

Intensive Agriculture: Pathways of Water Pollution and Ecosystem Disruption

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ABSTRACT

Agricultural intensification has emerged as a key approach to meet the rising global demand for food, fiber, and fuel by increasing productivity through the use of high-yielding varieties, fertilizers, pesticides, and irrigation. While these practices have significantly improved agricultural output, they have also imposed considerable pressure on water ecosystems. Intensive agriculture often leads to excessive withdrawal of surface and groundwater resources, resulting in declining water tables and altered hydrological cycles. Additionally, the overuse of agrochemicals contributes to nutrient runoff and pesticide contamination, causing eutrophication and deterioration of water quality. These changes adversely affect aquatic biodiversity, ecosystem services, and human health. Sustainable management practices such as efficient irrigation, integrated nutrient and pest management, conservation agriculture, and precision farming are essential to mitigate these impacts. Balancing agricultural productivity with the conservation of water resources is crucial for ensuring long-term environmental sustainability and food security.

INTRODUCTION

Agricultural intensification has become a major strategy to meet the increasing global demand for food, fiber and fuel. It involves increasing agricultural productivity by using high-yielding crop varieties, chemical fertilizers, pesticides, mechanization and improved irrigation practices. Over the past few decades, these practices have significantly enhanced crop production and helped ensure food security for a rapidly growing population. However, the intensification of agriculture has also raised serious concerns regarding its environmental impacts, particularly on water resources (Tilman *et al.*, 2002).

Water is one of the most essential resources for agriculture, as crop production largely depends on the availability and quality of water. Intensive farming systems often require large amounts of irrigation water to maintain high yields. Excessive withdrawal of water from rivers, lakes, and groundwater aquifers can lead to water scarcity and declining groundwater levels in many agricultural regions (FAO, 2017). In addition, irrigation practices can influence the natural hydrological cycle and alter the availability of water for other uses. Another major issue associated with agricultural intensification is the deterioration of water quality. The extensive use of fertilizers and pesticides in modern farming can result in nutrient runoff and chemical leaching into nearby water bodies. Nutrients such as nitrogen and phosphorus may accumulate in rivers, lakes, and groundwater, causing eutrophication and posing risks to aquatic ecosystems and human health (Foley *et al.*, 2011).

Therefore, understanding the relationship between agricultural intensification and water resources is essential for achieving sustainable agricultural development. Sustainable farming practices and efficient water management

strategies are needed to balance agricultural productivity with the conservation of vital water resources for future generations.

Intensive Agriculture

An agricultural system with high productivity per unit area. Intensive agricultural systems also frequently have high input requirements per unit area, relying upon the use of mechanization, fertilizers, and agrochemicals.

Characteristics of intensive agricultural system

- Higher use of labour
- Higher use of pesticides
- Higher use of fertilizers
- Concentrated animal feeding operations
- Cultivating water intensive crops such as paddy, wheat and sugarcane
- Raising large number of animals on limited land
- Monocropping
- Higher crop yield per unit area

Importance of Water Ecosystem

- **Life Support:** Water is essential for all life, sustaining plants, animals, and human societies.
- **Nutrient Cycling:** Water carries nutrients through ecosystems, vital for plant growth and aquatic life.
- **Habitat:** Aquatic environments, fed by soil and water cycles, provide habitats for countless species, from fish to amphibians.
- **Climate Buffer:** Healthy water systems influence local and global climate patterns.

Interconnected Consequences

- **Loss of Ecosystem Services:** Degraded soils and polluted water reduce the natural ability to purify water, store carbon, and regulate floods, increasing costs and risks.
- **Water-Food-Energy Nexus Strain:** Intensified agriculture's high demands for water and energy create significant stress on these interconnected resources, threatening food security and sustainability.

Mitigation measures

To reduce the negative impacts of agricultural intensification on water resources, several sustainable management practices can be adopted. These measures help maintain water quality, improve water-use efficiency, and ensure long-term agricultural productivity.

1. Efficient Irrigation Practices

Adopting efficient irrigation methods such as drip and sprinkler irrigation can significantly reduce water wastage. These systems deliver water directly to the plant root zone, minimizing evaporation and runoff while improving water-use efficiency (FAO, 2017).

2. Integrated Nutrient Management

Balanced and judicious use of fertilizers through integrated nutrient management helps reduce nutrient leaching and runoff into water bodies. Combining organic manures with chemical fertilizers improves soil fertility and reduces water pollution.

3. Integrated Pest Management (IPM)

Integrated pest management promotes the use of biological control agents, resistant crop varieties, and cultural practices to reduce dependence on chemical pesticides. This approach helps prevent pesticide contamination of surface and groundwater resources (Tilman *et al.*, 2002).

4. Conservation Agriculture

Practices such as minimum tillage, crop rotation, and residue management help improve soil structure and water retention. Healthy soils enhance infiltration and reduce runoff, thereby protecting water quality.

5. Rainwater Harvesting and Groundwater Recharge

Collecting rainwater through farm ponds, check dams, and recharge structures helps increase groundwater levels and provides additional water for irrigation during dry periods.

6. Precision Agriculture

Precision farming technologies, including sensors and satellite-based monitoring, allow farmers to apply water, fertilizers, and pesticides in precise amounts according to crop needs. This reduces resource wastage and environmental pollution.

7. Buffer Strips and Vegetative Barriers

Planting grasses or vegetation along field boundaries and water bodies acts as a natural filter. These buffer zones reduce sediment, nutrients, and agrochemical runoff entering rivers and lakes.

Implementing these mitigation strategies can help balance the need for increased agricultural production with the protection of water resources. Sustainable water management is essential to ensure food security while safeguarding the environment for future generations.

CONCLUSION

Agricultural intensification has increased food production but has also placed significant pressure on water resources through excessive water use and pollution from fertilizers and pesticides. These practices can lead to

groundwater depletion and deterioration of water quality. Therefore, adopting sustainable approaches such as efficient irrigation, integrated nutrient management, and conservation practices is essential to protect water resources while maintaining agricultural productivity.

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