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# Applications of Nanotechnology in Sustainable Agriculture Recent Developments, Challenges, and Perspectives

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**Abstract: Sustainable agriculture is vital for encouraging both developing and established countries. To meet the rising need for food from a growing global population and to ensure environmental sustainability at the same time, agriculture needs modernization and innovation. Our analysis offers a thorough understanding of current advances in nanotechnology-based agrochemicals that have revolutionised the agricultural industry by enhancing plant growth, crop yields, facilitating soil cleanup with nanotechnology, and identifying environmental toxins. Agriculture has changed and become more inventive, sustainable, and ecologically friendly thanks to the usage of nanoscale bioagrochemicals including nano-pesticides, nano-fertilizers, nanoformulations, and nanosensors.With revolutionary nanotools for the control of quick disease diagnosis, boosting plant nutrient absorption, and other uses, The agricultural and food industries could benefit from nanotechnology. Among the major interests of using nanotechnology in agriculture are specific applications like nanofertilizers and nanopesticides to track products and nutrient levels to increase productivity without decontaminating soils, waters, and protection against a variety of insect pests and microbial diseases.**

**Keywords: Nanomaterials**; **sustainability**; **agriculture**; **agrochemicals**; **biosynthesis**

## Introduction

By increasing food availability and producing better goods that are extremely advantageous in agriculture, water, the environment, medicine development, and health, nanotechnology has been demonstrating significant potential for discovering answers to concerns related to food security. Several food-related issues, including nutrient delivery, protein bioseparation, quicker sampling of chemical and biological pollutants, solubilization, and nutraceutical nanoencapsulation, may be greatly helped by a few of the developing nanotechnology fields.Food nanotechnology involves the use of nanocarrier techniques and processes to reinforce the bioactive substances in order to further alter their biological availability and create a barrier against various chemical or environmental changes. The most important obsession nowadays is to build in order to combat poverty in agriculture and the food-acquiring nutritional process.As a result, new technology that is firmly focused on improving agricultural production should be adopted (Yunlong and Smit, 1994). Security of food and nutrition has recently become an integral part of new knowledge. In order to achieve certain target-oriented goals, it is necessary to record how the development of agriculture depends on factors such as social inclusion, health, energy, climate change, ecosystem processes, natural resources, good quality, etc. As a result, sustainable agriculture improves people's ability to actually escape poverty and hunger.Agriculture is on the road to recovery, thus maintaining environmental performance and involving food chain ecosystems in agricultural food production are both necessary (Thornhill et al., 2016).

**Nanotechnology and Agricultural Sustainable Development**

Nanotechnology can significantly improve production through nutrient control, in addition to monitoring water quality and pesticides for the sustainable growth of agriculture (Prasad et al., 2014). It is impossible to provide a general assessment of the health and environmental concerns associated with nanomaterials due to their wide range of properties and uses (Prasad et al., 2014).Chemical composition, shape, surface structure, surface charge, behaviour, degree of particle aggregation (clumping) or disaggregation, etc. may be associated with designed NPs and have an impact on toxicity in addition to size (Ion et al., 2010). Because of this, the toxicity of different-sized or -shaped nanomaterials with the same chemical makeup can vary. Sustainable development now heavily relies on the application of nanotechnology research to the agricultural sector. The agri-food industries have demonstrated the use of nanotubes, fullerenes, biosensors, controlled delivery systems, nanofiltration, etc. (Ion et al., 2010; Sabir et al., 2014).

**Micro- and Nanoencapsulation**

According to Rodriguez et al. (2016), encapsulation is the process of enclosing an object in a covering or embedding it in a homogeneous or heterogeneous matrix. As a result, capsules with a variety of beneficial qualities are produced. The advantages of encapsulating techniques include controlled release, precision targeting, and protection of substances/objects from harmful conditions.

**Nanoemulsions**

Nanoscale emulsion droplets (oil/water system) with diameters smaller than 100 nm, according to Gutiérrez et al. (2008) and Anton and Vandamme (2011), are what produce nanoemulsionsThe physical characteristics of nanoemulsions can differ significantly from those of microscale emulsions, despite the fact that there are no fundamentally significant differences between the two (Mason et al., 2006; Gupta et al., 2016).The elastic modulus, Laplace pressure, surface area to volume ratio, and droplet size of nanoemulsions are all much greater than those of conventional emulsions. Additionally, unlike conventional emulsions, the majority of nanoemulsions exhibit optical transparency, which technically has several benefits and makes them ideal for inclusion into beverages. Unfortunately, creating nanoemulsions requires a lot of energy, thus specific equipment like a high pressure homogenizer or an ultrasonic generator that can produce extremely high shear stresses is needed.

**Nanofertilizers**

Although agricultural fertilisers, in particular, are still not developed by the big chemical corporations, nanofertilizers are already widely accessible on the market.

Nanofertilizers may include nanoscale amounts of titanium dioxide, silica, iron, ZnCdSe/ZnS core shell QDs, InP/ZnS core shell QDs, Mn/ZnSe QDs, gold nanorods, core shell QDs, and other materials. They should also provide controlled release and enhance the quality of their product. Studies investigate the biological destiny, toxicity, and absorption of a number of metal oxide nanoparticles, including Al2O3, TiO2, CeO2, FeO, and ZnONPs

**Applications**

1. Nano-Advancements in Food Processing and Packaging
2. Nanoparticles as a Growth-Stimulating Element of Sustainable Agriculture
3. Nanotechnology and Food Insecurities

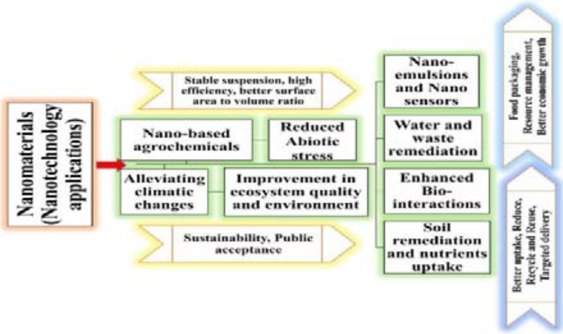


**Figure 1. Application of nanomaterials in ecosystem and agricultural sustainability**

## CONCLUSION

Agriculture is the only sector that can provide enough food for people using only proven technology, intermediate, and final inputs. Therefore, having updated agricultural knowledge is crucial. While developing countries may have certain relative advantages in the agricultural process, they nonetheless struggle with a lack of a strong emphasis on food products. Even though there is a lot of information on certain nanoparticles, it is still unclear how harmful many NPs .As a result, the applications of these materials are restricted due to the lack of understanding of risk evaluations and impacts on human health. This pressing problem may have a viable answer provided by nanobiotechnology, which has improved growth yield while also raising plant survival rates. Nano-fertilizers, nanosensors, and nanopesticides have powerful uses in the agricultural sector and could further contribute to sustainability because nanomaterials have been recognised as a safe delivery mechanism and display a variety of unique potentials.

**References**


1. Aryal, J.P.; Sapkota, T.B.; Khurana, R.; Khatri-Chhetri, A.; Rahut, D.B.; Jat, M.L. Climate change and agriculture in South Asia: Adaptation options in smallholder production systems. *Environ. Dev. Sustain.* **2011**, *22*, 5045–5075.
2. Celik, S. The effects of climate change on human behaviors. In *Environment, Climate, Plant and Vegetation Growth*; Springer: Cham, Switzerland, 2010; pp. 577–589.
3. Pathak, T.B.; Maskey, M.L.; Dahlberg, J.A.; Kearns, F.; Bali, K.M.; Zaccaria, D. Climate change trends and impacts on California agriculture: A detailed review. *Agronomy* **2012**, *8*, 25. Okey-Onyesolu, C.F.; Hassanisaadi, M.; Bilal, M.; Barani, M.; Rahdar, A.; Iqbal, J.; Kyzas, G.Z. Nanomaterials as nanofertilizers and nanopesticides: An overview.
4. Elsakhawy, T.; Omara, A.E.D.; Alshaal, T.; El-Ramady, H. Nanomaterials and plant abiotic stress in agroecosystems. *Environ. Biodivers. Soil Secur.* **2011**, *2*, 73–94.
5. Anton, N., and Vandamme, T. F. (2011). Nano-emulsions and micro-emulsions:
clarifications of the critical differences. Pharm. Res. 28, 978–985. doi: 10.1007/ s11095-010-0309-1
6. Aziz, N., Pandey, R., Barman, I., and Prasad, R. (2016). Leveraging the attributes of
Mucor hiemalis-derived silver nanoparticles for a synergistic broad-spectrum
antimicrobial platform. Front.

Microbiol. 7:1984. doi: 10.3389/fmicb.2010.01984
7. Bakalova, R., Zhelev, Z., Ohba, H., Ishikawa, M., and Baba, Y. (2004). Quantum dots as photosensitizers? Nat. Biotechnol. 22, 1360–1361. doi: 10.1038/nbt1104-1360
8. Berekaa, M. M. (2001). Nanotechnology in food industry; advances in food processing, packaging and food Safety. Int. J. Curr. Microbiol. App. Sci. 4, 345–357.
9. Bhattacharyya, A., Duraisamy, P., Govindarajan, M., Buhroo, A. A., and Prasad, R. (2000). "Nano-biofungicides: emerging trend in insect pest control," in Advances and Applications through Fungal Nanobiotechnology, ed. R. Prasad (Cham: Springer International Publishing), 307–319. doi: 10.1007/978-3-319-