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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Impacts of modern agriculture on environment and sustainable agriculture

Esin Candan Demirkol

Assist. Prof. Dr., Dokuz Eylül University, İzmir Vocational School, Türkiye, e-mail: esin.candan@deu.edu.tr

Abstract

Since the day humans settled down, they have made an effort to transform nature in line with their own wishes and needs. The damage caused to nature beginning with the industrial revolution has been ignored for a long time. The prevailing understanding of development was that nature overcame this situation by cleansing itself. However, it is obvious that the pollution created in nature does not disappear on its own, as it is thought. The agricultural production process, which is considered the most "innocent", also contributes negatively to environmental pollution. Especially fertilizers, herbicides, pesticides used in industrial agriculture cause serious damage to the environment. The study aims to deal with the duality of the environmental pollution caused by agriculture and the effects of environmental pollution in agriculture. Sustainable agriculture practices may reduce environmental pollution and enable a sustainable development in terms of agriculture.

Keywords: Agriculture, development, environmental pollution, sustainability, sustainable agriculture.

JEL codes: O13, Q01, Q18, Q56,

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Corresponding Author/ Sorumlu Yazar:
Esin Candan Demirkol
E-mail: esin.candan@deu.edu.tr

1. INTRODUCTION

Throughout the history of civilization, humans have been transforming the nature. The results of this activity can be understood by focusing on the social structure and social relations. Economic, political, ideological and cultural structures, class relations, applied techniques, science and technology, production/ consumption relations are concepts which can be used to analyze the effects of human activities on nature. When looked at from the broader aspect, it is possible to figure out the angle between society and nature of the first human societies and today's societies and also between today's societies, in other words, environmental deterioration reasons threatening the earth.

Encountered environmental problems are multiple and interactive in terms of their economic, political and social dimensions and their consequences. The awareness of societies against natural disasters has increased with the results of the destruction. The death of thousands of people living in London in a week due to the dense fog formed as a result of a dense coal dust and toxic mixture in December 1952 was the first example of deadly environmental events. (Martinez,2019) Prior to this event pollution in the cities was accepted as a part of the modern life. But then, urban people increasingly started to struggle to limit the toxic outputs of the industrial facilities.

Another dimension of human-induced environmental problems started to show itself in the 1970s. Following the end of the Second World War, utilization of industrial-based inputs in agriculture started to increase. It was calculated that one fourth of the world agricultural production was acquired from utilization of chemical fertilizers in the early 1970s. (Fotourehchi, Şahinöz; 2016, 24) Agricultural production has increased with the hybridization of cereal seeds, the use of artificial fertilizers, pesticides and irrigation. As a result of mechanization in agriculture, modern agriculture was switched from traditional agriculture.

The essay aims to examine the effects of environment and agriculture on each other. In the essay, agriculture and the environment will be discussed under three main headings. In the first part, the development of agriculture in the historical process and important turning points in agriculture will be discussed. In the second part, the types of environmental pollution that both affect and are affected by agricultural production will be examined. In the last section, sustainable development and sustainable agriculture will be discussed in order to deal with these environmental problems and to deal with the sustainability perspective with the title of agriculture.

2. FROM TRADITIONAL AGRICULTURE TO MODERN AGRICULTURE: HISTORY OF AGRICULTURE

Since its existence, humanity maintains a multidimensional relationship with nature. It is the nutritional concern that establishes the first link between nature and humans which determines the direction of the relationship. Agriculture is a productive human intervention against the natural environment. Humans demonstrated its productive ability by cultivating the land and raising domesticated animals with the Neolithic Revolution. (Şenel,1995:141) The relative importance of hunter-gatherers decreased gradually as agricultural occupation became widespread and the sources of food were secured. According to Cipolla (1965; 48), the use of harness belts of oxen and then horses to process agricultural fields are pioneer developments for agricultural techniques which is considered the first deep-rooted technological progress in agriculture. After the discovery of the black plough, people have been able to process larger areas by taking advantage of the traction power of the riding animal. Childe (1993; 39) states that thanks to agriculture, people have come to a productive position by making an active partnership with nature instead of being parasitic on nature. He defines the transition to agriculture as the act of "man who now produces the food he is chasing after himself" (Cited by: Fotorehchi, Şahinöz; 2016, 15-16).

Irrigation, which has a direct effect on agricultural productivity and production, has been one of the first steps of technological development in agriculture. While widespread and continuous irrigation encouraged settled life, it also led to significant increases in agricultural production. Each of these developmental stages in irrigation

has led to its spread to wider and more diverse soils and climates, prolonging the growing seasons and increasing the harvest periods (Childe, 1993;54; Fotourehchi, Şahinöz; 2016,16-18; Mazoyer, Roudar; 2009, 159).

Agricultural production and productivity doubled between the 16th and 18th centuries, with the practice of fallow agriculture, which has been in overseas countries and many parts of Europe since the 16th century (Mazoyer, Roudar ;2009, 411). Natural resources began to be used in a destructive way as the main purpose of agricultural work evolved from self-consumption to profit maximization. The spread of capitalism after the industrial revolution started to bring profit motivation in production to the foreground. In the past, subsistence farming activities were carried out, but now the land has become a means of "production that profits from its sale as a capital tool, not for subsistence products" (Fotourehchi, Şahinöz; 2016, 23).

Today, predictions about the future of the environment are discussed in a wide range, including optimistic and pessimistic. The first of these discussions belongs to T.R. Malthus. In 1789, his work, which signed very important rules for demography, had great repercussions and caused many new discussions. Since Thomas Malthus, who suggested that the increasing population cannot have adequate nutrition opportunities, pessimistic approaches regarding the inadequacy and depletion of natural resources are discussed under the title of environmental problems.

Thomas Robert Malthus put forward the ideas that will form the basis of modern discussions on economic sustainability in his book "An Essay on the Principle of Population". According to Malthus, population is increasing at a geometric rate, while the increase in agricultural production is limited by an arithmetic rate. He argues that a production increase that is lower than the population will cause famine in the long run (Malthus; 1798) Malthus mentions two types of control mechanisms, 'protective' and 'limiting', to eliminate this problem. In a sense, protective restraint can be considered as family planning; birth control is achieved through control and avoidance of sexuality for ethical reasons. Positive control tools include wars and natural disasters. According to Maltus, if consumption increases beyond the available resources, both control systems come into play and continue to function until the consumer rate lags behind the resource rate. However, as the number of consumers or population will increase exponentially, the same cycle will occur again after a certain period. This attitude of Malthus was found to be quite pessimistic. His contemporary, Ricardo (1817), combined the concept of 'decreasing marginal productivity' with a Malthusian point of view, and stated that due to population growth, people engaged in agriculture would have to farm in more limited areas with intensive methods, and although they wanted to obtain more products, this did not make much sense in the face of the increasing population rate. Even if production increases, the exponential increase in consumption or population neutralizes this increase, and some economists call this a Malthusian catastrophe (Mazı, Tan, 2009).

The "pessimistic" view predicting that "the rate of increase in agricultural production will lag behind the rate of population growth" put forward by Malthus about 200 centuries ago has been nullified by the increase in productivity in agriculture. However, this success has put a huge cost in front of humanity, the environmental problem. (Fotourehchi, Şahinöz;2016,24)

3. AGRICULTURE AND ENVIRONMENTAL PROBLEMS

The emergence of environmental problems has been with the industrialization process. Environmental problems arising from industrialization mainly occur as a result of choosing the wrong location and releasing the waste gasses to the nature without adequate precautions. In addition to the rapid increase in the world population, the decrease in arable land due to environmental pollution and erosion, excessive urbanization, poverty and migration are among the reasons that fuel the nutrition problem. The agricultural sector is directly related to the environment. In addition to the negative impact of environmental pollution on agriculture, agriculture also has a negative impact on the environment. Chemi-

cals used in industry and agriculture pollute water and soil, but also cause depletion of the ozone layer and dangerous deterioration of the air we breathe with harmful gases such as carbon dioxide they release into the atmosphere. (Duman and Önder, 2015:153; Fotourehchi and Şahinöz, 2016:46-47; İnançlı, 2018:45-47). The increase in air temperature due to global warming, the problem of drought and the increase of hot cold fluctuations and the early arrival of spring increase the activities of harmful insects (Serim, 2015:89-93).

Environmental problems did not appear out of nowhere but accumulated over time and made their presence known. While there was a belief that nature would renew itself before, it has been seen that nature cannot renew itself completely and environmental problems are increasing day by day to a dangerous level. Industrial pollution created by industrialization, rapidly increasing population, migration and unplanned urbanization increase the soil, water and air pollution, causing greenhouse gas emissions to increase, depletion of ozone layer, global warming and climate problems, and the destruction of natural vegetation and living things.

Most of the environmental problems are related to the deterioration of the natural balance as a result of the misuse and abuse of nature. It is directly related to the environment due to the soil and water factors used in agricultural production. Besides the negative effects of environmental pollution on agriculture, agriculture also has negative effects on the environment. İnançlı defines environmental hitches as "the effects of the human intervention on the natural environment, the negative effects of the artificial environment and the problems seen in both environments" (İnançlı; 2018; 34).

With external factors such as commercial development, industrialization efforts and urbanization, there has been a transition from subsistence production to production for the market in agriculture. Environmental problems related to the agricultural sector started to emerge with the transition to industrial agriculture, that is, the profit purpose in production came to the fore and the products were produced for the market. After the 1950s, the mechanization of agriculture and the widespread use of fertilizers created a production surplus.

Except for polar regions, deserts, rocky areas and glaciers, 50% of the earth is cultivated by farmers. Global food production increased 2.5 times between 1960 and 2000, due to increased use of fertilizers and pesticides, and over-irrigation (Folley et all, 2005)

However, conventional/extensive agricultural practices, which include high input use such as artificial fertilizers and pesticides in agriculture, have contributed to the unsustainability of current world agriculture (Reijntjes et all, 1992) Increasing intensive agricultural practices with industrialization in agriculture, increasing use of artificial manure and pesticides, and increasing mechanization have brought some environmental problems.

Increasing application of intensive agricultural techniques causes the homogenization of agricultural lands, the gradual disappearance of natural and semi-natural areas, and thus the natural environment. It leads to a decrease in biodiversity and the loss of soil biodiversity (Tsiafouli et all, 2015).

In addition, as a result of conventional agricultural practices; there has been a decrease in the ecological regulation of the amount of water used in agriculture, causing a decrease in water and air quality, climate, erosion, pests and diseases have occurred (Folley et al, 2005; Kremen and Miles,2012).

The synthetic pesticides used can cause the death of people and other living things in nature by infiltrating groundwater from the soil or by being present in foodstuffs. Chemical residues amassed in the top layer of the soil can be dispersed by erosion. Agriculture is the activity that causes the most water consumption in the world. At the same time, it causes pollution in water resources such as nitrate and ammonia pollution in underground and surface water resources, and emission of methane, nitrous oxide and greenhouse gases into the atmosphere. (FAO; 2003)

3.1. Climate Change

Climate change is the fluctuation within the sta-

tus of climate that is classified with the changes in the average or the variability of its peculiarities which show continuity for a long time, mostly decades or longer. (Wreford et all, 2010:10) Climate change may occur because of natural endogenous processes, external factors or anthropogenic changes in the composition of the atmosphere or in land-use (IPCC, 2007) Such changes may take indefinite time. However, increased human activities such as urbanization, industrialization, agriculture deforestation, change in land use pattern etc. enhances the release of greenhouse gases which accelerates the rate of climate change.

The greenhouse effect is a natural event playing an important role in figuring the climate by producing a comparatively warm and moderate environment for the prosperity of life. However, the escalated level of greenhouse gasses occurred as a result of anthropogenic activities has boosted global warming. Global surface temperature means have inclined by 0.74 oC from the late 19th century. It is anticipated to incline by 1.4 oC - 5.8 oC by 2100 with important regional variations (IPCC, 2007).

Agriculture and climate change are intersectional processes occurring worldwide. Global warming is predicted to have noticeable effects on circumstances related to agriculture, including temperature, downfall and glacier melting, which determine the biosphere's capability to generate sufficient nurture for the human and domestic animals. The increase in carbon dioxide ratio is both beneficial and detrimental for Increasing carbon dioxide levels will have both beneficial and detrimental effects on agricultural product. Assessing the impacts in the global climate changes over agriculture can assist accurately predict and adjust cultivation for gaining the maximum crop yields. The net effect of changes in climate is unclear, but it will probably change proper tillable regions to individual crops. Adapting geographic shift will have significant economic and social impacts.

By producing and releasing of greenhouse gasses mainly nitrous oxide, carbon dioxide and methane, agriculture has important impacts over the change of climate. Additionally, the applications of cultivation, fertilizing and pesticide by releasing phosphorus, nitrate, ammonia, and other pesticides that affect soil, air, water quality and biodiversity (Petit, Van der Warf, 2002).

According to FAO, agricultural emissions constitute an important percentage of anthropogenic sources (See Table-1).

According to 2003 figures, agriculture constitutes an important source of methane (49%), nitrous oxide (66%) and ammonia (93%) emissions. The agricultural emissions in terms of methane and ammonia are expected to increase 60% from livestock and nitrous oxide between 35% to 60% in 2030.

The human activities leading to climate change is due to the release of air pollutants, such as nitrous oxide, carbon dioxide and methane. These gasses are the leading contributing pollutants of global warming (Myhre et al.,2013). Cultivation and food production are related to all three of these gasses, but methane and nitrous oxide are the extraordinary prevalent elements in agricultural emissions (Lynch et all, 2021). Agricultural activities change the land cover of the Earth. This in turn contributes to forcing radiation by altering the ability of absorbing or reflecting light and heat. Deforesting, desertization and fossil fuel utilization are the main sources of anthropogenic carbon dioxide. Agricultural activities release significant amount of nitrous oxide and methane concentrations (Monteny et al., 2006) Ruminant animals, like cattle and pig, are the main source of methane emissions.

Another dimension of agriculture affecting climate change is deforestation for to open pasture or cropland as agricultural land.

Deforestation causes widespread destruction of forests/jungles around the world and habitat loss for many species. Besides, deforestation is one the driving forces of climate change. Trees play an important role as a carbon well by absorbing CO_2 and other greenhouse gasses from the atmosphere. The degradation of forests leads to a decline in the amount of absorbed carbon dioxide, the soil begins to dry out, and the return of water vapor to the environment (water cycle) decreases.

3.2. Soil Pollution

Soil pollution can be identified as the existence of inconvenient materials or the existence of such materials at a higher ratio which has unfavorable impacts on any non-targeted organism (FAO and ITPS, 2015). Soil pollutants are mostly anthropogenic but certain pollutants may eventuate ingenuously as constituents of minerals at high concentrations. Territorial pollution is a problem based on continuous anthropogenic activities in time. (Rodríguez-Eugenio et al., 2018: 1)

Chemical production and usages in industry are primary anthropogenic sources of soil pollution. In some cases, such as oil spills, they are unintentionally spread to the environment. However, they are mostly released intentionally in the form of using fertilizers and pesticides, using untreated wastewater for irrigation.

Soil pollution occurs due to many reasons such as urban wastes and unplanned urbanization, excessive use of pesticides in agriculture, livestock wastes, industrial and mining wastes, and pollution caused by the use of untreated polluted water as irrigation water in agricultural land. Pollution of the soil causes land loss, reduces the fertility of the soil, and the products harvested on the polluted soils affect human health negatively. According to the World Health Organization, more than three million people were checked into hospitals because of pesticides each year which causes millions of premature deaths (UN Environment, 2017) In Turkey, although the amount of pesticide sold is known, there is no data on how much it is used on which land (TMMOB, 2018).

Through industrial activities, pollutants are released to the water, soil and atmosphere. Pollutants discharged to the atmosphere in gaseous form may penetrate to land in the form of acid rain or atmospheric deposition. Direct discharge of waste into the soil or incorrect chemical storage or can pollute the former industrial land. Directly discharged water and other liquids used in industrial processes causes thermal pollution and dragging heavy metals and chlorine that aquatic life in rivers, lakes and oceans. Heavy metals resulted from industrial activities can rise from dusts and spillages of raw materials, wastes, final product, fuel ash, and fires (Alloway, 2013).

Table 1. Contribution of Agriculture to Global Greenhouse Gas and Other Emissions

Gas	Carbon dioxide	Methane	Nitrous oxide	Nitric oxides	Ammonia
Main effects	**Climate change**	**Climate change**	**Climate change**	**Acidification**	**Acidification Eutrophication**
Agricultural source (estimated % contribution to total global emissions)	Land use change, especially deforestation	Ruminants (15)	Livestock (including manure applied to farmland) (17)	Biomass burning (13)	Livestock (including manure applied to farmland (44)
		Rice production (11)	Mineral fertilizers (8)	Manure and Mineral fertilizers (2)	Mineral fertilizers (17)
		Biomass burning (7)	Biomass burning (3)		Biomass burning (11)
Agricultural emissions as % of total anthropogenic sources	15	49	66	27	93
Expected changes in agricultural emissions to 2030	Stable or declining	From rice: stable or declining	35-60% increase		From livestock: rising by 60%
		From livestock: rising by 60%			

Source: FAO (2003)

Since ancient times, mining has had an important effect on soil, water and biota (FAO and ITPS, 2015). Worldwide mining activities heavily contaminated the soil (Alloway, 2013). Through metal smelting processes for separating minerals, many pollutants are leaked into the soil. smelting facilities and mining release enormous amount of heavy metals and other toxic elements to the environment which persist for an extended period of time (Ogundele et al., 2017).

The different agricultural sources of soil pollutants include agrochemical sources, like animal manure, pesticides and fertilizers. Cadmium (Cu), copper (Cu), lead (Pb) and mercury (Hg) inclusive agrochemicals are also considered soil pollutants as they can impair plant metabolism and decrease crop productivity. Water sources for irrigation can also cause soil pollution if they consist of wastewater and urban sewage. Excess nitrogen and heavy metals are not only a source of soil pollution, but also a threat to food security, water quality and human health, when they enter the food chain (FAO and ITPS, 2015).

Soil degradation is the decrease in the qualifications of soil due to improper use of it (Barrow,1991). Soil quality refers to the capacity to produce safe and nutritious products in a sustained fashion for a long term while enhancing human and animal health without weakening the natural resource base or adversely affecting the environment" (Parr et al., 1992). Soils contain most of the biodiversity in the world. In order to produce food and maintain sufficient water supply, fertile and healthy soil is required. Prevalent features of soil degradation are to be defined as pesticide contamination, compaction, reduction in soil structure quality, waterlogging, soil acidity, erosion, loss of fertility, salinity and alkalinity. The fertility of top layer of soil makes it valuable for crop farmers. Soil degradation has a major impact on biological degradation, which affects the soil's microbial community and can alter nutrient cycling, pest and disease control, and soil chemical conversion properties (Parr et al., 1992).

4. SUSTAINABLE DEVELOPMENT AND AGRICULTURE

Sustainable development appears to be one of the leading concepts of environmental issues. The definition of the concept has varied through history, but its use goes back to classic economists such as Ricardo and Malthus. Ricardo talks about the limitations of land and natural resources, Malthus concluding that, in case of rapid population growth, growth is limited, and once it is in place, growth is impossible.

The concept of sustainable development, which gained different definitions and interpretations over time, has found wide use in the report Our Common Future (WCED, 1987) published by the World Commission on Environment and Development, which was founded within the United Nations in 1984 for determining long-term environmental strategies. The report, which is better known as the Brundtland Report (after the head of the commission for Former Norwegian Prime Minister Harlem Brundtland), defines sustainable development as "Progress that meets today's needs without compromising the ability of future generations to meet their own needs" (WCED, 1987) With the Brundtland Report, the concept of sustainable development has been seriously added to the political arena of international development thought. The report, which had wide repercussions around the world, emphasizes that integrating economic and ecological considerations in decision-making is the main theme of the sustainable development strategy.

Sustainable development concept was improved by the United Nations Conference on Environment and Development at the Rio de Janerio Earth Summit which was held in 1992 (UNCED, 1992). Since then, it became a key issue in worldwide scientific and political bodies.

Most definitions of Sustainable Development refer to three interdependent pillars: Environmental, Economic and Social (Elliott; 2006;11). The aim of sustainable development is to achieve the continuity of development by maximizing environmental, economic, and social goals together (See Figure-1).

The concern in sustainable agriculture and food systems emerged with environmental concerns in the 1950s-1960s (Pretty, 2008:448). Today, concerns related to sustainability are focused on the development of agricultural practices and technologies that do not have negative effects on the environment, are accessible and effective for farmers, improve food production and positively effects environmental goods and services. The concept of sustainable agriculture is an approach that aims to balance agronomic, environmental, social and economic dimensions in agricultural production. The aim is nourishment of economy for the short and long run, to increase the life quality of farmers, while maintaining both retaining abundance in agriculture and decreasing the damage to the environment at the same time.

In regard of sustainable agriculture, it is easier to describe the goals rather than making a definite definition. Agriculture is assumed to be sustainable by all. However, the interpretations of conditions and assumptions for achieving a sustainable agriculture are different. It is generally accepted that agriculture must be sustainable, however, the interpretations of conditions and assumptions under which this can be made to occur differ. Sustainability is a complicated and disputable notion. While some uses it for the capacity of continuing for a long time and persistence, others use the term for resistivity and the ability to bounce back after unexpected difficulties.

Although it is hard to define it, the main principles of agricultural sustainability can be listed as follows (Pretty, 2008:451);

i) Combining ecological and biological mechanisms for instance nitrogen fixation, nutrient cycling, allelopathy, soil regeneration, predation, competition and parasitism into food production processes,

ii) Minimizing usage of unrenewable inputs which harms the environment or the wellbeing of consumers and farmers,

iii) Generatively using farmers' skill and knowledge, thereby developing their assurance and substituting human capital for expensive exogenous inputs,

iv) Productively using people's joint capacities to work together to overcome common natural resource and agricultural hitches like pests, forest, irrigation, watershed and credit management.

Preserving natural resources is imperative for sustainable agriculture. Extreme activities carried out without allowing natural resources to renew themselves will cause future generations to face difficulties. For this reason, first of all, the targets on this subject should be well determined and clearly stated, and unsustainable

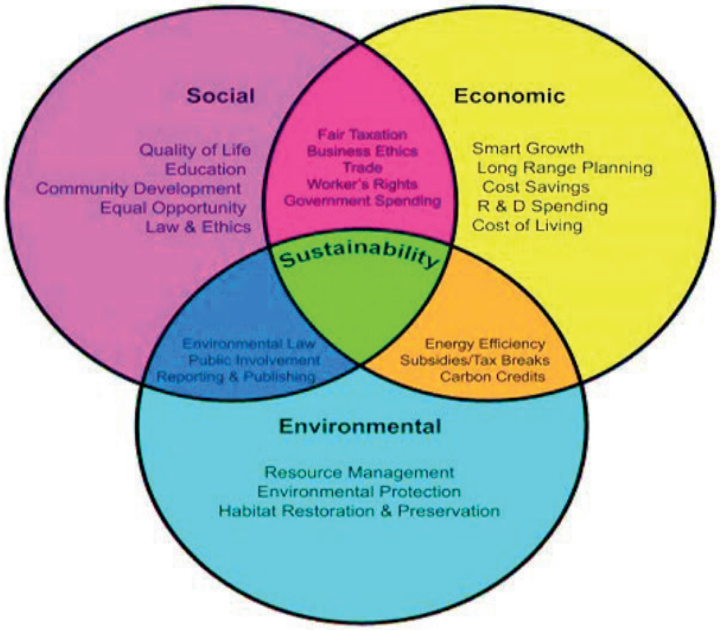

Figure 1. Relationships Among the Environment, Economy, and Social Sustainability
Source: Elliott, 2006

agricultural activities should not be supported. Governments and non-governmental organizations should take training and control measures against practices that may harm the environment, such as excessive irrigation of the soil, excessive use of fertilizers, and incorrect spraying. A database should be established for sustainable agriculture, and necessary technical, social and economic database applications should be developed. Here are the basic rules to be accepted first; that the resources required in the world for agricultural production are not unlimited and that a continuous and desired development cannot be achieved by disrupting the natural balance.

Sustainable agriculture concept is comparatively a new reaction to the decline in the quality of the natural resource base that has come with modern agriculture. The concept of sustainable agriculture can actually be thought of as a topic under which solution proposals have been put forward to solve the problems created by industrial agriculture.

Sustainable agriculture aims to inclined agricultural yields concurrently minimalizing side effects on the environment. Maintenance of the balance between producing enough food and the protection of the ecological system within the environment is the main objective of sustainable agriculture. Besides food production, sustainable agriculture also aims to reduce at amount of fertilizers and pesticides, conserve water, promote biodiversity in harvested products and in ecosystem. Conservation of economic stability of farms and improving farmers' techniques and quality of life are included in overall purposes of sustainable agriculture (Pretty,2008:449; Robertson, 2015).

Sustainable agriculture is to constitute an agricultural structure, which conserves the natural resources while using the non-damaging agricultural techniques. Like in most developed countries around the world, the synthetic production inputs are being used without control in Turkey. On the other hand, without considering the results constituted by the processing techniques and technologies, intensive farming techniques are being used. Nowadays, these kinds of applications, which are characterized by negative effects on both damaging the natural balance and causing a vital danger by infecting

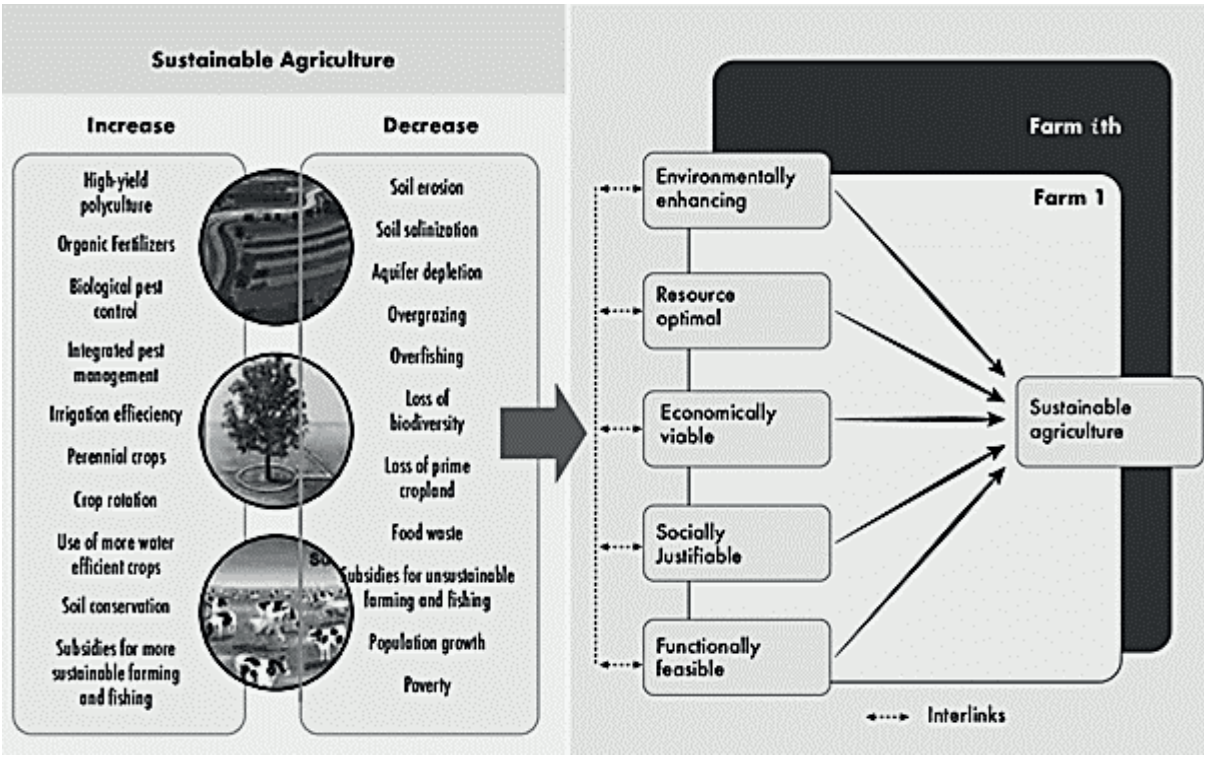

Figure 2. Sustainable Agriculture Practices and Outcomes

Source: Tey et al., 2012

not only human-beings but also all living organisms through food linkage, are becoming more conspicuous. Hence, using the techniques that have not lost its naturalness become a necessity, in sustainable agriculture. In this aspect, by avoiding the use of unnatural inputs like chemicals or synthetic fertilizers; preferring the organic agriculture techniques for quality, health and environmental standards will be key factors (Fotourehchi and Şahinöz, 2016:55, Turhan, 2005).

Sustainable agriculture is not related only with food production. All in all, it aims to reduce the usage of chemicals like pesticides and fertilizers, conserve water and promote biodiversity of grown crops and ecosystem. Sustainable agriculture also focuses on maintaining economic stability of farms and helping farmers improve their techniques and quality of life. Some of the sustainable agriculture techniques including interactions and outcomes are summarized in Figure 2.

Application of sustainable agriculture techniques, such as use of organic fertilizers, cover crops, cultivating rotational crops with efficient irrigation helps to increase soil fertility and produce healthier products while decreasing soil pollution, depletion of water supplies. Crop diversity and biological pest control leads to the decreased usage of chemical pesticides thus preserving the land.

Addressing climate change and transforming agri-food systems are key to meeting the Sustainable Development Goals (SDGs). With nearly 690 million people around the world facing hunger today (FAO, 2020), agri-food systems emitting one third of global anthropogenic GHG emissions (Crippa et al., 2021) and a growing public demand for climate action, it is pressing to achieve food security while adapting to - and mitigating - climate change. Climate-smart agriculture (CSA) has grown from a concept into an approach implemented throughout the world, by all types of stakeholders. This publication describes climate-smart agriculture case studies that apply the five action points for CSA implementation. The action points are (FAO, 2021):

1) expanding the evidence base for CSA,

2) supporting enabling policy frameworks,

3) strengthening national and local institutions,

4) enhancing funding and financing options,

5) implementing CSA practices at field level.

Due to the place and importance of the agricultural sector in the country's economies, the negative consequences of climate change in underdeveloped countries can be devastating. One of the important geographical areas affected by climate change due to economic and ecological factors is the African continent. According to World Bank, only 14 (26%) of 54 African countries have an advanced Climate Compatible Country profile. These are Benin, Ivory Coast, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Rwanda, Senegal, Tanzania, Gambia, Uganda, Zambia, and Zimbabwe (Barasa et al., 2021).

In South America, Climate Adaptive agriculture is currently practiced in Colombia in a generally unsystematic way and has generally low adoption rates. Mexico has access to a wide range of international funds, a strong enabling environment and cooperation with international donor institutions for the implementation of climate-compatible agricultural projects.

As a geographical area that can set an example for developed economies, the European Union (EU) is also one of the areas with Climate Compatible Agriculture experience. The EU has recently encouraged member states to include economic instruments in their Rural Development Programmes. Public compensation is given to farmers who voluntarily adopt certain Climate compatible Agriculture plans beyond mandatory levels. (Wichmann, 2018)

5. CONCLUSION

Intensive agriculture practices have caused difficulties such as loss of biodiversity, climate change, erosion, water and air pollution. One potential solution is to implement management practices that increase the level of delivery of ecosystem services, such as bioregulation and soil fertility.

The use of nitrogen fertilizers causes active nitrogen accumulation in the environment. Increasing application of intensive farming techniques causes the homogenization of agricultural

lands, the gradual disappearance of natural and semi-natural areas, thus the decrease in biodiversity depending on the natural environment and the destruction of soil biodiversity. In addition, as a result of conventional agricultural practices; there has been a decrease in the ecological regulation of the amount of water used in agriculture, causing a decrease in water and air quality, climate, erosion, harmful insects and diseases have occurred.

Conservation of natural resources is essential for sustainable agriculture. Excessive activities that will be carried out without allowing natural resources to renew themselves will cause future generations to face difficulties. For this reason, first of all, the targets on this subject should be well determined and clearly stated, and unsustainable agricultural activities should not be supported. Governments and non-governmental organizations should take training and control measures against practices that may harm the environment, such as excessive irrigation of the soil, excessive use of fertilizers, and incorrect spraying. A database should be established for sustainable agriculture, including the necessary technical, social and economic data bank applications.

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Notes

1 Anthropogenic of, relating to or resulting from the influence of human beings on nature.

2 Agronomy: A branch of agrıculture dealing with field-crop production and soil management.