals. Detailed and effective Environmental Impact Assessments (EIAs) for new greenhouse projects can minimize harm to ecosystems and water resources. Incorporating green infrastructure, such as ecological corridors and buffer zones, into regional plans can enhance biodiversity and reduce the environmental impacts of agricultural activities (Demirayak, 2023).

The expansion of greenhouses must align with Turkey’s 2053 net-zero emissions target (Climate Change Authority, 2024) and the European Union’s Green Deal (Turkish Ministry of Foreign Affairs, 2024). Promoting climate-resilient practices will ensure compliance with environmental standards and maintain the competitiveness of agricultural exports.

Sustainable economic development requires education, infrastructure, and investment to equip farmers with knowledge of sustainable agricultural practices. Diversifying the regional economy can reduce dependency on banana production and enhance economic resilience.

To implement these strategies effectively, robust monitoring systems should be established to track the impacts of greenhouse expansion. Inclusive stakeholder engagement in decision-making processes and international collaborations for funding and technical expertise are also essential. By adopting these measures, Turkey can achieve sustainable development in its Mediterranean region, balancing economic growth with environmental and social priorities.

## CONCLUSION

The expansion of banana greenhouses in Turkey's Mediterranean region has reshaped the agricultural landscape, offering significant economic benefits such as increased agricultural output, local economic growth, and reduced reliance on imports. However, this rapid development has also raised critical environmental and socio-economic challenges. Issues like water resource depletion, soil degradation, biodiversity loss, income inequality, and the impact on the tourism industry highlight the need for a more balanced and sustainable approach.

To ensure the long-term sustainability of banana greenhouse farming, several key steps are essential. Ongoing environmental monitoring is needed to assess the cumulative effects of greenhouse agriculture on local ecosystems. Research should focus on sustainable agricultural practices, including alternative crops that require less water and are more climate-resilient. Policy reforms must integrate environmental and social considerations, such as stricter regulations on resource usage and incentives for adopting sustainable farming methods. Additionally, international collaboration can provide valuable knowledge, funding, and technical support for sustainability efforts.

In conclusion, a holistic approach that balances economic growth with environmental protection and social equity is crucial for the sustainable development of banana greenhouses. By addressing these challenges proactively, Turkey can secure the long-term competitiveness and sustainability of its agricultural sector.

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# CHAPTER IX

## EVALUATION OF ENVIRONMENTAL SUSTAINABLE DEVELOPMENT IN THE SCOPE OF TÜRKİYE'S TWELFTH DEVELOPMENT PLAN

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## INTRODUCTION

According to Garren and Brinkman (2018), sustainability has emerged as a key idea in the solution of environmental, social, and economic issues that the modern world confronts and that are frequently addressed in various fields. Sustainability is a comprehensive framework that addresses social equality and economic development jointly. It was first defined in the Brundtland Report in 1987 as "*meeting the needs of the present generation without compromising the ability of future generations to meet their own needs*." Sustainability is not just a strategy for protecting natural resources (Brundtland, 1987; United Nations World Commission on Environment and Development, 1991). Accordingly, preserving biodiversity, promoting long-term use of natural resources, and safeguarding ecosystem health are the cornerstones of environmental sustainability (Daly, 1990).If the concept of sustainability is not used to express environmental issues, climate change, waste management, national and international goals, the circular economy, and many other concepts, they will not be able to convey their significance and meaning. These are all small but integral components of the big picture (Figure 1).

One of the biggest and most serious worldwide threats in sustainability talks is still climate change. The Earth's surface is warming quickly, sea levels are rising, and extreme weather events are becoming more frequent and severe as because of human activity-induced increases in greenhouse gas emissions. This condition has major ramifications for vital industries including agriculture, energy, health, and water supplies in addition to natural ecosystems. As a factor that makes it challenging to attain sustainable development goals, climate change has gained attention in both national and international policy (Steffen et al., 2007; IPCC, 2021).


**Figure 1.** The relationship between sustainability and environmental concepts (created using ChatGBT 4o)

Türkiye's sustainable development strategies are especially significant in this global scenario. The strategic roadmap outlined in Türkiye's 12th Development Plan shapes sustainable development in a way that strikes a balance between environmental preservation and economic growth. Targets for environmental sustainability in this strategy include increasing energy efficiency and promoting the use of renewable energy sources,safeguarding water supplies, creating waste management systems, and putting adaptation measures in place to fight climate change. Critical actions are also being conducted to lower carbon emissions and promote environmentally friendly production methods (T.C. Twelfth Development Plan, 2024).

Sustainable development and waste management are complementary elements in terms of protecting natural resources, reducing environmental pollution and balancing economic development with environmental impacts. One of the basic principles of sustainable development is to reduce waste generation by minimizing resource use and to recycle waste and reintroduce it into the economy. This approach, as part of the circular economy model, provides both environmental and economic benefits. An effective waste management system reduces the pressure on the ecosystem by preventing the overuse of natural resources, while also saving energy and reducing carbon emissions (Ellen MacArthur, 2013).

The waste management policies in Türkiye's 12th Development Plan encourage a zero waste approach in line with sustainable development goals. The plan prioritizes practices that support the separation of waste at source, increasing recycling rates, and energy production from waste. In this context, it is aimed not only at minimizing environmental impacts but also at creating new employment opportunities and obtaining economic value in waste management. Waste management is a critical tool that not only supports the environmental dimension of sustainable development but also contributes to its social and economic dimensions (T.C. Twelfth Development Plan, 2024).

## 1. TÜRKİYE’S TWELFTH DEVELOPMENT PLAN GOALS, OBJECTIVES AND POLICIES

In Türkiye, development plans are prepared every five years, aiming development in many areas. The 12th Development Plan for Türkiye for the years 2024-2028 has been published.

The Twelfth Development Plan has basic objectives within the scope of sustainable environment. Some of these objectives can be listed as follows;

- The frequency and severity of natural disasters increase due to climate change. Disasters such as drought, floods, forest fires and extreme weather events make the effects of climate change more evident.
- In addition to climate change, the pressure of increasing population, urbanisation, economic activities and changing and diversifying consumption habits on the environment and natural resources continues to increase, and efforts at national, regional and international scales are intensifying in order to ensure the balance between protection and utilisation.
- Low carbon growth, green economy and sustainable management of natural resources are becoming widespread.
- Climate change adaptation and emission mitigation policies are determined.

- In order to tackle climate change, a number of actions are being done, including mitigation, adaptation, funding, compensation for losses and damages, technology development and transfer, and capacity building.
- Investments are projected to increase in sectors like sustainable transportation, the circular economy, renewable energy generation and energy efficiency, green infrastructure and urban planning, sustainable agriculture and food production, and green transformation in industry.

The Twelfth Development Plan has objectives and policies on Environmental Protection and Urban Infrastructure under the title of Sustainable Environment (T.C. Twelfth Development Plan, 2024).

The main objective of Sustainable Environment is to ensure transition to a low-carbon economy that is resilient to the effects of climate change in line with the Sustainable Development Goals, to protect and manage the environment and natural resources with an understanding of social justice, and to increase the sensitivity and awareness of the society towards the environment. The main policies and measures related to sustainable environment are given below.

- Addressing climate change related practices in a holistic manner,
- Updating sectoral road maps within the scope of the ‘Green Consensus Action Plan’,
- Dissemination of existing best environmental practices on sustainable consumption and production,
- Taking necessary measures regarding the release of all wastes to air, water and soil in order to minimise their harmful effects on human health and the environment,
- Dissemination of the environmental labelling system,
- Increasing capacity and public awareness in combating climate change
- Dissemination of training, awareness raising and capacity building activities for all stakeholders,
- Carrying out studies for the improvement of damaged ecosystems,

- Carrying out research, monitoring and evaluation activities to determine the impacts of climate change on biodiversity, ecosystem services and land degradation,

The main objective in Urban Infrastructure is to create sustainable systems where access to healthy and reliable drinking and potable water is ensured, the effects of wastewater and solid wastes on human and environmental health are minimised, and in urban transport, cost-effective, clean and energy efficient, easily accessible for all individuals and strong inter-modal connectivity is ensured. The main policies and measures related to urban infrastructure are given below.

- Ensuring sustainable, holistic, effective and efficient management of water resources by considering the balance of protection and utilisation,
- Implementation of river basin management plans,
- The effects of climate change on water resources will be determined and adaptation to climate change will be ensured,
- Ensuring water efficiency by switching to the best available techniques in industry,
- Reduction of energy costs in water supply,
- Preparation of a National Circular Economy Action Plan,
- Zero waste practices will be made widespread and public awareness will be raised on recycling of waste,

The Sustainable Development Goals, which focus on the social, economic and environmental dimensions of development in a balanced manner, emphasise equality and justice between and within countries, and adopt the principle of ‘leaving no one behind’, have assumed a decisive role in the development agendas of all countries.

The Sustainable Development Goals have been a comprehensive and holistic reference for Türkiye's people-oriented development efforts, and Türkiyehas acted together with the international community around this inclusive global agenda. The Twelfth Development Plan provides an important opportunity to strengthen Türkiye's efforts to realise the Sustainable Development Goals as a whole with their economic, social and environmental dimensions.

### 1.1. Sustainable Development Goals

Ending poverty, safeguarding the environment, combating the climate crisis, equitable wealth distribution, and promoting peace are the objectives of the Sustainable Development Goals. Figure 2 displays the Sustainable Development Goals developed by the United Nations.


**Figure 2.** United Nations Sustainable Development Goals, (The Global Goals, 2024)

Climate Action, which is one of the Sustainable Development Goals within the scope of sustainable environment, directly or indirectly affects all goals.

Targets set within the scope of Climate Action;

- *"Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries,"*
- *"Integrate climate change measures into national policies, strategies and plans,"*
- *"Improving education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, mitigation and early warning,"*
- *"Implement the commitment undertaken by developed countries party to the United Nations Framework Convention on Climate Change to jointly mobilise $100 billion annually by 2020 to address the needs of developing countries, in the context of meaningful mitigation actions*

*and transparency in implementation, and fully operationalise the Green Climate Fund through capitalisation as soon as possible,”*

- *“Support mechanisms to increase capacity for effective climate change planning and management in least developed countries and small island developing States, with a focus on women, youth, local communities and marginalised groups”*

## 2. ASSESSMENT OF ENVIRONMENTAL SUSTAINABILITY WITHIN THE SCOPE OF NATIONAL LEGISLATION

In Türkiye, there are legislations such as laws, regulations and communiqués for a sustainable environment.

To ensure the preservation of the environment, which is the shared resource of all living beings, in accordance with the concepts of sustainable development and the environment, the Environmental Law dated 11.08.1983 and numbered 18132 was published in the Official Gazette and entered into force (Environmental Law, 1983). In this law, definitions related to environment and sustainability have been made.

The term "environment" refers to the biological, physical, social, economic, and cultural context in which organisms sustain their relationships and engage in lifelong interactions.

Environmental protection encompasses all efforts to prevent the degradation, disruption, and destruction of ecological balance and environmental values. It includes actions to address existing damage, enhance and improve the environment, and mitigate environmental pollution.

Environmental pollution involves a wide range of harmful effects that can disturb the ecological balance, environmental values, and the health of living organisms.

The process of improving, protecting, and developing all environmental values (social, economic, physical, etc) that make up the environment for both current and future generations in all areaswithout endangering the availability and quality of resources that future generations will require—is identified to as a sustainable environment.

Sustainable development means development and progress based on a balance between environmental, economic and social objectives that ensure that present and future generations live in a healthy environment.

The Environmental Law constitutes the basis of the legislation on environmental sustainability. With the Zero Waste project, which has been implemented in our country since 2017, it is aimed to collect waste separately at its source and recycle it into the economy.

The Waste Management Regulation, which includes the monitoring and management of all stages from the generation of waste to its final disposal, was published in the Official Gazette dated 02.04.2015 and numbered 29314 and entered into force. The purpose of this regulation is to: *"a) Ensure the management of waste from its generation to its disposal without harming the environment and human health, b) Reduce the use of natural resources through methods such as reducing waste generation, reuse, recycling and recovery of waste, and ensure waste management, c) Determine the general procedures and principles regarding the production of products within the scope of this regulation, which have certain criteria, basic conditions and features in terms of environment and human health, and market surveillance and inspection"* (Waste Management Regulation, 2015).

Waste Management Regulation basically classifies wastes into two categories as hazardous and non-hazardous wastes. These wastes are classified in detail from generation points to disposal processes. Each type of waste is categorised with its own waste code. Sustainable management of wastes without harming the environment and human health is carried out within the framework of the legislation.

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