AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 09 (September, 2026)
Available online at http://www.agrimagazine.in

Why Wetlands Are Called the Kidneys of the Landscape

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Wetlands are sometimes dismissed as waterlogged or unproductive land. In reality, they are among the hardest-working ecosystems in any landscape. Marshes, peatlands, mangroves, floodplains and shallow lakes continuously receive water from surrounding areas and influence what happens to it before it reaches rivers, reservoirs or groundwater. Their ability to trap sediments, retain nutrients and transform pollutants has earned wetlands the description "the kidneys of the landscape." The comparison is easy to understand. Just as kidneys remove unwanted substances from the bloodstream, wetlands help remove or retain materials carried by water. They also store floodwater, recharge groundwater, preserve biodiversity and capture carbon. Although wetlands cover only a small proportion of the Earth's surface, they support a considerable share of global biodiversity and provide ecological services far beyond their boundaries (Abdenour et al., 2025).

Hydrological Regulation and Sediment Retention

Water entering a wetland does not move as quickly as it does through a drainage channel or across bare land. Wetland vegetation obstructs its movement, while shallow depressions spread the water over a wider area. This slower flow gives suspended particles time to settle. Sediment carried from farms, roads and construction areas gradually accumulates on the wetland floor. Nutrients and contaminants attached to these particles may also be retained. Plant stems and roots provide additional surfaces on which fine particles can settle. This filtering process becomes particularly important in agricultural landscapes. During heavy rainfall, runoff may carry eroded soil and fertilizers away from fields. A wetland situated between the field and a river can intercept part of this material before it travels downstream. Wetlands also regulate the quantity of water moving through the landscape. During intense rainfall, they temporarily store excess water and release it gradually. This reduces the speed and volume of runoff entering nearby streams. Some of the retained water may infiltrate the soil and contribute to groundwater recharge. For this reason, wetlands function as both natural filters and natural sponges.

Nutrient Retention by Wetland Vegetation

Wetland plants are central to the purification process. Reeds, grasses, sedges and other aquatic plants absorb nitrogen, phosphorus and micronutrients from water and sediment. These nutrients are then used to produce roots, stems and leaves. Dense plant cover also protects the soil from erosion. Roots bind wetland sediments, while above-ground vegetation reduces the force of flowing water. The spaces around plant roots provide habitats for microorganisms involved in nutrient cycling. Plant uptake, however, does not always represent permanent nutrient removal. When vegetation dies and decomposes, some of the stored nutrients may return to the water. A portion may remain buried in the soil or become incorporated into stable organic matter. In managed wetlands, harvesting selected vegetation can physically remove some of the absorbed nutrients from the system. The efficiency of nutrient capture varies among wetlands. It is influenced by the plant community, water depth, season, nutrient concentration and the length of time water remains in the wetland. Reviews of wetland performance have found that nitrogen removal is generally more consistent than phosphorus removal because the two elements behave differently in waterlogged environments (Fisher & Acreman, 2004).

Microbial Transformation of Nitrogen

Much of the purification occurring in wetlands is invisible. Wetland soils remain saturated for extended periods and contain very little oxygen. These conditions support specialised microbial communities capable of transforming nutrients and organic matter. Nitrogen may enter a wetland as nitrate, ammonia or organic nitrogen. Plants and microorganisms use a portion of it, while another portion becomes attached to soil or organic matter. The most important removal pathway is denitrification. During this process, microorganisms convert nitrate into gaseous forms of nitrogen, which are released into the atmosphere. This conversion differs from simple nutrient storage. Once nitrogen has been converted into gas, it has effectively left the water. The rate of denitrification depends on temperature, water availability, organic carbon, oxygen conditions and the amount of nitrate entering the wetland. These interacting factors explain why the nutrient-removal efficiency of wetlands can vary between locations and seasons (Martínez-Espinosa et al., 2021). Other microbial processes also occur. Organic nitrogen may be converted into ammonia, while ammonia may subsequently be transformed into nitrate in oxygenated zones close to roots or the water surface. The presence of both oxygen-rich and oxygen-poor microsites allows several stages of the nitrogen cycle to occur within a relatively small area.

Differences Between Nitrogen and Phosphorus Removal

Wetlands do not remove every pollutant in the same manner. Nitrogen can be transformed into gas and permanently removed through denitrification. Phosphorus cannot leave the ecosystem in this way. It is mainly retained through sedimentation, plant uptake and binding with soil minerals. Phosphorus may therefore accumulate in wetland sediments. When the soil is disturbed or environmental conditions change, some of it can be released back into the water. Phosphorus that has remained in soil for many years is often described as legacy phosphorus. Its continued presence means that water quality may improve slowly, even after new fertilizer inputs have been reduced. Restoring a drained wetland may also disturb soil that contains accumulated phosphorus. Rewetting can temporarily release part of this stored nutrient. Such an increase does not necessarily mean that restoration has failed; it may be a short-term response while the wetland's soil, vegetation and microbial processes become re-established. A large-scale study of restored wetlands in the Mississippi River Basin found significant reductions in ammonia and total Kjeldahl nitrogen in local and downstream waters. These improvements generally appeared around three years after restoration and continued for more than a decade. The phosphorus response was less straightforward, with a temporary local increase after restoration but evidence of reductions farther downstream (Karwowski & Skidmore, 2026).

Wider Ecological and Social Functions

The kidney comparison mainly highlights water purification, but wetlands perform many other functions. By holding stormwater, they reduce flood intensity and protect downstream areas. Their vegetation limits erosion, while their waterlogged soils store substantial amounts of organic carbon. Wetlands also provide breeding, feeding and resting habitats for fish, amphibians, insects, migratory birds and mammals. Many species depend on the changing boundary between land and water and cannot survive in completely terrestrial or permanently deep-water environments. People benefit from wetlands through fisheries, reed production, grazing, tourism, recreation and cultural activities. In agricultural regions, small natural or constructed wetlands can help reduce runoff while allowing most surrounding land to remain under cultivation. These benefits demonstrate that agriculture and wetland protection need not always be treated as opposing goals. Carefully planned farmland-wetland systems can maintain agricultural production while improving water quality and biodiversity. Research on wetland agriculture increasingly supports coexistence based on the ecological capacity of the wetland rather than continued drainage and conversion (He et al., 2025).

Threats to Wetland Functioning

Wetlands have been widely drained to create land for farming, housing, roads and industries. Others have been damaged by pollution, river modification, excessive groundwater withdrawal, invasive species and uncontrolled resource extraction. Climate change places additional pressure on these ecosystems. Altered rainfall can leave seasonal wetlands dry for longer periods or expose them to unusually intense floods. Rising sea levels threaten coastal wetlands, while changes in temperature and salinity can affect vegetation and microbial activity. When a wetland is lost, the surrounding landscape loses more than a patch of water. Runoff reaches rivers more rapidly, sediments move farther downstream and nutrients enter water bodies without passing through a natural filtering system. Communities may then have to replace these services through reservoirs, flood-control structures and costly water-treatment facilities. Restoration can recover many wetland functions, but the process takes time. Water flow must be re-established, native vegetation must return and suitable soil conditions must develop. A restored wetland may require several years before measurable improvements in water quality become apparent.

Conservation and Sustainable Management

Wetland protection begins with maintaining the natural movement of water. A wetland may lose much of its ecological value if it is cut off from its river, drained through channels or deprived of seasonal flooding. Buffer vegetation around the wetland can reduce the direct entry of sediments, fertilizers and pesticides. Where degradation has already occurred, restoration may include blocking drainage channels, removing barriers, controlling invasive species and reintroducing native plants. Monitoring water quality, vegetation and seasonal water levels is necessary to determine whether ecological functions are recovering. Wetlands should not, however, be expected to absorb unlimited pollution. Excessive inputs of sediment, fertilizer, sewage or industrial waste can overwhelm their natural capacity. Appropriate fertilizer use, erosion control and wastewater treatment must accompany wetland conservation. Calling wetlands the kidneys of the landscape is therefore more than a convenient metaphor. It reflects their role in receiving water from surrounding land, slowing its movement, trapping sediments and transforming nutrients. Protecting these ecosystems helps preserve clean water, reduce flooding, support biodiversity and maintain the environmental health of the wider landscape.

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