Japan Bilingual Publishing Co.

New Countryside

https://ojs.bilpub.com/index.php/nc

ARTICLE

Nature-based Solutions for Sustainable Food Systems in a Warming World

Shoba Suri [*], ***Madhavi Jha***

[1]*Senior Fellow-Health Initiative, Observer Research Foundation, New Delhi 110002, India*

[2]*Intern- Health Initiative, Observer Research Foundation, New Delhi 110002, India*

ABSTRACT

Climate change, environmental degradation, and biodiversity loss are placing unprecedented stress on global food systems. Rising temperatures, erratic rainfall, increased frequency of extreme weather events, and soil degradation threaten food production and exacerbate existing inequalities in access to food. The urgency to feed a growing population—projected to reach 10 billion by 2050—demands a rethinking of how food is produced, distributed, and consumed. Nature-based Solutions (NbS), defined by the IUCN as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively," offer a promising pathway. When integrated into food systems, NbS can simultaneously enhance ecosystem health, increase resilience to climate change, support livelihoods, and ensure food and nutrition security. Disruptions to ecosystem services due to climate change and human activity undermine food security. NbS in food systems seek to restore and protect these services while making agriculture and food production more resilient. This study explores the role of NbS in promoting sustainable food systems in the face of climate change. It assesses various NbS strategies across agriculture, forestry, and fisheries, and examines their ecological, economic, and social benefits, as well as challenges to their adoption and scaling. One way forward is to create enabling environments and integrate NbS into national climate and food policies.

Keywords: Nature-based Solutions; Climate Change; Biodiversity; Food Security; Food System

*CORRESPONDING AUTHOR:

Shoba Suri,Senior Fellow-Health Initiative, Observer Research Foundation, New Delhi 110002, India; Email: shoba.suri@orfonline.org

ARTICLE INFO

Received:27 May 2025 | Revised: 17 June 2025 | Accepted:26 June 2025 | Published Online: 1 July 2025

DOI: https://doi.org/10.55121/nc.v4i2.488

CITATION

Suri, S., Jha. M., 2025. Nature-based Solutions for Sustainable Food Systems in a Warming World. New Countryside. 4(2): 28–36.

DOI: https://doi.org/10.55121/nc.v4i2.488

1. Introduction

Numerous effects of climate change jeopardise the stability of the world's food systems, lowering diet quality and food security while putting vulnerable groups at risk for various types of malnutrition. The problem is worsened by pandemics like COVID-19, which further complicate interactions [1]. According to recent IPCC reports, "food, land, and water systems are at the forefront of the climate crisis," with increasingly frequent extreme events such as heatwaves, droughts, floods and rising temperatures already lowering crop productivity and even lowering nutritional quality [2]. By 2050, there will likely be 9.7 billion people on the planet, which will strain resource management and increase the need for sustainable, wholesome, and safe food production. Our food systems must be resilient and sustainable because of the rapid rise in global food consumption, urbanisation, and agricultural growth, which have a correspondingly greater impact on the environment [3].

Climate change is disrupting agricultural value chains, underscoring the need for more sustainable and resilient agri-food systems. Nature-based Solutions (NbS), which involve managing and restoring ecosystems to address societal challenges, offer a promising approach [4]. NbS can enhance soil health, biodiversity, water quality, carbon mitigation, and agricultural productivity, supporting climate goals and ensuring food and water security [5,6]. Biodiversity at genetic, species, and ecosystem levels is vital for ecosystem services and resilient agriculture, helping mitigate climate change, pests, diseases, and resource scarcity [7]. Biodiversity-rich systems enhance pollination, pest control, water regulation, and soil fertility, reducing dependence on chemicals. However, human activities like deforestation and climate change are rapidly eroding biodiversity, threatening essential services and human health [8]. Nature-based Solutions (NbS) aim to restore and protect these services, strengthening the resilience of food systems.

2. Climate Change and Food Security: The Case for NbS

Globally, the productivity of crops and livestock is already being threatened by climate change. Yields are declining due to rising mean temperatures, changing precipitation patterns, and increasing extremes, particularly in tropical and subtropical areas [9]. In regions where certain crops have been grown for years, some crops may become less viable as temperatures rise, while new sites appropriate for cultivation may appear. As a result productivity declines and crop yield diminish. Moreover, diseases and pests can flourish in temperature fluctuations, creating more difficulties in managing crop health, yield and food security [10]. In many nations, rising average temperatures have also resulted in decreased soil moisture, increased water demand, and water stress. All of this significantly impacts the farmer income and food security. The regions that will be most affected are West Africa and India. Due to the effects of climate change, scientists predict that crop yields will drop by 2.6% to 2.9% by 2050 [11].

Intensive agriculture is causing unsustainable soil degradation, marked by loss of organic matter, pollution, erosion, and reduced genetic diversity. This weakens ecosystems and threatens future food production [12]. Monocultures are especially vulnerable, as their genetic uniformity increases the risk of total crop failure from pests, diseases, or extreme weather events due to a lack of resilience [13]. Climate change has worsened malnutrition and disease, especially among vulnerable groups like women, children, low-income communities, and small-scale farmers [14]. Female farmers face added challenges due to limited resources and land ownership, making them more vulnerable to climate impacts and forcing reliance on unsustainable coping strategies [15]. Nature-based Solutions (NbS), including agroforestry, conservation agriculture, and mangrove restoration, offer sustainable ways to address food system challenges like pollution, biodiversity loss, and climate change [16]. NbS also contributes significantly to climate mitigation by reducing emissions and capturing carbon [4]. Strengthening the role of NbS in agriculture requires focusing on both productivity and socio-economic benefits for farmers.

3. Typologies and Case Studies of NbS for Sustainable Food Systems

Agroforestry and agroecology have long been acknowledged as strategies that support the reconciliation of human and natural needs by boosting climate change resil-

ience, restoring degraded land more quickly, and producing wholesome food. Redesigning rural properties and agricultural landscapes to improve their long-term production and ecosystem services can be accomplished using a range of concepts and instruments provided by both fields [17]. The more comprehensive agroecology approach includes agroforestry as a technique. In order to improve the resilience and sustainability of food and farming systems while maintaining social integrity, agroecology examines the entire food system and builds upon 13 principles. Both encourage and raise the proportion of biological pest management techniques (biopesticides and biofertilisers), which are seen to be both economically and environmentally sound [6].

By systematically regrowing and managing remnant vegetation across various landscapes, Farmer Managed Natural Regeneration (FMNR) is a technical practice and community development strategy that empowers and mobilises local communities to restore their natural environment. Around 200 million trees have been planted in a previously arid landscape because of FMNR, which was created as a unique strategy in the Republic of Niger in 1983 [18]. The FMNR program learned from past efforts and has encouraged reforestation on over 5 million hectares of land [19]. FMNR uses vegetation restoration to address several issues at once, such as land degradation, biodiversity loss, food insecurity, fuel wood, building timber, and fodder shortages, soil erosion and infertility, and dysfunctional hydrological cycles (dying springs, wells, and streams, reduced groundwater recharge, and exacerbated flood and drought events). FMNR is a successful strategy for both adaptation and climate mitigation [20].

The importance of regenerative agriculture in addressing various ecological and socio-economic problems is becoming more widely acknowledged. Beyond sustainable practices, it actively revitalises ecosystems, emphasising biodiversity, soil health, and climate change mitigation [21]. Using techniques like cover crops to keep roots in the ground throughout the year can boost biodiversity, soil organic matter, soil structure, and nutrient availability [22]. Indian agriculture has a chance to change with regenerative agriculture. By emphasising soil health restoration, biodiversity enhancement, and better water management, it provides a sustainable solution to address the problems of contemporary agriculture and slow down climate change. The degradation of soil and climate resilience is addressed by techniques including controlled livestock grazing, varied crop rotations, and no-till farming [23].

By increasing soil organic carbon (SOC), which improves water retention and nutrient availability, projects in Maharashtra's cotton farms produced yields that were 20–30% higher and input costs that were 30% cheaper. Furthermore, it was discovered that by using regenerative methods on one hectare of land, smallholder farmers in India may be able to sequester one to four tons of carbon [24]. The Zero Budget Natural Farming (ZBNF) movement has demonstrated encouraging outcomes in terms of improving farm earnings and soil health. Regenerative agriculture is becoming more and more popular in India, and the government is supporting it with training initiatives, subsidies, and legislation. Organic farming and the enhancement of soil health are the goals of programs like the Paramparagat Krishi Vikas Yojana (PKVY) [25].

Wetland restoration is the process of restoring a damaged or former wetland to its natural functioning by altering its physical, chemical, or biological properties. Because they are natural buffers that absorb and hold a large quantity of floodwater, they can help lessen the frequency and severity of floods [26]. Farmers in Mekong Delta have long considered ducks and rice to be "good friends." In the Mekong Delta, farmers have long planted rice paddies and reared ducks by letting them forage for scraps in the paddy fields after harvest [27]. Additionally, they boost dissolved oxygen and stimulate rice roots to encourage rice development. Also, the rice absorbs these organic fertilisers to purify the water, and the dung from fish and ducks increases soil fertility. Additionally, the system's species diversity is enhanced by the symbiotic relationship between duck, fish, and rice. In this way, a complex food chain network is created, with high energy, water, and fertiliser use efficiency, increased stability, and resilience to external shocks [28].

For thousands of years, the practice of raising cattle in open grazing areas, or pastoralism, has been a fundamental aspect of human communities. Pastoralists have evolved their ways of life to coexist with nature in various environments, from lush meadows to arid deserts, supporting healthy ecosystems while offering communities necessary commodities and services. Pastoralist communi-

ties like the Maasai, Samburu, and Turkana raise cattle, goats, sheep, and camels, making pastoralism an important aspect of Kenyan culture [29]. Dalmas Tiampati founded the Maasai Center for Regenerative Pastoralism in 2013 after the terrible drought in Kajiado County killed nearly all of the livestock in their Maasai village.

By addressing the causes of drought and seeking solutions to preserve Maasai culture in a changing world, the goal is to make the Maasai more resilient [30]. Three Maasai villages in Tanzania's Arusha region are working to restore grassland biodiversity by replanting native species on 15 acres of land through the UNDP-Adaptation Fund Climate Innovation Accelerator (AFCIA), which is part of the worldwide Adaptation Innovation Marketplace. The Maasai communities' efforts to reestablish their ancestral grasslands highlight how important Indigenous knowledge and community-led projects are in halting the effects of climate change [31].

The significance of NbS in preserving and restoring seas and coastal ecosystems is also becoming more widely acknowledged. A variety of significant ecosystem services are offered by coastal habitats, including seagrass beds, salt marshes, and mangroves. These can lessen the effects of climate change and extreme weather occurrences. They include storm surge attenuation, erosion control, and coastal protection [32]. Mangrove restoration has become a crucial NbS in Bangladesh, boosting local livelihoods and fisheries while increasing coastal resilience against storms. For millions of people living along the Bay of Bengal, the Sundarbans, the largest contiguous mangrove forest in the world, serve as a natural buffer, lowering the risk of flooding and storm surges [33].

The 2015 introduction of the Integrating Community-based Adaptation into Afforestation and Reforestation (ICBAAR) program is a more recent restoration effort. The ICBAAR program restored more than 650 hectares of degraded mangrove plantation sites with assistance from the UNDP and the Global Environment Facility. Using a varied mix of eight to ten species, this project used a participatory planning approach, involving local populations in restoration with the aim of creating a more stable and climate-resilient green belt along the fragile coastlines of districts like Barguna, Patuakhali, Bhola, and Noakhali [34].

4. Benefits of Nature-based Solutions in Food Systems

Utilising natural biological processes, Nature-based Solutions (NbS) including integrated water management, agroforestry, and cover crops improve the health of ecosystems. Tree-based agricultural systems that resemble natural forests, for instance, have been demonstrated to be particularly durable and biodiverse. By reducing erosion and sediment discharge, increasing soil organic matter and structure, and sequestering carbon in biomass, these systems preserve soil and water [35]. There is increasing confirmation that NbS, which prioritise ecological methods and biodiversity preservation, have a great chance of converting aquatic and terrestrial systems into climate-resilient ones [6]. Moreover, because natural ecosystems are important sources and sinks of greenhouse gases (GHGs), there has been increasing interest in the potential of NbS to help fulfill global goals for reducing GHG emissions to prevent climate change. According to the IPCC's Climate Change and Land Report, mitigation strategies for land use change and economic decarbonisation are crucial to all scenarios that keep global warming to 1.5°C [36].

By reducing input costs and diversifying outputs, NbS improve agricultural resilience and income. In China, integrated systems that include crops, aquaculture, and livestock—such as rice-fish-duck farming—have been found to produce 2.4 times more profit than monoculture rice. This kind of diversification generates several revenue streams and boosts productivity [37]. These affordable solutions to many societal issues while creating jobs and economic opportunities are made possible by the socio-economic advantages that NbS has produced. Greening cities and other NbS initiatives can increase an area's appeal to potential inhabitants, investors, and tourists while generating new green jobs across a range of industries [29]. Additionally, NBS enhances local communities' economic prospects, quality of life, and public health. Urban parks and green areas, for example, offer leisure possibilities, support mental health, and raise property prices. Furthermore, sustainable agricultural methods boost local economies, enhance food security, and promote rural livelihoods [38].

5. Challenges and Barriers to Implementation

Although nature-based farming methods provide long-term remedies for climate change and environmental deterioration, there are several barriers in the way of their adoption. For agricultural systems to shift to more robust and sustainable ones that strike a balance between environmental stewardship and productivity, these barriers must be addressed. Implementing sustainable land management techniques is significantly hampered by the policy fragmentation between agricultural and environmental governance organisations. Farmers are often given conflicting incentives by agricultural policies that emphasise productivity metrics and environmental policies that emphasise conservation [39]. Similar to this, research on urban governance demonstrates that restrictive institutional structures and divided administrative roles hinder cross-sectoral collaboration, restricting the incorporation of NbS into national strategies and local planning [40].

There are significant obstacles to ecological investments in agricultural systems because of the ongoing focus on production maximisation. According to research, productivity-only strategies hinder the long-term sustainability of our agroecosystems by not maximising whole-ecosystem performance [41]. Research shows that annual performance measures and short planning cycles put short-term rewards ahead of long-term ecosystem investments, locking landscapes into deterioration patterns that NbS seeks to reverse [42]. Encouraging long-term ecological stewardship, which is inherent to NbS, requires secure land and resource tenure. Farmers run the danger of losing future benefits on investments like planting trees or restoring wetlands when they lack official ownership or defined user rights, which deters them from using sustainable land-use practices [43].

Even though investor interest in nature-based agriculture solutions is expanding, there are still large funding gaps. An estimated $711 billion is missing from the sector's finances, and farmers frequently struggle "to obtain medium-term financing for improving their natural resources base and infrastructure." For investments in natural capital, financial organisations lack standard goods and procedures, which leads to missed chances for significant solutions [44]. This funding gap is caused by a number of structural obstacles, such as a mismatch in the tenor preferences of investors and firms, a lack of strong track records for funds and companies, poor investment fundamentals and low risk-adjusted returns, and liquidity issues [45].

Naturally, one of the main obstacles is the general lack of knowledge about sustainable farming practices and their long-term advantages. Although traditional knowledge is important, it frequently conflicts with more recent, sustainable approaches that call for knowledge of biodiversity, soil health, and climate resilience. Many farmers, for example, abuse pesticides and fertilisers without understanding their long-term detrimental effects on crop yields and soil health, according to studies [46]. To convert NbS knowledge into practical guidelines and context-specific decision-support tools, multi-stakeholder assessments emphasise the necessity of interdisciplinary research agendas and inclusive co-design procedures [47].

6. Enabling Conditions and Policy Recommendations

Integrate NbS into national climate and food policies—For Nature-based Solutions (NbS) to be implemented successfully, institutional structures, financing mechanisms, and supportive policy frameworks are needed. Although over 77% of Nationally Determined Contributions (NDCs) acknowledge NbS, only roughly 26% of them contain quantified mitigation pledges about these solutions. NbS must be thoroughly incorporated into climate policies in order to close this implementation gap. This integration would acknowledge that, by 2030, NbS can provide around one-third of the cost-effective CO_2 reduction required [48]. Governments should update their National Adaptation Plans, NDCs, and food security plans to include specific NbS goals (such as hectares of wetlands, conservation agriculture, or restored agroforestry). For instance, Belize's amended NDC pledges to improve fisheries and coastal protection by restoring 2,000 hectares of mangroves by 2025 (and another 2,000 hectares by 2030) [49].

Incentivize ecosystem services—Farmers may receive incentives under Payment for Ecosystem Services (PES) programs for improving water quality, preserving biodiversity, or increasing soil carbon sequestration. It is recommended that soil carbon and blue carbon credits

from coastal and agricultural environments be added to carbon markets. Fair pay for farmers using NbS practices, including agroforestry, which has been demonstrated to improve carbon sequestration and storage while lowering sediment and nutrient runoff, must be guaranteed by these markets [50]. Likewise, voluntary carbon programs are starting to acknowledge soil carbon: In Kenya, the GIZ ProSoil project in Germany is creating a soil-carbon certification program that compensates farmers for managing their land sustainably and sells credits to businesses looking to offset leftover emissions [6].

Invest in community-led solutions by strengthening indigenous knowledge and co-management—Community-driven and respectful of customary stewardship are essential for NbS. Indigenous and local knowledge systems are often disregarded, but they already provide sustainable food and ecological management [51]. Land and resource rights should be protected, and community co-management agreements should be funded. International guidelines, such as the UNDRIP and CBD rulings, highlight that local actors are the most effective in leading NbS. For instance, Costa Rica's blue carbon program promotes a paradigm that benefits people who directly rely on the ecosystem services that these habitats provide by using markets and financial incentives to reverse the loss and degradation of blue carbon ecosystems and wetlands [52].

Foster cross-sector collaboration to break silos between agriculture, environment, health, and water—Approaches to integrated landscape management can let many ministries and stakeholders work together more easily. Multi-stakeholder platforms can align incentives and coordinate policies across sectors [53]. Strong monitoring frameworks are required to follow the effects of NbS in various dimensions. Continue observing, assessing, and learning to inform scalability and ongoing improvements. Effective policy implementation is hampered by gaps in quantifying GHG emissions and removals from land-use sectors [54]. Metrics should account for socio-economic advantages like food security, livelihoods, and resilience as well as ecological effects like carbon sequestration, biodiversity, and water quality. These systems must integrate community-based participatory monitoring with remote sensing technology [55].

7. Conclusions

To conclude, there is need for a holistic approach to implementing Nature-based Solutions for sustainable food system in the face of climate change. Governments must prioritize and invest in community driven solutions that are grounded in indegeneous and local food systems recognizing their resilience and also incentivize farmers for preserving biodiversity.

Author Contributions

Conceptualization, S.S.; writing—original draft preparation, M.J. and S.S.; writing—review and editing, S.S. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

No dataset generated/used.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Owino, V., Kumwenda, C., Ekesa, B., et al., 2022. The impact of climate change on food systems, diet quality, nutrition, and health outcomes: A narrative review. Frontiers in Climate. 4, 941842. DOI: https://doi.org/10.3389/fclim.2022.941842

[2] CGIAR, 2023. IPCC climate report draws urgency to food systems transformation. Available from: https://www.cgiar.org/news-events/news/ipcc-climate-report-draws-urgency-to-food-systems-transformation (cited 21 March 2023).

[3] Galanakis, C.M., 2024. The future of food.

Foods. 13(4), 506. DOI: https://doi.org/10.3390/foods13040506

[4] UNDP Climate Change Adaptation, 2021. Tackling the climate crisis in agri-food systems through nature-based solutions. Available from: https://www.adaptation-undp.org/scala-tackling-the-climate-crisis-in-agri-food-systems-through-nature-based-solutions (cited 21 September 2021).

[5] Geneva Nature-based Solutions Dialogues, 2021. Nature-based Solutions and the Post-2020 Biodiversity Framework. Available from: https://www.genevaenvironmentnetwork.org/events/nature-based-solutions-and-the-post-2020-biodiversity-framework/ (cited 23 February 2025).

[6] Miralles-Wilhelm, F., 2023. Nature-based solutions in agricultural landscapes for reducing tradeoffs between food production, climate change, and conservation objectives. Frontiers in Water. 5, 1247322. DOI: https://doi.org/10.3389/frwa.2023.1247322

[7] International Food Policy Research Institute, n.d.. Ecosystem services and biodiversity. Available from: https://www.ifpri.org/topic/ecosystem-services/ (25 November 2024).

[8] Diyaolu, C.O., Folarin, I.O., 2024. The Role of Biodiversity in Agricultural Resilience: Protecting ecosystem services for sustainable food production. International Journal of Research Publication and Reviews. 5(10), 1560–1573. DOI: https://doi.org/10.55248/gengpi.5.1024.2741

[9] World Health Organization, 2025. Biodiversity. Available from: https://www.who.int/news-room/fact-sheets/detail/biodiversity (cited 18 February 2025).

[10] Mbow, C., Rosenzweig, C., Barioni, L.G., et al., 2022. Chapter 5: Food Security — Special report on climate change and land. In: Shukla, P.R., Skea, J., Calvo Buendia, E., et al. (eds.). Climate Change and Land: an IPCC special report on climate change, desertiffcation, land degradation, sustainable land management, food security, and greenhouse gas ffuxes in terrestrial ecosystems. Cambridge University Press: Cambridge, UK. pp. 437–550. DOI: https://doi.org/10.1017/9781009157988.007

[11] SBI General Insurance, 2023. Impact of climate change on crops. Available from: https://www.sbigeneral.in/blog/general-insurance/general-articles/impact-of-climate-change-on-crops (cited 31 July 2023).

[12] Sakai, O., 2024. Climate Change and Agriculture: Why are Farmers Vulnerable? - TechnoServe. Available from: https://www.technoserve.org/blog/climate-change-and-agriculture-smallholder-farmers/ (cited 24 January 2024).

[13] Kopittke, P.M., Menzies, N.W., Wang, P., et al., 2019. Soil and the intensification of agriculture for global food security. Environment International. 132, 105078. DOI: https://doi.org/10.1016/j.envint.2019.105078

[14] is Mirzabaev, A., Kerr, R. B., Hasegawa, T., Pradhan, P., Wreford, A., Von Der Pahlen, M. C. T., & Gurney-Smith, H. (2022). Severe climate change risks to food security and nutrition. Climate Risk Management, 39, 100473. https://doi.org/10.1016/j.crm.2022.100473 (cited 21 June 2025)

[15] IPCC, 2022. Working Group II – Impacts, Adaptation and Vulnerability. Cambridge University Press: Cambridge, UK; New York, NY, USA. DOI: https://doi.org/10.1017/9781009325844

[16] Dibakoane, S., Siyongwana, P., Shabalala, A.N., 2022. Vulnerability, impact and adaptation strategies of female farmers to climate variability. Jàmbá Journal of Disaster Risk Studies. 14(1), 1302. DOI: https://doi.org/10.4102/jamba.v14i1.1302

[17] International Union for Conservation of Nature, n.d.. Nature-based solutions for climate. Available from: https://www.iucn.org/our-work/topic/nature-based-solutions-climate (cited 27 March 2025).

[18] Agroforestry Network, 2025. Agroforestry and agroecology - Sustainable and safe alternatives to pesticides. Available from: https://agroforestrynetwork.org/database_post/agroforestry-and-agroecology-sustainable-and-safe-alternatives-to-pesticides/ (cited 27 March 2025).

[19] Rinaudo, T., McKenzie, S., Huynh, T., et al., 2021. Farmer Managed Natural Regeneration: community driven, low cost and scalable reforestation approach for climate change mitigation and adaptation. In: Leal Filho, W., Luetz, J., Ayal, D. (eds.). Handbook of Climate Change Management: Research, Leadership, Transformation. Springer International Publishing: Cham, Switzerland. pp. 4319–4351. DOI: https://doi.org/10.1007/978-3-030-22759-3_281-1

[20] NDC Partnership, n.d.. From vulnerability to resilience: Farmer Managed Natural Regeneration in Niger. Available from: https://ndcpartnership.org/knowledge-portal/good-practice-database/vulnerability-resilience-farmer-managed-natural-regeneration-niger (cited 1 April 2025).

[21] United Nations Department of Economic and Social Affairs, n.d.. Farmer Managed Natural Regeneration (FMNR): a technique to effectively combat poverty and hunger through land and vegetation restoration. Available from: https://sdgs.un.org/partnerships/farmer-managed-natural-regeneration-fmnr-technique-effectively-combat-poverty-and (cited 1 April 2025).

[22] Sher, A., Li, H., Ullah, A., et al., 2024. Importance of regenerative agriculture: climate, soil health, biodiversity and its socioecological impact. Discover Sustainability. 5(1), 462. DOI: https://doi.org/10.1007/

s43621-024-00662-z

[23] British Ecological Society, 2025. End of the brown field? Regenerative agriculture brings ecological benefits. Available from: https://www.britishecologicalsociety.org/content/end-of-the-brown-field-regenerative-agriculture-practices-bring-ecological-benefits/ (cited 14 April 2025).

[24] Das, B., 2024. How is regenerative agriculture changing India's farming culture. The CSR Universe. Available from: https://thecsruniverse.com/articles/how-is-regenerative-agriculture-changing-india-s-farming-culture (cited 2 January 2024).

[25] Chattopadhayay, S., 2025. Degrowth and the reimagining of Indian agriculture. Available from: https://www.orfonline.org/research/degrowth-and-the-reimagining-of-indian-agriculture (cited 24 March 2025).

[26] KhetiBuddy, 2024. How regenerative soil techniques increase farm profitability and crop yields. Available from: https://khetibuddy.com/ca/blogs/how-regenerative-soil-techniques-increase-farm-profitability-and-crop-yields/ (cited 9 August 2024).

[27] U.S. Environmental Protection Agency, 2025. Basic information about wetland restoration and protection. Available from: https://www.epa.gov/wetlands/basic-information-about-wetland-restoration-and-protection (cited 27 January 2025).

[28] Food and Agriculture Organization of the United Nations, n.d.. Ecologically integrated farming system in the south of Vietnam: Rice-duck-shrimp farming in Ben Tre Province. Available from: https://openknowledge.fao.org/server/api/core/bitstreams/20524c66-f4eb-4f88-9600-3599b3544fab/content (cited 30 November 2024).

[29] Zhang, Y., Guan, C., Li, Z., et al., 2023. Review of Rice–Fish–Duck Symbiosis System in China—One of the globally important Ingenious Agricultural Heritage Systems (GIAHS). Sustainability. 15(3), 1910. DOI: https://doi.org/10.3390/su15031910

[30] Hasan, T., 2024. Pastoralism: Sustainable solutions for livestock communities. AgriNext Conference. Available from: https://agrinextcon.com/sustainable-solutions-for-pastoralism/ (cited 26 April 2024).

[31] Masai Center for Regenerative Pastoralism. "We must regenerate our lands to support our future.", https://www.maasaiactionfordevelopment.org/ (cited 17 March 2025).

[32] UNDP Climate Promise, 2024. Maasai communities harness the resilience of native plants to restore grasslands in Tanzania. Available from: https://climatepromise.undp.org/news-and-stories/maasai-communities-harness-resilience-native-plants-restore-grasslands-tanzania (cited 23 September 2024).

[33] UNEP FI, Baker, K., Fritsch, D., et al., 2023. Investing with Nature: Exploring Investment Opportunities Across Ecosystems Primer 2: Nature-based Solutions in Oceans and Coastal Ecosystems. UN Environment Programme Finance Initiative: Geneva, Switzerland. Available from: https://www.unepfi.org/wordpress/wp-content/uploads/2023/06/Primer-2-Marine-coastal-ecosystems.pdf (cited 17 April 2025).

[34] LLAHub, 2022. Villagers regenerating the world's largest mangrove in Bangladesh. Global Center on Adaptation. Available from: https://llahub.gca.org/stories/72cc515c-77d6-49ee-8e8d-af1c7b21c16e (cited 27 April 2025).

[35] Hossain, M., Saha, C., Saha, S., 2025. Mangrove restoration in Bangladesh. Open Journal of Forestry. 15(1), 35–52. DOI: https://doi.org/10.4236/ojf.2025.151003

[36] Bezner Kerr, R., Hasegawa, T., Lasco, R., et al., 2022. Food, fibre, and other ecosystem products. In: Pörtner, H.-O., Roberts, D.C., Tignor, M., et al. (eds.). 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: Cambridge, UK. pp. 713–906. Available from: https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-5/ (cited 27 April 2025).

[37] Seddon, N., Chausson, A., Berry, P., et al., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B Biological Sciences. 375(1794), 20190120. DOI: https://doi.org/10.1098/rstb.2019.0120

[38] Kopsieker, L., Gerritsen, E., Stainforth, T., et al., 2021. Nature-based solutions and their socio-economic benefits for Europe's recovery: Enhancing the uptake of nature-based solutions across EU policies. The Institute for European Environmental Policy: Brussels, Belgium. Available from: https://ieep.eu/wp-content/uploads/2022/12/Nature-based-solutions-and-their-socio-economic-benefits-for-Europes-recovery-IEEP-2021-WEB.pdf (cited 23 March 2025).

[39] Teracon, 2024. The advantages and disadvantages of nature-based solutions. Available from: https://www.terraconindia.com/2024/04/12/the-advantages-and-disadvantages-of-nature-based-solutions-nbs/ (cited 12 April 2024).

[40] Lyandres, O., LeZaks, D., Shorofsky, B., et al., 2019. LAND TENURE AND CONSERVATION IN AGRICULTURE: CREATING INCENTIVES FOR LANDOWNERS. Delta Institute: Chicago, IL, USA. Available from: https://delta-institute.org/wp-content/uploads/2020/04/Land-Tenure-and-Conservation-in-Agriculture-2019.pdf (cited 23 March 2025).

[41] Kauark-Fontes, B., Marchetti, L., Salbitano, F.,

2023. Integration of nature-based solutions (NBS) in local policy and planning toward transformative change. Evidence from Barcelona, Lisbon, and Turin. Ecology and Society. 28(2), 25. DOI: https://doi.org/10.5751/es-14182-280225

[42] Li, M., Peterson, C.A., Tautges, N.E., et al., 2019. Yields and resilience outcomes of organic, cover crop, and conventional practices in a Mediterranean climate. Scientific Reports. 9(1), 12283. DOI: https://doi.org/10.1038/s41598-019-48747-4

[43] Chaplin-Kramer, R., Chappell, M.J., Bennett, E.M., 2022. Un-yielding: Evidence for the agriculture transformation we need. Annals of the New York Academy of Sciences. 1520(1), 89–104. DOI: https://doi.org/10.1111/nyas.14950

[44] UNCCD, FAO, 2024. Securing tenure to restore land and safeguard livelihoods. United Nations Convention to Combat Desertifcation (UNCCD): Bonn, Germany. Available from: https://www.unccd.int/sites/default/files/2024-04/UNCCD-FAO_Synergy%20Brief_May%202024.pdf (cited 17 Juy 2025).

[45] McQuillan, D., 2024. Catalyzing the capital flow toward nature-positive agriculture. World Wildlife Fund. Available from: https://www.worldwildlife.org/blogs/sustainability-works/posts/catalyzing-the-capital-flow-toward-nature-positive-agriculture (cited 10 September 2024).

[46] WWF Germany, WWF Indonesia, WWF Malaysia, et al., 2024. Financing nature-based solutions in Southeast Asia. World Wildlife Fund: Washington, DC, USA. Available from: https://wwfint.awsassets.panda.org/downloads/financing-nature-based-solutions---wwf-iki-august-2024.pdf (cited 17 July 2025).

[47] Das, B., 2025 Sustainable farming practices in India: key challenges and emerging solutions. The CSR Universe. Available from: https://thecsruniverse.com/articles/sustainable-farming-practices-in-india-key-challenges-and-emerging-solutions (cited 17 July 2025).

[48] Grace, M., Balzan, M., Collier, M., et al., 2021. Priority knowledge needs for implementing nature-based solutions in the Mediterranean islands. Environmental Science & Policy. 116, 56–68. DOI: https://doi.org/10.1016/j.envsci.2020.10.003

[49] United Nations Development Programme, 2019. Pathway for Increasing Nature-based Solutions in NDCs: A Seven-Step Approach for Enhancing Nationally Determined Contributions through Nature-based Solutions. United Nations Development Programme: New York, USA. Available from: https://climatepromise.undp.org/sites/default/files/research_report_document/undp-ndcsp-NBS-in-NDCs-Pathway-Report-english2.pdf (cited 17 March 2025).

[50] Nature-based Solutions Initiative, 2022. Revised climate pledges show enhanced ambition for nature-based solutions. Available from: https://www.naturebasedsolutionsinitiative.org/news/nbs-policy-platform-ndc-submissions (cited Day Month Year).

[51] Wollenberg, E., Tennigkeit, T., Dinesh, D., et al., 2022. Compensating farmers for ecosystem services. CompensACTION Policy Brief. Available from: https://www.globallandscapesforum.org/wp-content/uploads/2023/08/Compensating-farmers-for-ecosystem-services-policy-brief.pdf (cited 17 July 2025).

[52] Vijayan, D., Ludwig, D., Rybak, C., et al., 2022. Indigenous knowledge in food system transformations. Communications Earth & Environment. 3(1), 213. DOI: https://doi.org/10.1038/s43247-022-00543-1

[53] Global Mangrove Alliance, n.d.. Legal and policy recommendations to support international mangrove targets. Available from: https://www.mangrovealliance.org/news/legal-and-policy-recommendations-to-support-international-mangrove-targets/ (cited 23 February 2025).

[54] WHO, IUCN, 2023. HIGHLIGHTS BRIEF ON WHO- IUCN REPORT ON DESIGNING NATURE-BASED SOLUTIONS FOR HUMAN HEALTH. Available from: https://iucn.org/sites/default/files/2023-12/final-highlights-brief-1.pdf (cited 23 February 2025).

[55] Nature-based Solutions Initiative, 2024. Monitoring and reporting outcomes of Nature-based Solutions projects. Available from: https://www.naturebasedsolutionsinitiative.org/news/monitoring-nbs-projects/ (cited 10 April 2024).