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CHAPTER 1

A Study on Occupational Health and Safety of Fishing Boats in Ahlat (Bitlis, Türkiye)

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Introduction

An endeavor to safeguard employees and others from potential hazards that could endanger their health is known as occupational health and safety (OHS) (Utama et al., 2024) and in order for workers (fishermen) to perform properly and boost productivity, OHS is required to provide a sense of security and comfort. Improving fishermen's performance will affect their earnings, which will subsequently affect the economy and the standard of living for fishermen and their families (Dharmawirawan and Modjo, 2012).

As Turner et al. (2024) point out, the fishing has a bad reputation for health and safety and is a dangerous industry. One of the most hazardous jobs in the world is still commercial fishing. The annual number of casualties is about 32.000 (FAO, 2021). It is seen that the application of occupational health and safety (OHS) in fisheries has expanded from larger vessels to small-scale fisheries in recent years, and its development has been expanding, globally. Preventing accidents and injuries has been the main goal of these applications, which are frequently technical and specifically designed to address certain risks and practices (Windle et al., 2008).

There has never been a study on OHS for fishermen in Ahlat district (Van, Türkiye). The purpose of this study is to identify the risks to occupational health and safety that fishing boat workers in the area experience as well as the preventative measures that can be implemented.

Materials and Methods

One of Bitlis Province's six districts is Ahlat District. Ahlat district and Bitlis province are roughly 65 kilometers apart and the district in guestion is one of the areas in the Van Lake basin where substantial fishing operations are carried out (Figure 1). 20 questions were posed to commercial fishers in the Ahlat district through in-person surveys conducted between August and November 2022.

Figure 1. Ahlat (Bitlis, Türkiye)

Due to its practicality in the field and ease of application across all sectors, the "L Type Matrix" method was employed to examine the risk aspects of fishing activities in Ahlat district. Analysis of the cause-and-effect relationship is done using the "L-Type Matrix" approach. This approach uses numerical values ranging from 1 to 5 to reflect the likelihood that a risk/dangerous event is likely to happen (Table 1) and the severity of that risk/dangerous event, should it happen (Table 2). The chance of the risk/dangerous event occurring and the degree of severity of this probability are then multiplied to determine the risk score (Table 3). In this way, the necessary steps (control measures) are determined.

Table 1. The likelihood of the risk becoming realized

Possibility	Risk Realization Frequency
Too small (1)	Hardly ever
Small (2)	Very little (once a year)
Medium (3)	Few (several times a year)
High (4)	Frequently (once in a month)
Very high (5)	Very often (once a week / every day)

Table 2. Risk severity, if actualized

Severity	Possible Outcome
Very light (1)	No loss of working hours, needing first aid
Light (2)	No loss of working hours, no lasting effect and requiring outpatient treatment
Medium (3)	Condition that causes minor injury and requires inpatient treatment
Serious (4)	Condition that causes serious injury and requires long-term treatment, occupational disease
Very serious (5)	Condition causing death or permanent incapacity for work

Table 3. Deciding what should be done based on the risk score.

Risk Score	Meaning	Action
1	Minor risks	There is no need to take measures to eliminate the identified risks.
2-3-4-5-6	Low risks	There is no need for additional measures to eliminate the identified risks. Existing measures need to be maintained and their sustainability monitored.
8-9-10-12	Medium risks	Although not urgent, measures should be taken to reduce the identified risks.
15-16-20	High risk	Work should not be started until the risk has been reduced. Considerable resource allocation may be required to mitigate risk. If business is to continue despite this risk, urgent measures must be taken.
25	Intolerable risks	Work is not started until the identified risk is reduced to an acceptable level. Ongoing activities are stopped.

Using the "L Type Matrix" approach, a risk evaluation table was constructed for the fisherman in the Ahlat district. The sample table was created using Tantoğlu (2016) and Soykan (2018)'s own findings and experiences. Twenty significant risks are outlined in Table 4, together with possible outcomes. As part of the study, the fishermen were inquired:

a) What precautions are in place against these risks, and what the risks' potential outcomes could be,

b) The possibility that these risks will materialize as well as the severity if they come about,

c) Using a risk score to determine whether the safety precautions in place are adequate,

d) Even if it is adequate, it has been determined that more safety precautions ought to be implemented.

Results and Discussion

Seventeen commercial fisherman in the Ahlat district were interviewed in-person, and the results of their responses are shown in Table 4. The average of the numbers provided by the fisherman represents the risk's likelihood and severity.

Table 4. Findings from the Ahlat district's risk analysis of fishing operations.

Risk/Dangerous Event	Possible Outcome	Current Safety Measure	Risk Level			Additional Safety Measure
			Likelihood of Risk	Severity of Risk	Risk Score	
1) Not checking the weather before sailing	Boat sinking, loss of life	Weather is checked, regularly	2	2	4	Current safety measure are sufficient
2) The occurrence of unpredictable weather conditions	Boat sinking, loss of life	Boats return to fishing coastal structure	1	3	3	Current safety measure are sufficient
3) Not using the pier during boarding and disembarking.	Falling overboard, injury	The scaffold is in continuous use	1	2	2	Current safety measure are sufficient
4) Boats are not equipped with fenders	Damage/material loss caused by boats rubbing against each other	There are fenders, but not enough	2	2	4	The number of fenders should be increased
5) Unevenness of the working area on the deck	Injuries resulting from falls, loss of life	Working area is kept tidy	1	2	2	Current safety measure are sufficient

6) Working hanging from the deck	Falling overboard, loss of life	Not working by hanging	1	2	2	Current safety measure are sufficient
7) Fishermen's inexperience	Injuries, decreased in work efficiency	Newly hired fisherman is being informed	4	3	12	This information should be provided by specialized institutions
8) Working in wet and cold conditions	Employee cold, decrease in work efficiency	Fishermen wear underwear and overalls	1	1	1	Current safety measure are sufficient
9) Falling overboard	Death by drowning	All fishermen can swim	1	1	1	Current safety measure are sufficient
10) Noise	Not hearing instructions	Sign language is used when necessary	1	2	2	Current safety measure are sufficient
11) Transport of catch/fishing gear	Injuries to the hands, back and lumbar	Fishermen help each other	3	3	9	Current safety measure are sufficient
12) Fatigue from irregular and long working hours	Injuries, decreased in work efficiency	No current safety measures	4	4	16	Fishermen must work in shifts
13) Fire	Boat sinking, loss of life	Such a situation has never happened	1	1	1	Fire extinguishers should be available on the boats.
14) Fishermen do not know how to swim	Death by drowning	All fishermen can swim	1	1	1	Current safety measure are sufficient
15) Problems with freshwater requirement	Infectious disease risk, hygienic problems	There is no problem with the freshwater requirement.	1	1	1	Current safety measure are sufficient
16) Lack of first aid cabinet on the boat	Injury	There is a first aid cabinet according to the first aid regulations	1	1	1	Current safety measure are sufficient
17) Lack of first aid training	Injury	Fishermen have the information they need	2	3	6	Current safety measure are sufficient
18) Having no training in occupational health and safety (OHS)	Injury, loss of life, occupational disease, material damage	No informing about OHS	4	4	16	Fishermen should be given training in OHS as soon as possible
19) Trying to land before the boat docks fully at the pier	Falling overboard, injury	No current safety measures	3	3	9	Do not go ashore before the boat is moored to the port and the engines are turned off.
20) Electric leakage	Injuries due to electric shock, loss of life, fire	It is stated that the sockets are solid	2	4	8	Plugs should be checked periodically.

Of the 20 risks, 6 fell into the inconsequential risk category (30%), 8 into the low risk group (40%), 4 into the medium risk group (20.0%), and 2 into the high risk group (10%), based on the fishermen's responses. This study indicates that "Fatigue because of irregular and long working hours" and "Having no training in occupational health and safety" are among the high-risk groups. The same results were obtained from the studies conducted in the Van Lake Basin's Çitören (Atay and Cengiz, 2022), Lake Erçek (Cengiz, 2022), and Gevaş (Cengiz et al., 2023).

Conclusion

The vocational training is one of the primary practices to be implemented to minimize accidents resulting in death or injury in the fishing industry. Through training activities provided by experts in their fields, the experiences of people engaged in fishing activities can be shared and new employees can be employed knowing the risks involved. In this way, possible occupational accidents and occupational diseases can be reduced within the scope of risk assessment by occupational health and safety officials who are experts in their fields. Thus, the accidents that occur will not be repeated and fishing will be known as a safer business.

Acknowledgments

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CHAPTER 2

On Maximum Observed Size Record of White Seabream (*Diplodus sargus* Linnaeus, 1758) for Aegean Sea (Türkiye)

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Introduction

A significant demersal commercial sparid, the white seabream (*Diplodus sargus* Linnaeus, 1758) is found in the eastern Atlantic from the Canary Islands and Madeira north to France (Fishbase, 2020) and the Mediterranean Sea (Fischer et al., 1987), with a preference for residing in seagrass beds, sand, and rock (Vigliola and Harmelin-Vivien, 2001). Mollusks are the primary food source for this species, which gathers in schools of five to fifty individuals (Rosecchi, 1987). Estuaries and coastal lagoons (less than two meters) are typically home to juveniles (Macpherson, 1998). Long lines are typically used to catch white seabream, while gill and trammel nets are also occasionally used (Mahmoud et al., 2010).

To monitor and safeguard fish stocks, fisheries management personnel must examine certain biometric data. Fish sample programs are typically used to collect important statistics like fish weight and length. To evaluate growth rates, length and age ranges, and other facets of fish population dynamics, the collected data is essential (Kolher et al., 1995). Peak performance weight and length are the two main theoretical pillars of fish research (Dulčić and Soldo, 2005). These measurements are encapsulated in the majority of stock evaluation models, both directly and indirectly (Borges, 2001).

Because ecological roles and biological rates change with measurement, biologists and ecologists must accurately determine the largest fish size present in a population (Peters, 1983; Pope et al., 2005). For instance, body length is positively correlated with total food consumption and negatively correlated with metabolic rate. A fish's size at hatch, throughout its life, sexual development, and maturation all have a significant impact on its maximum size (Freedman and Noakes, 2002; Vander Veer et al., 2003). The specified length is the second-largest length in the Aegean Sea that has ever been documented.

Materials and Methods

The Edremit Bay, Saros Bay, the Gökceada and Bozcaada Islands, and the Gallipoli Peninsula comprise Turkey's northern Aegean coastline (Cengiz and Paruğ, 2020) (Figure 1).

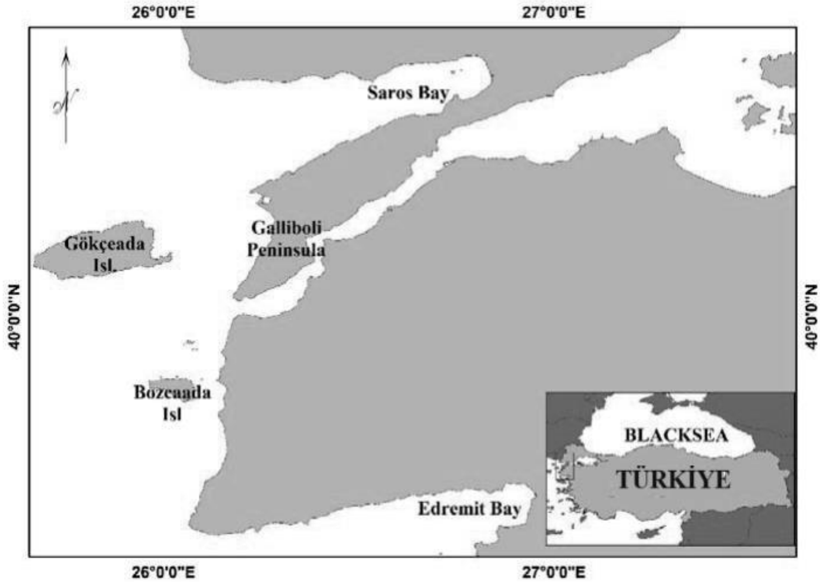

Figure 1. Gallipoli Peninsula and Türkiye's northern Aegean shores

One *Diplodus sargus* specimen was captured by a commercial fisherman off the Gallipoli Peninsula (Northern Aegean Sea, Turkey) on January 10, 2025, at a depth of about 15 meters. According to Anderson and Gutreuter (1983), the length of a fish when compressed dorso-ventrally is determined by measuring the distance between its anteriormost part and the end of its caudal fin rays. A centimeter scale was used as a reference, and a picture of the fish was taken with a ruler to precisely measure its length.

Results and Discussion

At a depth of around 15 meters, a commercial fisherman captured a single specimen of *Diplodus sargus* on January 10, 2025. The specimen was 36.4 cm long overall (Figure 2)

Figure 2. White seabream (*Diplodus sargus* Linnaeus, 1758)

As to Greece Sea, Moutopoulos & Stergiou (2002) underlined that the largest size value was 32.3 (TL). On Türkiye's Aegean coast, Paruğ and Cengiz (2020) reported the largest length record as 40.5 cm (TL).

Populations under heavy fishing pressure are known to respond by producing fewer individuals at average ages and sizes, which may result in a reduction in the maximum lengths reaching. But that length could only be attained by one individual that had not been susceptible to overfishing pressure (Filiz, 2011). However, factors that may impact growth encompass the availability of nutrients, oxygen, nourishment, conditions of lighting, temperature, contamination, current speed, nutritive concentration, salinity, predator density, intraspecific relations with others, and heredity (Helfman et al., 2009). These perspectives highlight how environmental conditions and overfishing pressure cause regional differences in maximum length and weight.

Conclusion

Given the significance of the maximum length and/or weight for particular fishery types, such as the Gompertz and von Bertlanffy theories of growth, these habitat-specific observations may provide crucial information that is integrated into these computations and stock assessments (Quinn and Deriso, 1999). Taking into account the findings of this study could aid in the management of fisheries and add to the body of knowledge in the scientific community worldwide.

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CHAPTER 3

Drought Stress and Wheat

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Introduction

It is obvious that heat waves and extreme high temperature events known as global warming are becoming more common. Preliminary applications that will keep the changing environmental and genetic characteristics of plant species and varieties due to drought stress at an optimum level without affecting germination, growth and development are becoming increasingly important. According to the United Nations, desertification and drought affect more than 4 billion hectares of land in the world and directly threaten the lives of 1.2 billion people.

It has been reported that it is important to decrease product lost owing to several environment conditions to meet increasing food demand (Tuomisto et al., 2017). Eventually the rapid rise of population, more food will be needed to ensure food security. Therefore, it seems inevitable that agricultural lands allocated to plant production will increase significantly (Bensidhoum and Nabti, 2021). The agricultural sector is under great threat from increasing global climate change. These changes are known as abiotic stress factors such as drought frequency, drought severity, irregularity of rainfall, temperature changes and salinity. Vegetative and generative propagation is very important in ensuring a sustainable production model in plant production. Since the industrial revolution in 1760-1830, human activities have increased greenhouse gases in the atmosphere and caused average temperatures to rise (Alshboul and Lorke, 2015; Mehmood et al., 2020). As an estimation, frequency and intensity of drought may increase by 50% to 200% in various geographical regions in the 21st century (Trenberth et al., 2014; Zhao and Dai, 2016). In addition to drought, extreme weather conditions such as floods also make it difficult to manage water resources (Srivastav et al., 2021). The effects welded by diverse factors such as the formation and distribution of precipitation, the amount of evaporation, and the moisture storage capacity of the soil on the available water for plants has made drought stress an unpredictable factor (Barzana et al., 2014).

Drought reflects the perspectives of many disciplines, including meteorologists who define it as low annual rainfall and agronomists who attribute it to water deficiency and evaluate it as a loss of yield. According to Kunert and Vorster (2020), term of "drought" in agriculture is the situation where the quantity of water provided by precipitation and/or the irrigated water is insufficient for providing the transpiration demands of plants. It has been revealed that more than 20% of the land used for agricultural purposes has a high salinity problem and these areas are expanding by 2 million hectares every year (Singh, 2022). Agricultural production and water consumption constitute ¾ of total water consumption (Ritchie and Roser, 2018). In modern agricultural practices, irrigated agriculture has become widespread and therefore there is a significant increase in water demand (Rosa et al., 2020). Moreover, plants are subjected to many biotic and/or abiotic based stress types throughout their lives. These stresses negatively affect the growth, development and productivity of plants. Among abiotic based stress types, salinity of soil is featured factor that most affects plant productivity, and salt stress poses a serious threat to food demand and security (Anjum et al., 2015; Angon et al., 2022).

Determining besides optimization of the crops pattern in agricultural production is one of the main elements of agricultural development, and it is of great importance to decision makers for organize - optimization of the crop pattern, especially owing to demand for market (He et al., 2021). Studies emphasize that the negative effects of stress factors affecting plant production will increase with the increase in climate change and climate fluctuations (Denby and Gehring, 2005). According to the reports of the Intergovernmental Panel on Climate Change, it is assumed that the detriment of globally air and temperature of surface change will increase in the range of 1-4.5°C, and as a result, drought events will intensify and increase the need for irrigation (Anonymous, 2007; 2013). Determination and optimization of crop pattern in plant production is kind of complex process and demands for multi-dimensional optimizing (Ji et al., 2021). Irrigation applied on semi-arid regions and arid regions supports plant development, but at the same time negatively affects soil and plants as a result of low water quality. In recent years, the risk of land loss has increased due to salinization as a result of intensive irrigation (Bensidhoum and Nabti, 2021).

There are different contradictory relationships between economic improvements besides being a good ecologic environment, as well as between the inadequacy for resources of water, economic and social development, between various dimensions in crop pattern optimization (Brenner and Hartl, 2021). Current climate forecasts predict that in the next 50-100 years, temperatures will increase in the interior of continents such as Central Africa and Central Europe, and the production period in the region will shorten, agricultural areas will face serious salinization and desertification threats with rising sea levels, and agricultural lands will decrease (Arneth et al., 2020). Promotion of sustainable development of agriculture, multidimensional coordination for environment, economy, water resources, ecology and society should be taken into consideration in the crop pattern optimization process. Most of the current crop pattern optimization studies focused for effects on economic utilities on growth (Li et al., 2022). While global climate change poses significant risks to all agricultural production due to its effects on water resources, it also poses serious threats to wheat production, which is considered a staple food product. The reduction of water resources due to increasing temperatures and decreasing precipitation creates a worrying situation in terms of sustainability, especially in wheat production areas grown with irrigation (Ding et al., 2021).

Wheat (*Triticum* spp.) is a quite valuable cereal crop which is widely cultivated worldwide and plays fundamental role in human nutrition (Igrejas and Branlard, 2020). Wheat is a self-pollinating, oldest cultivated allohexaploid species belonging to the family *Poaceae*, subfamily *Pooideae*, and tribe *Triticeae* (Zhang et al., 2014). In order to meeting of food requirements for the increasing population, annual production boost level must be increased to 38% from now on (Tester et al., 2010). When world wheat data is examined, it is known that approximately 80% of world wheat production in 2023/24 will be in China, the EU, India, Northwest Asia, Russia and the USA (Anonymous, 2024). Wheat agriculture is a critical sector for the economies of many countries and accounts for a large portion of agricultural income. Countries such as China, India, Russia, the United States and France are the main countries that carry out a significant portion of world wheat production (Erenstein et al., 2022).

Drought makes it difficult by view of plants to absorption of water in the soil, while salt stress prevents the water movement through the roots into plants. Water restriction due to drought causes salts to accumulate in the soil and exposes plants to salt stress (Roy and Shil, 2020).

The responses of plants to drought stress vary according to species and breeds, and are under the influence of genetic and environmental factors. The periods while a plant is most sensitive to drought stress are the germination and seedling formation periods. During this period, it has been determined that many physiological and biochemical events such as photosynthesis, respiration, uptake of nutrients, and transpiration change. In this study, information about drought and wheat plant responses is provided.

Drought and Wheat

Water, which is the basis of sustainable development, is considered the most important factor limiting plant productivity, especially in agricultural systems in arid and semiarid climate regions. Drought stress observed in the early stages of growth and development can cause early onset of the generative period in plants. In order to developments of plants which are more tolerant to abiotic stresses at the field scale and under controlled conditions, studies on whole plant wilting processes are widely carried out (Hwang et al., 2015; Kunert and Vorster, 2020).

Drought is considered the most important environmental stress factor in the world, affecting the growth and development of many plants and, as a result, causing significant decreases in yield (Anjum et al., 2015). In plants that are tolerant to stress, osmotic protectors, antioxidant and hormonal systems work as defense mechanisms and ensure that the plant survives and develops until the reproductive period (Khan et al., 2011). Some views evaluate leaf wilting and leaf death as a defense mechanism to reduce water use and extend plant life in a long-term drought (Blum and Tuberosa, 2018). In drought conditions and salt stress, plants maintain intracellular ion balance. In this regard, plants can reduce Na+ accumulation in cells and alleviate ion toxicity by limiting Na+ absorption with their roots (Liu et al., 2021). It has been stated that the response mechanisms of plants under two or more stress conditions are different and that plant performances can be explained by the interaction of stress factors rather than by their response to a single stress (Suzuki et al., 2014).

Water deficit prevents cell division, leaf surface expansion, root growth and root cell proliferation (Osmolovskaya et al., 2018). Drought stress based effect on the root and/or shoot development is also different. Root and leaf growth can be seriously reduced under these stress conditions, and according to research, root growth is generally less affected than shoot growth (Albaşavat et al., 2023). Increasing wheat yield by developing drought-tolerant, high-performance varieties is a continuous process that uses existing genetic resources. This helps breeders design a plant ideotype and create the optimum breeding strategy to maximize drought tolerance and performance response (Senapati et al., 2019). Potassium nitrate provides important nutrients such as potassium and nitrogen that support root and shoot development, thus increasing seedling growth under salt and drought conditions (Hasanuzzaman et al., 2018; Javed et al., 2024). Researchers (Patel et al., 2018) determined that seaweed extract application improved shoot and root length, biomass and photosynthetic pigments of wheat plants. By examining genetic variation during the seedling period, it is possible to increase the selection intensity in breeding for drought-tolerant genotypes (Hameed et al., 2010).

Usage of chemical based pesticides and fertilizers causes various environmental problems worldwide. It has been found that excessive use of phosphate fertilizers increases salinity in irrigation water and nutrient addition in the aquatic environment. It has been explained that natural salinity is the result soil and groundwater based salt accumulation by a time period (Chourasia et al., 2022). Germination period of the seeds is known as the highest critical period for obtaining high and quality yield. Numerous methods have been used to promote seedling formation and also seed germination that are caused by stressful and/or normal situations (Ambreen et al., 2021). For example, in another relative research, it was found that Sargassum wightii extract increased the germination of wheat seeds (Kumar and Sahoo, 2011). Especially in irrigated agriculture, higher yields are obtained from wheat (Memon et al., 2021).

Soil salinity has been a problem since ancient times and is considered to be one of the factors that led to the collapse of the Sumerian civilization (Jacobsen and Adams, 1958). It was determined that the application the extract of *Kappaphycus alvarezzi* to several wheat genotypes under saline conditions and drought stress increased root length and chlorophyll content. In addition, electrolyte conductivity, lipid peroxidation decreased, and the ratio between Na+ and K+ decreased (Patel et al., 2018). In their studies conducted with 13 SSR primers (associated with drought tolerance) in order to screen the genetic diversity and drought tolerance in wheat in 26 wheat varieties in Bangladesh, they reported that polymorphic bands revealed differences between genotypes (Haque et al., 2020). Salt stress causes oxidative damage and nutrient imbalance in plants, negatively affecting photosynthesis and protein metabolism, and causing serious adverse effects on the growing of plants and also for yield of fruits (Hussain et al., 2020). Scoring leaf wilting every other day during drought treatments may have the advantage of fully assessing to tolerance for drought for the relevant plant genotypes over the time (Sallam et al., 2019).

It has been determined that polysaccharides obtained from *Lessonia nigrescens* are effective for wheat seedlings development under the stress based on salt conditions (Zou et al., 2019). In another previous research (Arjumend and Turan, 2020), they reported that the effect of combined-applications of the cotton biochar and salinity tolerant bacteria (PGPR) can be evaluated to improve the growth of wheat plants and the quality of soils affected by salinity. As a result, they determined that the combine usage of cotton biochar besides halotolerant bacteria can be a good and smart method to improvement of the quality of soils that are covering salt stress and growing of plant. Seaweed applied as fertilizer in wheat provided a rise for chlorophyll content, tolerance for drought and salinity, and an increase in protein content and yield (de Carvalho et al., 2014).

In a field study (Munsif et al., 2022), they investigated the effects of different amounts of potassium and different doses of salicylic acid on the drought resistance and plant antioxidant mechanism of wheat plants grown under drought conditions. In conclusion, it was determined that the combined usage of the salicylic acid together with potassium (100 kg ha^{-1}) could reduce the negative effects of mild and severe drought stress, increase wheat yield, and increase potassium use efficiency by increasing potassium and phosphorus content.

Owing to the evolution and adaptation ability of wheat, it has been possible to spread to Europe, Asia, North America and other continents and to be successfully grown in various ecosystems around the world (Djakhangirova et al., 2023). Plants have pre-established physical, biochemical and molecular pathways for cell or tissue resistance, or they have the ability to produce higher levels of lignin, suberin, callose and epidermal cell thickening and antimicrobial stress metabolites such as phytoalexins through systemic acquired resistance (SAR), i.e. salicylic acid (SA) pathway, or induced systemic resistance (ISR) pathways. After drought, drought symptoms are likely to occur severely after disease or disease infection, leading to quite devastating results in the plant. A similar situation occurs with cold stress (Weldon et al., 2020). They evaluated the genetic diversity of 20 wheat genotypes in Nepal with 12 SSR primers associated with drought tolerance and 4 SSR primers associated with heat stress tolerance (Poudel et al., 2019). They reported that in the cluster separations created as a result of the study, alleles associated with drought and heat stress tolerance defined both closely related and distantly related genotypes of wheat. In grain yield trials conducted in three low rainfall locations for two years in some bread wheat genotypes known to be superior in terms of drought tolerance traits, it was reported that genotypes with high yield potential were also the most tolerant genotypes for drought during the period of seedling (Eltaher, 2019).

Drought is a complex trait due to its polygenic inheritance, and gene expression is affected by various environmental factors. Therefore, in order to minimize the effects of drought caused by climate change and to better understand drought, there are many studies in the literature on drought tolerance in different conditions and developmental stages (Sankar et al., 2008). Plants that protect their cells from oxidative damage include antioxidant enzymes that control the level of the ROS (reactive oxygen species) besides AS (antioxidant systems) and catalyze their conversion to normal levels (Liu et al., 2022). These antioxidant enzymes (peroxidase, catalase, superoxide dismutase, etc.) contribute to reducing cell damage caused by ROS (Mir and Khah, 2024). In another experiment in the pots realized under controlled conditions (Sedaghat et al., 2020), they examined the effects of salicylic acid and strigolactones (GR24) applied externally to wheat genotypes grown under drought stress. Consequently the both applications could improve osmotic regulation and decreased negative affects based on drought stress for the wheat plants.

About 25-30% of wheat production in the world is lost due to abiotic and biotic factors (Porras et al., 2023). In another field research (El-Saadony et al., 2021), they examined the effects of different SA and Sikosel (CCC) doses on yield and yield components in three different wheat varieties (Misr 1, Giza 171 and Gemmieza 11) grown under drought stress and in sandy soils. As a result, they shared that Misr 1 variety has the highest yield characteristics, biochemical - physical properties likewise protein, chlorophyll and proline and thus when CCC or SA is performed on plant as foliar spray, the total yield in the wheat variety is maximized and thus drought tolerance can be increased. It has been revealed that the application of analcite nano-particles in wheat and maize significantly alleviates drought stress by enhancing the accumulation of photosynthetic pigments and protective antioxidants (Zaimenko et al., 2014). The seedling period in wheat is a critical period for moisture stress (Sallam et al., 2019). They reported that wheat genotypes can be tested for drought tolerance during this period since some genotypes can tolerate drought during the seedling period.

In a different study conducted with the saponin-rich Yucca schidigera plant, the effect of stem extract on coleoptile length, which is emphasized in terms of improving drought tolerance in wheat, was investigated and its growth stimulating effects were determined (Weston and Duke, 2003). Another field research (Khan et al., 2022), they revealed the effect of salicylic acid on five different wheat varieties grown under deficit irrigation conditions. In the study, they studied two different irrigation subjects and two different salicylic acid doses (0.7 and 1.44 mM). At the end of the study, drought stress reduced chlorophyll content, osmotic potential, potassium accumulation and grain yield, while proline accumulation increased compared to the fully irrigated subject. Characteristics such as leaf wilting, greenness, etc. can be visually scored in an easy, cheap and repeatable way to include physiological characteristics in plant breeding (Sallam et al., 2018). They obtained the effects based on different salicylic acid doses on yield and yield components of wheat plants grown under deficit irrigation conditions (Mohammed et al., 2023). Drought stress caused a significant decrease in all vegetative growth, physiological and yield parameters of the plant, but led to a rise in the efficiency of irrigation water. Transfer of the AtDREB1A gene obtained from Arabidopsis plant to wheat enabled the development of wheat varieties resistant to drought conditions (Shinozaki and Yamaguchi-Shinozaki, 2007).

There is a serious needs for increasing of wheat output for ensuring the sustainable food security. Despite its socio-economic importance, global wheat production is generally threatened by biotic and abiotic stresses. Effective management of water resources should include equitable distribution and use of water among different sectors such as agriculture, industry (Berger et al., 2021) and energy (Molajou et al., 2023). In combating biotic and abiotic stress factors, resistant genotypes should be developed with a practical, economical and environmentally friendly approach. The fact that both stress factors work with different mechanisms is one of the most challenging issues for those working in plant breeding. Optimization of water consumption in wheat cultivation is of critical importance for many countries. Concerns about climate change and water scarcity have made it even more important to focus on water efficiency in wheat agriculture (Pequeno et al., 2021).

Existing water resources are becoming scarce day by day and the value of water is increasing day by day. Therefore, the use of existing water resources should be more efficient. The droughts that have occurred in recent years around the world have made it necessary to use existing water much more efficiently. Therefore, the necessary precautions should be taken in all sectors where water is used, especially in irrigation water used in agricultural production, and the economical use of water and the correct plant selection and breeding should be ensured urgently.

Conclusions

Drought and the resulting ecosystem disruptions further increase the existing tensions over water availability and rights. Environmental degradation has an essential role for the interactions amongst climate change, peace and security dynamics. Classical breeding approaches, genetic engineering studies and marker technologies should be used together to elucidate the genotypic mechanisms of drought tolerant genotypes.

Sustainability of water resources is a fundamental challenge for humanity and access to water has become complex due to the effects of global warming. Breeding for drought tolerance is an economical and sustainable approach to improve performance in marginal environments. Breeding for higher performance under drought stress has become a target research area for plant breeders combating the threat of global food security. Management of water resources and protection of health of water-related ecosystems are of great importance on a global scale. Therefore, both adaptation to climate and mitigation of the effects of climate-related disasters are vital for sustainable living and production. Proper management planning/tools and innovative cyclical planning covering the entire ecosystem are needed to maintain and improve the current structure.

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CHAPTER 4

Agricultural Ecosystems and their Interactions with Climate Change

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Introduction

Agricultural ecosystems are the basic building blocks of food production. However, climate change seriously threatens the functioning and productivity of these ecosystems. Increasing temperatures affect the growth processes of plants. High temperatures can negatively affect the basic processes of plants such as photosynthesis, water uptake and nutrient delivery. For example: Plants grow optimally within certain temperature ranges. If temperatures rise above this range, it causes stress in plants, which leads to yield loss. Especially in cereal crops, extreme temperatures can negatively affect the spike and ripening processes (Lobell et al., 2011).

Climate change affects the amount and distribution of rainfall. This complicates the management of water resources and affects agricultural production. Prolonged droughts cause water resources to decrease and soil moisture to drop. This increases the need for irrigation and puts pressure on irrigation resources. Drought can stop plant growth and lead to crop loss. Sudden and excessive rainfall can cause flooding. This leads to erosion of agricultural land, damage to the root systems of plants and deterioration of soil structure.

Climate change also affects the dynamics of the spread of agricultural pests and diseases. Changes in temperature and humidity can accelerate the life cycles of pests and pathogens. Warmer and more humid conditions create ideal habitats for pests, which increases crop losses (Kleinteich et al., 2017).

Climate change can also affect soil quality and health. Extreme rainfall and storms lead to soil erosion. Soil loss leads to nutrient depletion and reduced productivity. Temperature increases and drought can lead to loss of soil nutrients. Nutrients, especially nitrogen and phosphorus, are critical for plant growth. Deficiency of these nutrients prevents the healthy development of plants.

For these reasons, climate change seriously threatens the functioning and productivity of agricultural ecosystems. Farmers and agricultural policies have to develop strategies against these challenges. Sustainable agricultural practices and adaptation methods can play an important role in coping with these threats.

Structure of Agricultural Ecosystems

Agricultural ecosystems are complex systems shaped by interactions between plants, animals, soil, water and microorganisms. These systems are critical for sustaining natural cycles. While plant diversity increases the resilience of ecosystems, different agricultural practices can also support biodiversity (Altieri, 1999).

Agro-ecosystems consist of several main components. Plants are the main component of agriculture. Different plant species, such as field crops, vegetables and fruits, produce energy through photosynthesis and provide food (Altieri, 1999). Furthermore, plant diversity increases the resilience of ecosystems. Animals, both cultivated animals (cattle, sheep, chickens, etc.) and natural animal species (predators, pollinators) are found in agriculture. Animals play an important role in organic matter cycling, soil fertility and biodiversity conservation (Gliessman, 2007). Soil is the backbone of agro-ecosystems. Soil provides the nutrients necessary for plant growth. It also provides ecosystem services such as water retention and organic matter cycling (Baveye et al., 2016). Microorganisms, Microorganisms in soil and plants perform critical functions such as the breakdown of nutrients, improvement of soil structure and control of plant diseases (Holt et al., 2008). Water is a vital component for plant growth in agro-ecosystems. While water resources are used for irrigation, they also affect soil health (Postel et al., 1996).

Agricultural ecosystems are shaped by interactions and feedback loops between their components. Nutrients in the soil are taken up by plants and returned to the soil when plants die or are harvested. This cycle sustains soil fertility (Robertson et al., 2013). Rainfall allows water to reach agricultural land. Water is essential for plant growth and is stored in the soil. Excessive irrigation or rainfall can lead to erosion (Gleick, 1993). Solar energy allows plants to produce energy through photosynthesis. This energy is transferred to other living organisms through the food chain. In agroecosystems, energy flow is an important factor affecting productivity (Odum, 1996).

Biodiversity is a critical element for the health and resilience of agricultural ecosystems. The coexistence of different plant and animal species makes ecosystems more resilient. Biodiversity provides a natural protection mechanism against agricultural pests and diseases (Naylor et al., 2004). Agricultural ecosystems have a complex structure and a series of dynamic interactions. Understanding the components and functioning of these ecosystems is important for developing sustainable agricultural practices and increasing agricultural productivity.

Impacts of Climate Change on Agriculture

Climate change has many negative impacts on agricultural ecosystems. High temperatures can adversely affect the growth and maturation processes of sensitive crops such as cereals and vegetables. Temperature increase can lead to crop yield losses by reducing photosynthesis and water uptake (Lobell et al., 2011). Plants grow optimally within certain temperature ranges. Extreme temperatures create stress in plants, which can lead to reduced resistance to disease. Prolonged droughts reduce soil moisture and increase the need for irrigation. This threatens agricultural production, especially in regions with limited water resources (Porter et al., 2014). Sudden and heavy rainfall can cause erosion and soil loss. It also leads to damage to plant roots and drowning of plants in waterlogged soils.

Climate change can affect the dynamics of the spread of agricultural pests and diseases, leading to faster reproduction and spread of these species (Kleinteich et al., 2017). Changing climatic conditions can increase the rate of spread of plant diseases and cause the emergence of new diseases (Fig.1).

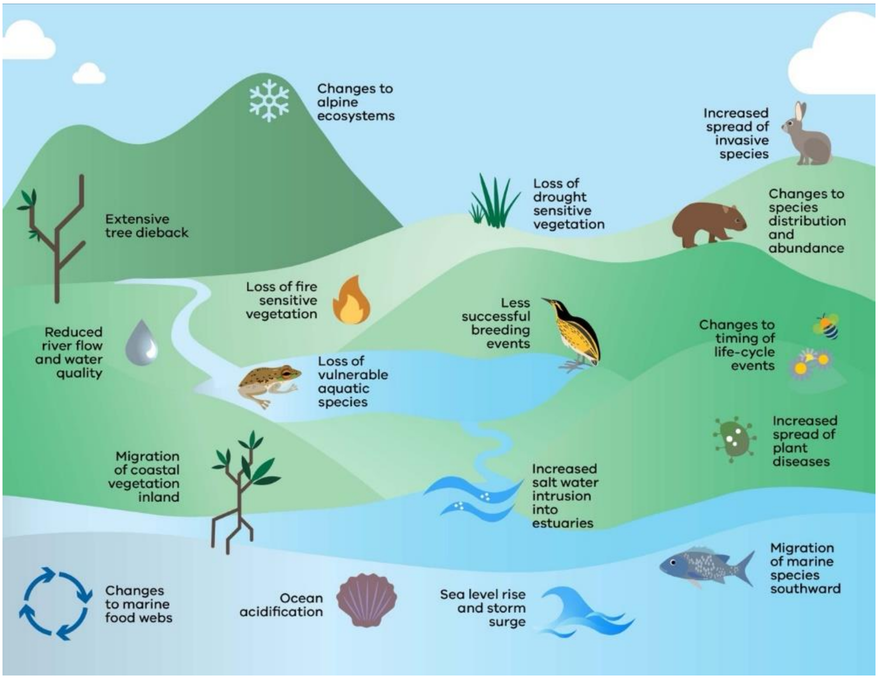

Figure 1. Flowchart of climate change local and community-wide effects (Anonymous., 2021).

Excessive rainfall increases soil erosion, which reduces soil fertility. Soil loss leads to nutrient depletion (Gleick, 1993). Climate change can adversely affect soil structure, which can lead to loss of nutrients. Changing rainfall patterns can affect the water resources required for irrigation. Drought and water scarcity are factors that threaten agricultural production.

If agricultural production efficiency decreases due to climate change, farmers may face higher costs. Drought or excessive rainfall may lead to crop loss, resulting in reduced incomes for farmers. Scarcity of agricultural products can lead to price fluctuations, which creates uncertainty for both producers and consumers. Climate change may lead to displacement of communities, especially those who depend on agriculture for their livelihoods. Water and food shortages may lead people to leave their places of residence (World Bank, 2018).

Climate change is having diverse and serious impacts on the agricultural sector. This situation threatens food security and increases the challenges faced by farmers. Developing sustainable agricultural practices and adaptation strategies is critical to addressing these challenges.

Adaptation of Agricultural Ecosystems to Climate Change

Climate change threatens food security by seriously affecting agricultural ecosystems. Therefore, adaptation of agricultural systems to climate change is vital for the development of sustainable agricultural practices.

Agroecological methods increase the resilience of agriculture to climate change by enhancing ecosystem services. These methods contribute to the conservation of natural resources, biodiversity enhancement and pest management (Gliessman, 2007). Organic farming improves soil health and biodiversity by reducing the use of chemical fertilisers and pesticides. This creates a more resilient agricultural system against climate change conditions (Reganold & Wachter, 2016).

Water-saving irrigation techniques such as drip irrigation ensure efficient use of water resources. These methods increase water efficiency under drought conditions, enabling healthy plant growth (Postel et al., 1996). Rainwater harvesting allows the collection and storage of natural rainfall. This increases agricultural water supply and reduces water scarcity, especially in arid regions (Zhao et al., 2015).

Growing different plant species together increases the resilience of ecosystems. Diversified systems increase disease resistance and reduce yield losses (Naylor et al., 2004). Conservation of pollinators in agriculture increases biodiversity and supports crop productivity. Protection of pollinator habitats can improve ecosystem health (Klein et al., 2007).

Increasing soil organic matter content improves water holding capacity. Compost utilisation and circular farming practices can increase resilience to climate change by improving soil health (Lal, 2004). Afforestation, vegetation enhancement and other erosion control methods prevent soil loss and increase agricultural productivity (Pimentel et al., 1995).

Training farmers on climate change and adaptation strategies can increase the adoption of sustainable agricultural practices. Training programmes increase access to new techniques and information (Bennett et al., 2018). Raising public awareness on climate change increases the resilience of agricultural communities. Information sharing and community-based projects can accelerate adaptation processes.

Technologies such as sensors, data analytics and remote sensing enable efficient use of resources while increasing agricultural productivity. These technologies support agricultural decision-making processes to better respond to climate change impacts (Kumar et al., 2018). The development of climate-resilient plant varieties can increase agricultural productivity. Genetic engineering and breeding methods allow to obtain more resistant plant species (Tuberosa, 2012).

Adaptation of agricultural ecosystems to climate change is possible by adopting sustainable agricultural practices and implementing innovative solutions. These adaptation strategies will support environmental sustainability while increasing agricultural productivity. Developing agricultural systems that are more resilient to the impacts of climate change will be a critical step to ensure food security in the future.

The Role of Agriculture in Combating Climate Change

The agriculture sector stands out as a critical actor in combating climate change. Sustainable agricultural practices have significant potential for reducing greenhouse gas emissions, improving soil health and protecting ecosystems.

Agricultural land management can increase the carbon sequestration capacity of soils. This stands out as an important strategy in combating climate change. Correct agricultural practices improve the carbon storage capacity of soil by increasing its organic matter content. For example, methods such as minimum tillage, rotation and ground cover crops improve soil health and reduce carbon emissions (Smith et al., 2008). Some methods used in agriculture, particularly approaches such as organic farming and agroecology, increase soil carbon storage capacity. These practices ensure the sequestration of carbon in the soil, while at the same time supporting biodiversity and ecosystem health (Lal, 2004).

The use of innovative technologies in agriculture can help reduce environmental impacts while increasing productivity. Smart agriculture uses technologies such as sensors, data analytics and remote sensing to enable farmers to produce more efficiently. These technologies optimise the use of water and fertiliser, prevent wastage of resources and reduce greenhouse gas emissions (Kumar et al., 2018). Data analysis in agriculture is an important tool in combating climate change. Models that predict climatic conditions and plant growth help farmers make the right decisions. In this way, critical elements such as harvest timing and irrigation needs can be managed more effectively. Through mobile apps and digital platforms, farmers can learn best practices appropriate for climate conditions. Such applications provide farmers with quick access to information and popularise sustainable agricultural practices.

The agricultural sector is a significant source of greenhouse gas emissions. However, these emissions can be reduced through sustainable practices and innovative technologies: Increasing biodiversity in agriculture, reducing the use of chemical fertilisers and improving organic matter content are effective strategies to reduce emissions. For example, reducing the overuse of nitrogen fertilisers can reduce nitrogen oxide emissions (Smith et al., 2008). Planting diverse crops prevents the spread of diseases while improving soil health. These methods contribute to increasing soil carbon and reducing greenhouse gas emissions (Fig. 2).

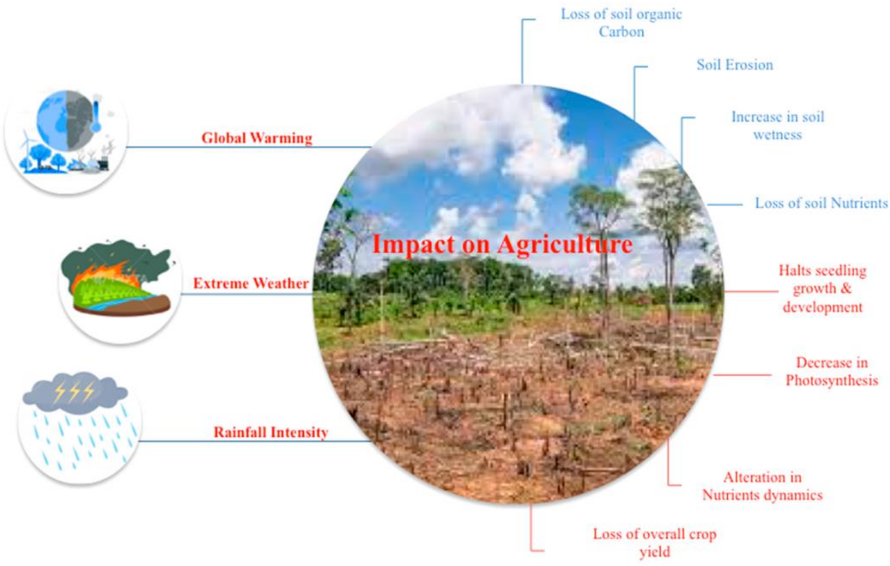

Figure 2. Impact of climate-induced environmental extremes on agriculture, soil and crops (Bibi and Rahman., 2023)

The agriculture sector plays an important role in combating climate change. Carbon storage, innovative technologies and sustainable agricultural practices can contribute to making agriculture resilient to climate change. Implementation of these strategies can both ensure food security and enhance environmental sustainability.

Policy Recommendations

Climate change threatens food security by seriously affecting agricultural ecosystems. In this context, it is important to develop various policies to make agricultural ecosystems more resilient to climate change (Fig. 3).

Training farmers in sustainable agricultural methods can accelerate adaptation processes. Training programmes should cover topics such as agroecology, soil management, water conservation and biodiversity. Such programmes increase farmers' knowledge on climate change and enable them to make more informed decisions. Awareness-raising campaigns involving large segments of society should emphasise the role of agriculture in combating climate change. These campaigns can address consumers as well as farmers and explain the importance of sustainable food systems. Establishing networks and platforms that promote knowledge sharing among farmers allows local experiences to be shared. This helps farmers learn from successful practices and accelerate their adaptation to climate change.

Investing in agricultural research on climate change can help develop new solutions. Research should focus on developing climate-resilient plant varieties, testing new agricultural techniques and effective water management strategies. Research and development efforts should be supported to develop and adopt innovative technologies for use in agriculture. Technologies such as smart agricultural practices, data analyses and remote sensing can reduce environmental impacts while increasing productivity. Research should be carried out to develop customised solutions based on the needs of local communities. This allows farmers to adopt practices appropriate to local climatic conditions.

Figure 3. Climate change and sustainable development (Anonymous., 2024)

Governments need to develop incentive policies for the sustainable management of agricultural products. This can be achieved through financial incentives, grant programmes and tax reductions that support agricultural sustainability. Financial support and agricultural insurance should be provided to farmers to mitigate climate change-related risks. Such support can encourage farmers to adopt climate-resilient practices. Policies to combat climate change can be made more effective by integrating them with agricultural policies. This ensures the co-operation of various sectors and the development of holistic solutions.

In order for agricultural ecosystems to become resilient to climate change, effective strategies need to be developed in areas such as education, research and supportive policies. Implementation of these policies will increase the sustainability of agriculture and strengthen resilience against the negative impacts of climate change. Thus, food security can be ensured and living standards of farmers can be increased.

Conclusion

Agroecosystems have an important role in combating climate change. This is a complex set of interactions that affect not only food production but also environmental sustainability. Sustainable agricultural practices increase the resilience of agroecosystems to climate change. These practices provide benefits in several areas, such as maintaining soil health, efficiently utilising water resources and increasing biodiversity. Soils rich in organic matter and nutrients increase the resilience of plants to climate change. Proper soil management reduces greenhouse gas emissions by increasing carbon storage capacity. Efficient use of water supports sustainability in agriculture. Techniques such as drip irrigation help to utilise water resources more effectively and sustain agricultural productivity under drought conditions.

Food security is a critical factor in combating climate change. Sustainable agricultural practices protect food production systems against the negative impacts of climate change. Supporting local food systems enables communities to meet their own needs. This increases the diversity of food supply and reduces the risks associated with climate change. Developing climate-resilient crop varieties ensures food security by increasing agricultural productivity. Such varieties are more resilient to climate stresses such as drought or extreme temperatures.

In the future, it is imperative to develop innovative solutions and policies in agriculture to cope with climate change. Investments in agricultural research on climate change enable the development of new technologies and practices. These innovations help farmers cope with climate change. Governments need to develop policies that support agricultural sustainability. These policies should provide opportunities such as financial support, training and infrastructure development to farmers. Educating farmers on climate change makes it easier for them to adopt sustainable agricultural practices. Education accelerates adaptation processes and increases farmers' access to information.

Innovative solutions and sustainable practices in agriculture support economic stability while ensuring environmental sustainability. Sustainable agricultural practices enable more efficient use of natural resources. This both reduces environmental impacts and lowers costs for farmers. Food systems that are more resilient to climate change contribute to global food security. Sustainable practices create economic opportunities at both local and global levels.

Agricultural ecosystems play a critical role in combating climate change. While sustainable agricultural practices ensure food security by increasing the resilience of these ecosystems, developing innovative solutions and policies is essential to ensure environmental sustainability and economic stability. In this process, the co-operation of all stakeholders and the development of effective strategies are key to securing future food security.

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