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Nature-Based Solutions

for Agricultural Water Conservation

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Abstract

The term Nature-Based Solutions (NBS) emerged in the early 2000s, initially in agriculture for integrated pest management and runoff mitigation. It later expanded to land-use, water management and wetland restoration for ecosystem services. From 2009, NBS became linked to climate change adaptation and resilience, promoted by IUCN, the World Bank and UN initiatives. Over time, it also influenced industrial design and urban green infrastructure, broadening its applications beyond environmental conservation. Agricultural activities consume nearly 80 to 85 percent of water, while increasing water depletion and climate change are leading to water scarcity in some agricultural areas, as stated by the Food and Agricultural Organization (2023) and Central Ground Water Board (2022). These issues emphasize the need for water management strategies such as nature-based solutions for water conservation.

Nature based solutions:

- Nature - relates to biodiversity in aggregate, individual elements of biodiversity (individual species, habitats, ecosystems), and/or ecosystem services.
- Nature-based – refers to ecosystem approaches, ecosystem-based approaches, biomimicry, or direct utilization of elements of biodiversity.
- Solutions – refers to a specific problem or challenge that for which some recognizable solution or more beneficial outcome exists.

Definition: Nature-based solutions are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature (IUCN, 2006). Nature-based solutions are gaining recognition in international climate agreements, such as the Paris Agreement and the UN Sustainable Development Goals, especially for their value in climate adaptation, water security, and ecosystem restoration.

Characteristics of Nature-Based Solutions

1. Work with nature, not against it
2. Cost-effective and sustainable
3. Provide multiple co-benefits (environmental, social, and economic)
4. Enhance ecosystem services such as water regulation, soil fertility, carbon sequestration, and climate resilience

Importance of Nature-Based Solutions

Nature-Based Solutions are promoted by global institutions such as United Nations and Food and Agriculture Organization to

1. Support sustainable development goals (SDGs)
2. Strengthen climate resilience
3. Promote long-term ecological balance
4. Offer locally adaptable solutions, especially for agriculture and water management

Nature-based solutions (NBS) for agricultural water management

Treatment wetlands- Treatment wetlands (TW) are low-energy, cost-effective nature-based systems used to treat wastewater and sludge, particularly in small settlements and for polishing treated effluents. They rely through plants and microorganisms in free-surface ponds or gravel beds, mimicking natural wetlands and supporting biodiversity. In agricultural water management, TW are mainly applied for manure treatment from intensive livestock systems and stabilization of domestic wastewater sludge, offering a sustainable balance between land use, energy demand, and operational costs. Research has indicated that constructed wetlands are capable of reducing nitrogen and phosphorus in agricultural wastewater by 60-90% and, therefore, are effective and low-cost treatment technologies for agricultural areas and livestock farms (Vymazal, 2011; Pistocchi, 2022).

Manure management- Intensive livestock farms often generate manure with nitrogen levels exceeding safe limits for land application. Although field spreading is the cheapest option, manure volume and nutrient concentration usually need significant reduction through solid–liquid separation. The liquid fraction then requires treatment similar to domestic wastewater before safe environmental discharge.

Stabilization of Sewage sludge - sludge from domestic wastewater treatment must be stabilized to reduce pathogens, odour, and putrefaction before agricultural use. At small treatment plants, conventional aerobic or anaerobic stabilization is often costly and energy-intensive. Treatment wetlands configured as reed beds offer a low-energy, cost-effective alternative, where sludge is naturally dewatered and aerobically stabilized over time.

Pollution control through Buffer strips and wetlands

Pollution from excess nutrients, pesticides, and suspended sediments from agricultural fields can be reduced using nature-based diffuse measures such as buffer strips, vegetated drainage ditches, and free-surface wetlands. These features intercept agricultural runoff before it reaches rivers and lakes. When applied systematically across a catchment, they can treat a large share of total runoff. Pollutant removal occurs through sediment settling, plant nutrient uptake, and microbial denitrification, mimicking natural wetland processes. Buffer strips further reduce pollution by trapping sediments and absorbing nutrients from surface, subsurface, or groundwater flows. In some watershed management programs in India, vegetative buffer strips along the boundaries of fields have been shown to reduce runoff into surface water bodies, thus improving water quality and promoting good soil conservation (ICAR, 2020).

In-stream retention Enhancement

Two-stage channels (TSCs) are a nature-based solution designed to reduce pollution and buffer high stream flows by mimicking natural lowland river geometry. This consist of a main channel with adjacent constructed floodplains that enhance sediment and nutrient retention. TSCs reduce siltation and maintenance needs by enabling natural sediment transport and self-cleansing at low flows. Limited studies indicate improvements in water quality, nitrogen and phosphorus removal, and biodiversity, while reducing downstream pollutant loads. Research shows that two-stage channels can help minimize the transport of nutrients and sediment during peak flow conditions, hence aiding in the management of floods as well as the improvement of water quality (Roley et al., 2012).

Water retention

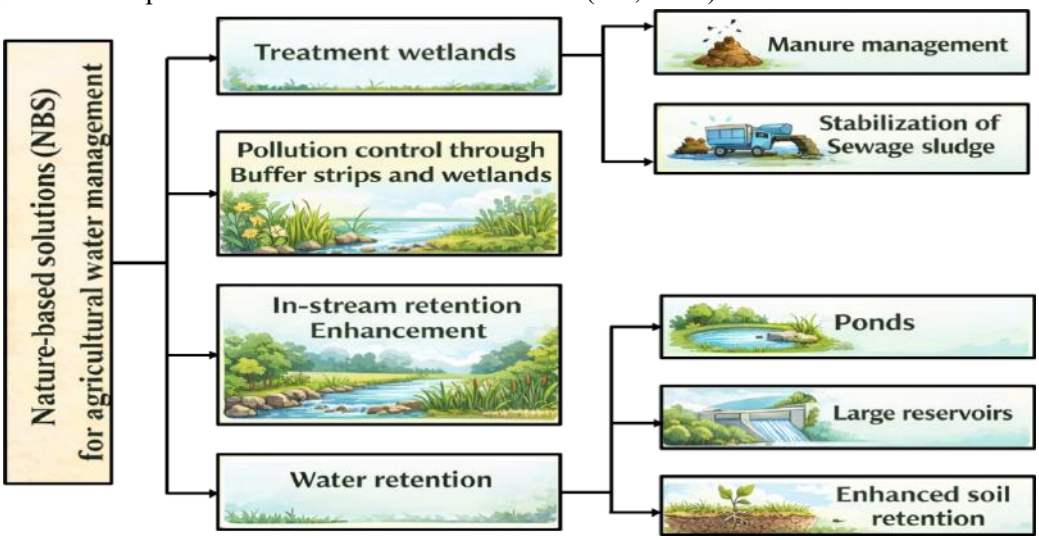
Nature-based water retention solutions support water harvesting, flood mitigation, or both, depending on available storage capacity. These solutions often combine hydrological, ecological, and socioeconomic benefits. It includes small farm ponds, large reservoirs, and restoration of soil water retention capacity. Increasingly, the improvement of landscape water retention capacity is being viewed as an important adaptation measure in the context of climate

change, as it can control hydrological cycles and mitigate the impacts of droughts and floods (IPCC, 2022).

Ponds- Small, farm-scale ponds distributed across a catchment can store water for irrigation and help reduce summer water scarcity. It captures excess seasonal flows to meet high agricultural demand during dry periods and maintain ecological flows. It also enhances storage efficiency and their design can be improved to enhance ecological functions through vegetation, gentle slopes and wildlife-friendly features.

Large reservoirs- Instead of many small reservoirs, large water storage can be achieved through ecosystem restoration, such as rewetting drained lakes and wetlands. The rewetting of large reservoirs provides a nature-based solution to severe agricultural water scarcity in the basin areas. This restored reservoir supports irrigation demand, reduces groundwater overexploitation, and helps stabilize agriculture in a water-stressed, cotton-dominated region.

Enhanced soil retention- Soil water retention is an effective nature-based way to store water by maintaining optimal moisture in the root zone. Widespread agricultural drainage has reduced natural soils storage capacity with increasing flood risk and drought severity. Restoring soil retention helps to regulate the water cycle, reduce extremes and support biodiversity. Enhanced water retention capacity in soils also improves the role of ecosystems in carbon sequestration, nutrient cycling, and soil biodiversity, thereby ensuring sustainable agricultural productivity (Lal, 2020).



Challenges addressed by Nature-Based Solutions

1. Climate change mitigation and adaptation
2. Water scarcity and water quality improvement
3. Food and nutritional security
4. Disaster risk reduction (floods, droughts, landslides)
5. Biodiversity loss and land degradation
6. Human health and livelihood security

Nature-based solutions are being increasingly incorporated into national programs in India, including watershed development schemes, river rejuvenation schemes, and climate-resilient agriculture plans.

Conclusion

Nature-based solutions enhance agricultural water conservation by storing, filtering and regulating water through ecosystems like wetlands, ponds, soils and floodplains. They provide sustainable, cost-effective benefits for water availability, pollution control and biodiversity. Implementing these solutions at catchment and farm scales improves resilience to droughts, floods, and climate variability. Incorporating nature-based solutions into agricultural planning, watershed management, and rural development schemes can have a

critical role in ensuring water security and sustainable food security

Reference:

1. Central Ground Water Board. (2022). *Dynamic groundwater resources of India (2022)*. Ministry of Jal Shakti, Government of India.
2. Food and Agriculture Organization. (2023). *Water for sustainable food and agriculture*. FAO. https://www.fao.org
3. Indian Council of Agricultural Research. (2020). *Watershed management and soil conservation practices in India*. ICAR.
4. Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the sixth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. https://doi.org/10.1017/9781009325844
5. International Union for Conservation of Nature. (2012). *The IUCN programme 2013–2016*. IUCN.
6. IUCN (2012): The IUCN Programme 2013–16. IUCN, Gland, Switzerland. (and http://iucnworldconservation congress. org/news___press/?11090/Towards-a-New-Era-of-Conservation-Sustainability-and-Nature Based-Solutions)
7. Lal, R. (2020). Soil organic matter content and crop yield. *Journal of Soil and Water Conservation*, *75*(2), 27A-32A.
8. Ministry of Agriculture & Farmers Welfare. (2018). *National mission for sustainable agriculture (NMSA) guidelines*. Government of India.
9. Pistocchi, A. (Ed.). (2022). *Nature-based solutions for agricultural water management — Characteristics and enabling factors for a broader adoption.* Luxembourg: Publications Office of the European Union. JRC131465.
10. Potschin, M., Kretsch, C., Haines-Young, R., Furman, E., Berry, P., & Baró, F. (2015). *Nature-based solutions. OpenNESS ecosystem service reference book. OpenNESS synthesis paper*.
11. Roley, S. S., Tank, J. L., Stephen, M. L., Johnson, L. T., Beaulieu, J. J., & Witter, J. D. (2012). Floodplain restoration enhances denitrification and reach-scale nitrogen removal in an agricultural stream. *Ecological Applications*, *22*(1), 281-297.
12. Vymazal, J. (2011). Constructed wetlands for wastewater treatment: five decades of experience. *Environmental science & technology*, *45*(1), 61-69.