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Natural Resources, Agriculture, and the Environment: From Traditional Practices to Modern Challenges and Solutions

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Abstract

Agriculture is a set of interdependent industries mainly specialized in the production of raw materials for the food and processing industries. This review explores the correlation between agriculture and the environment, spanning the practices of hunting and gathering to contemporary agricultural methods, while addressing the significant issues encountered within this pivotal domain. Plant and animal farming is affected by seasonal and environmental changes. Land is both a tool and a target for work in agriculture, and soil conditions greatly affect crop production. Intensive and wide cultivation is considered to meet the rising food demand. Intensive farming uses contemporary technology, high crop yields, and fertilizer, whereas extensive farming uses less labor and capital per unit of land. This study examines trade trends in agricultural export and import countries. It highlights the specialization of countries in agricultural products as a function of natural resources and economic choices. It also examines environmental issues linked to agriculture, such as soil erosion, surface water contamination, and water use. Sustainable agriculture and water resource management are essential for solving these problems. The research recommends coordinated management of soil, water, plants, and nutrients to conserve agricultural water. Emphasis is placed on demand-responsive irrigation, optimizing irrigation scheduling, and reducing evaporation losses. Nuclear and isotopic technologies can improve agricultural water management. These technologies include water isotope signatures, soil moisture, nitrogen fertilizer monitoring, and landscape water flows.

Keywords: Agriculture, Water management, Intensive productions, Negative effect of pesticides

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1. Introduction

The agricultural sector has significant importance within the economy as it fulfills the crucial roles of sustaining the inhabitants and supplying raw materials for industrial processes. In ancient times, humans initiated the cultivation of land as they transitioned from the rudimentary methods of collecting and hunting to a novel approach for addressing their sustenance needs. This included the adoption of domestic animal husbandry and agricultural production as more essential means of procuring food resources [1].

Furthermore, it is worth noting that agriculture has a unique and significant connection to the use of natural resources, unlike any other sector within the realm of social production. Ultimately, the occupation of a farmer and stockbreeder fundamentally revolves around using the resources provided by nature and the surrounding natural environment to fulfill human requirements. The agricultural sector should be seen as a whole system for safeguarding and nurturing live natural resources, operating continuously, and necessitating a different perspective that emphasizes environmental conservation. Therefore, within the context of agricultural production, it is essential to integrate the use of natural resources, particularly land, with environmental conservation measures. The essential need for the sustenance of every civilization, regardless of its level of advancement, is the products resulting from human effort on the planet [2].

The contemporary context has heightened the need to address environmental protection in agriculture, mostly because of the escalating pollution processes affecting the natural resources used in agricultural production. These pollutants contribute to a decline in soil fertility and productivity, degradation of water and air quality, and harm to plant and animal production, leading to a decrease in agricultural yield and deterioration in its overall quality. Contemporary environmental issues are of significant global importance [3]. The agricultural sector is a significant component of the agro-industrial complex, exerting substantial influence on the natural environment. The issue at hand is the extensive allocation of land for agricultural purposes. The land base serves as the fundamental basis for industry growth. The cultivation of extensive land areas results in the alteration of the landscape by human activities, which significantly influences the surrounding environment [4].

In the past, the agricultural industry did not pose a significant risk to wildlife. However, with the introduction of contemporary technology and industrial techniques in plant and animal development processes, the harmful impact of agriculture on wildlife has become more widespread and is now expanding. Environmental challenges encountered in agriculture arise from the suboptimal state of water, soil, and air. It is important to comprehend that the agricultural enterprise itself is responsible for the lamentable state of affairs because it functions as both the instigator and the entity impacted by the scenario [5].

This scientific study investigates the fundamental relationship between agriculture and the environment, tracing its evolution from basic hunting and gathering to contemporary farming methods. Emphasizing its substantial contribution to providing sustenance and raw materials for industry, the study acknowledges that agriculture is heavily dependent on natural resources.

2. Characteristics of worldwide agricultural development

Agriculture is a widespread global industry that employs approximately one billion people and covers a diverse array of fields. Specifically, it includes plant cultivation, which has been developed in almost every region except for tundra areas, Arctic deserts, and inhospitable highlands. Crop cultivation involves the production of cereals, industrial crops, and vegetables, making a substantial contribution to the world's food supply [6]. Livestock farming is a crucial component of agriculture because its growth is directly linked to the availability of livestock feed. This branch of agriculture includes a variety of specializations, including cattle, sheep, poultry, horse, and fish breeding, as well as beekeeping and fur farming [7]. Agriculture has several distinct features, the first being the seasonal nature of production. Seasonal cycles, which are determined by climate conditions, significantly impact agricultural activities, including planting, harvesting, and resting periods, which vary by climatic region [8].

Environmental factors such as climate, terrain, and soil quality strongly influence the structure and location of the agricultural industry. These factors determine the types of crops that can be grown in a particular region. A crucial aspect of agriculture is land usage as both the primary means and objective of labor. Agricultural production is intimately tied to the size and quality of the available land. Farmers rely primarily on soil as their essential tool and focus intently on improving its quality because it profoundly impacts crop yields [9]. Two primary methods seek to meet the increasing demand for food products by boosting agricultural production. Intensive farming is characterized by low crop rotation and high usage of modern technologies and agro-techniques. This involves the application of fertilizers, the use of modern machinery, and land reclamation practices to maximize crop yields. In contrast, extensive farming requires less labor, fertilizers, and capital per unit of cultivated land. This approach is often preferred when a large amount of land is available, and resources are scarce [10].

3. Geography of agricultural production

The data presented in (Table 1) reveal distinct trade patterns between exporting and importing countries. Each country specializes in specific agricultural products, reflecting both its natural resources and economic preferences [11]. For instance, the USA exports various products such as soybeans, corn, cotton, wheat, pistachios, almonds, and meat. In contrast, it primarily imports alcohol, beef, fruit, vegetables, and coffee. This duality reflects their central role in global agricultural trade. The Netherlands specializes in exporting horticultural products, particularly flowers, ornamental plants, vegetables, meat, and dairy products. As an importer, it relies on agricultural raw materials and fish products, reinforcing its position as a hub of European trade. Germany exports dairy products, meat, and grains, but imports agricultural raw materials, beverages, and tobacco. This dichotomy reflects the strength of the German economy and its domestic demand for agricultural products.

Brazil, the world's leading coffee producer, stands out for exporting coffee, sugarcane, cotton, cocoa, soybeans, corn, and bananas and plays a vital role in supplying agricultural products to the Netherlands. China exports tea, rice, pulses, fruits, and vegetables while primarily importing meat, cereals, soybeans, soybean and rapeseed oil, and food products. This diversity reflects its expanding role as a consumer market for various food products. Each of these countries contributes significantly to the global economy through its export and import choices while meeting the diverse food needs of populations worldwide. These commercial exchanges demonstrate the economic specificities, natural resources, and cultural preferences of each nation.

4. Global environmental problems in agriculture

As human civilization has advanced, there has been a gradual shift away from reliance on natural resources This transition has resulted in a range of issues related to environmental degradation and excessive depletion of resources. The equilibrium has been disrupted, and the task of reinstating it becomes ever more difficult with each passing year [12]. The three sectors that contribute the most to environmental degradation are transportation, energy production, and industrial activities. In 1980, the United Nations included agriculture as one of the sectors that significantly contribute to environmental degradation, so designating it as the fourth sector having a substantial negative influence on the environment. Crop agriculture inflicts far more harm than animal husbandry, with the latter having a comparatively lesser influence on the natural environment. Therefore, environmental issues in agriculture may be categorized into many types [13]:

- Soil erosion is the process through which the top layer of soil is displaced or removed because of natural factors such as wind, water, or human activities.
- The topic of concern is contamination of the uppermost layer of soil due to chemical pollutants.
- Water pollution is a significant environmental issue that involves the contamination of water bodies, such as rivers, lakes, and oceans, with harmful substances.
- The phenomenon of the extinction of certain animal and plant species.

Table 1: The world's major agricultural exporters and importers [11]

Exporting countries		Importing countries	
Country name	**Main types of products**	**Country name**	**Main product types**
USA	Soya, corn, cotton, wheat, pistachios, almonds, meat	**USA**	Alcohol, beef, fruit and vegetables, coffee
Netherlands	Flowers, ornamental plants, vegetables, meat, dairy products	**China**	Meat, cereals, soybeans, soybean and rapeseed oil, food products
Germany	Milk, dairy products, meat, cereals	**Germany**	Agricultural raw materials, beverages, tobacco
Brazil	Coffee, sugar cane, cotton, cocoa, soybeans, corn, bananas	**Netherlands**	Agricultural raw materials, fish products
China	Tea, rice, pulses, fruit, vegetables	**Japan**	Agricultural raw materials
France	Wine, cognac, cereals, citrus fruit, tomatoes, grapes	**Great Britain**	Agricultural raw materials
Spain	Wine, citrus, olives, olive oil	**France**	Agricultural raw materials
Italy	Vegetables, fruit, olives, grapes, pasta	**Italy**	Meat, cereals, dairy products
Canada	Cereals, oilseeds, meat, fish, seafood	**Spain**	Agricultural raw materials
Belgium	Meat, milk, tobacco, vegetables, fruit, chocolate	**Belgium**	Fish and seafood

Throughout history, humanity has consistently challenged the forces of nature, persistently engaging in the expansion and cultivation of new territory. This includes activities such as the reclamation of wetlands, the removal of forests, and the establishment of irrigation systems in arid regions. Continuous expansion of surface area for plant agriculture has been an ongoing activity since ancient times. As further regions were annexed, there was an irreversible loss of formerly cultivated land, rendering it unfit for agricultural purposes [14].

Pastoral landscapes, including pastures, hay meadows, and fields, together account for a mere 13% of the total land area of our planet. Prior to the implementation of pioneering agricultural technology, individuals had a total of 4.5 billion hectares of land that was deemed appropriate for cultivation. By the year 2015, this numerical value had decreased by about fifty percent, resulting in a more moderate measurement of 2.5 billion hectares. Annually, the agricultural industry experiences a loss of around 7 million hectares of land that has been damaged due to erosion, as well as contamination of soil, water, and air [15].

4.1. Soil erosion

Erosion, also known as soil erosion, is an inherent phenomenon characterized by the gradual degradation of the top layer of soil due to the forces of water and wind. Anthropogenic erosion refers to a comparable phenomenon that arises as a result of human activities, whereby the natural process of erosion is expedited by anthropogenic factors. Numerous agricultural enterprises disregard crucial intricacies of plant production technology in their pursuit of maximizing crop yields within minimal timeframes [16]. An example of how the abstention from fallowing and crop rotation expedites the phenomenon of soil erosion. Failure to implement crop rotation and allow for periodic fallow periods may result in erosion, leading to the degradation of productive soil and rendering it unsuitable for agricultural purposes. Individuals who prioritize the immediate gratification of reaping a crop by destroying their own fields tend to live in the now without considering future consequences [17].

4.2. Surface water pollution

Approximately 70% of global freshwater resources are allocated for agricultural use, mostly for irrigation reasons, with a significant proportion being consumed irretrievably. The substantial magnitude of this statistic serves as a strong indication of the industry’s reliance on water resources. Surface water pollution is a significant environmental issue within the agricultural sector and has a direct impact on the depletion of freshwater resources [18].

The primary cause of this phenomenon is eutrophication, which refers to the enrichment of water bodies with biogenic components such as domestic animal waste and agricultural herbicides. Under specific circumstances, pollutants can impact the physical properties of water, leading to changes in its composition, a decrease in oxygen levels, and alterations in the population and diversity of bacteria residing within it [19].

4.3. Water management: Case of Morocco

Sustainable agriculture has been included as a major component of the Green-Morocco Plan since its inception. The objective is to promote the efficient use of water resources and phytosanitary products alongside the widespread implementation of renewable energy sources [20]. In relation to the primary axis, it is noteworthy that the agricultural sector accounts for almost 80% of the nation ’s water resources. To address the issue of excessive water use, it is imperative to devise strategies and implement water-saving technologies and apparatus to regulate the utilization of this limited resource. In pursuit of this objective, Morocco is actively endeavoring to optimize water use for agricultural purposes and alleviate the ramifications of drought. It is essential that the suggested approaches possess economic viability for agricultural operations [21].

Drip irrigation, sometimes referred to as localized watering systems, is extensively advocated as the preferred method in Morocco. Many benefits are associated with the use of these systems, particularly in relation to water conservation, input efficiency, and labor reduction. The Kingdom has followed a program of constructing dams since its independence as an essential component of mobilizing water resources. The implementation of this proactive strategy has successfully facilitated the development of urban planning, industry, and agriculture [22].

At present, Morocco has a total of 145 dams, with a collective storage capacity of to around 18.67 billion cubic meters. By 2027, there are plans to build an additional 20 dams, while an additional 14 dams are currently in the process of being built. These developments will result in a significant increase in the overall capacity, surpassing 27 billion cubic meters. The expansion of irrigated lands has reached a total of 1.6 million hectares. Morocco achieves success in the agriculture sector by effectively and efficiently using plant protection products. The nation enhances the quantity of this particular input while ensuring minimal environmental repercussions [23].

The agricultural sector accounts for approximately 70% of global freshwater use, although the water usage efficiency in several nations falls below the threshold of 50%. Nuclear and isotope methodologies provide valuable insights into water use, including the quantification of losses attributed to soil evaporation. These approaches also contribute to the enhancement of irrigation plans and optimization of water usage efficiency [24].

According to the Food and Agriculture Organization (FAO), it is projected that the agricultural sector will experience a 50% surge in water needs by the year 2050. This escalation is anticipated to be necessary to adequately address the escalating food requirements of an expanding global population. The availability of freshwater is progressively diminishing on a global scale because of inadequate governance, indiscriminate use, and the impacts of climate change. The issue of water scarcity and quality in many regions around the globe presents a significant challenge to the future of food security and environmental sustainability. Addressing this issue necessitates the implementation of improved land and water management strategies. The International Atomic Energy Agency (IAEA) is working in partnership with the Food and Agriculture Organization (FAO) to assist member states in the advancement and implementation of nuclear-based technologies. These technologies enhance agricultural water management techniques, so facilitating the intensification of crop production and the conservation of natural resources [25].

However, one of the primary aims of World Water Day is to contribute to the realization of Sustainable Development Goal 6, which pertains to universal access to clean water and sanitation by the year 2030. The subject of World Water Day in 2022 is groundwater, emphasizing its significant importance in the provision of water for agricultural, industrial, ecological, and climate change adaptation purposes [26].

5. Using scientific methodologies for enhancing water conservation

sssTo ensure food security and promote sustainable water management in the agricultural sector, it is imperative to enhance crop production per unit volume of water utilized, thereby improving water use efficiency without compromising the quality and quantity of downstream waters. Enhancement of water resource management necessitates the adoption of an integrated strategy that encompasses soil, water, plant, and nutrient management. This should include the optimization of irrigation schedules and the development of more effective irrigation technologies, such as drip irrigation. Enhancing soil fertility is important to mitigate limitations imposed by physical limits or nutrient deficiencies and optimize water use for crop development. The optimization of water absorption by crops may be achieved by implementing a demand-driven irrigation scheme that considers the specific water needs and developmental stages of various crops, in addition to the prevailing environmental circumstances [27].

Enhancing the water use efficiency in agricultural practices may be achieved via the reduction of evaporative losses of soil water caused by plant transpiration within the cultivated area. Assessment of soil water evaporation and plant transpiration is crucial for understanding the irrigation water needs of different crop varieties and development phases. This knowledge is essential for effectively conserving and managing water resources [28].

5.1. Potential contribution of nuclear and isotopic methods

Nuclear and isotopic methodologies are important in furnishing crucial data for the formulation of improved agricultural water management strategies [29].

- The use of isotopic signatures of oxygen-18 and hydrogen-2 in water derived from agricultural fields enables the assessment of the relative amounts of irrigation water that undergo soil evaporation and plant transpiration. These valuable data contribute to the enhancement of crop water usage efficiency.
- The neutron moisture meter is well suited for quantifying the moisture content in the soil around crop roots, providing accurate information on water accessibility. The aforementioned device is very appropriate for quantifying soil moisture levels in saline environments, thus enabling the development of irrigation strategies that are optimized for efficiency and effectiveness. Furthermore, it is extensively used for calibrating traditional moisture sensors.
- The isotopic composition of nitrogen 15 was employed to monitor the displacement of nitrogen fertilizers labeled in soil, crops, and water. This is crucial information for assessing the many aspects that might impact the effectiveness of fertilizer usage and water quality in agricultural environments. The use of the isotopic compositions of nitrogen 15 and oxygen 18 in nitrate enables the identification and differentiation of the origins of nitrate contamination in agricultural basins.
- The use of the Cosmic Ray Neutron Moisture Meter is employed for evaluating water flows on a broader scale within the landscape, with the ultimate objective of formulating and implementing sustainable plans for land and water resource management.

6. Conclusion

In conclusion, this study highlights the significant importance of agriculture in the global economy because of its crucial role in providing essential foodstuffs and raw materials for industry. The evolution of agriculture, from primitive subsistence methods to modern practices, is documented in its history, while pressing environmental challenges are emphasized. Increasing pollution endangers the quality of natural resources, jeopardizing agricultural productivity and global biodiversity. To meet these challenges and simultaneously cater to the world’s growing food demand, sustainable agricultural practices, judicious water management, and the integration of scientific methods are imperative.

In addition, this study emphasizes the significance of agricultural trade between nations, which reflects their respective natural resources and economic preferences. This underscores the need for international collaboration to ensure a just distribution of food resources. By integrating scientific techniques such as nuclear and isotope technology into agricultural water management, we can enhance the water use efficiency while reducing environmental impacts.

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