Agroforestry solutions for zero hunger and net zero climate targets

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Transitioning to a net-zero world is one of the greatest challenges humanity may face across the world. Nonetheless, land-based carbon removal actions are vital to meet net-zero targets but involve significant trade-offs that may risk food security. The potential increase in demand for land in the near future for land-based climate mitigation methods across India could certainly threaten the right to land and food, especially for people and communities whose livelihoods depend on land. In the context of global efforts to address and combat the climate crisis and to improve food security, agroforestry is a sustainable land use with immense potential to achieve significant impact and synergy across priorities.

Global climate impacts that are now unfolding, from devastating heat waves and intense cyclones to melting glaciers, show the urgency of climate-smart actions[1]. Realizing the severity of the climate crisis, governments and corporate leaders aim to achieve net-zero emissions inside their jurisdictions or firms around mid-century. In the recent Glasgow Summit, India pledged to reduce its emissions by 2070, while the US and EU aim to achieve net zero by 2050 (ref. 2).

Technically, a net-zero climate target means counterbalancing the anthropogenic greenhouse gas (GHG) emissions by removing GHGs from the atmosphere through carbon-removal approaches[3]. Carbon removal till now has been almost exclusively by capturing carbon through natural or land-based solutions, such as planting trees. Nonetheless, other technological carbon removal methods, such as direct air capture (DAC), are also emerging; however, most of them are still untested and currently unviable economically[2].

An explosion of net-zero commitments could accentuate the demand for land in the near future, threatening the right to land vis-à-vis right to food, especially for people and communities whose livelihoods depend on land. Moreover, studies have indicated that land-based carbon removal methods to meet net-zero targets involve significant trade-offs that risk worsening poverty and hunger[4]. Land-based mitigation actions are vital for keeping global heating below 1.5°C; this must be done in ways that holistically respond to the interlinked challenges of climate change and food security. The irony is that the way we use land and grow our food is itself fuelling the climate and hunger crises. Land, agriculture, and food systems account for around 30% of global emissions[4]. Industrial agriculture and growing demand for livestock-based products like meat have led to deforestation on a massive scale and to an increase in emissions from the use of fertilizers and methane emissions from livestock. Climate change is severely impacting not only land productivity but also causing less nutritious harvest overall. Reportedly, around two-fifths of the global population is directly affected by land degradation[5]. Further, over 820 million people experience hunger, with climate change being a key driver of food insecurity[6]. As the impacts of climate change are projected to intensify, if appropriate mitigation strategies are not put in place, more communities could face food insecurity in the future.

Table 1. Comparative evidence on land-based climate action that supports zero hunger and zero emissions

Land-based climate change mitigation strategies	Carbon sequestration potential ($GtCO_2$ eq/yr)	Food security (people)
Bioenergy production	0.4–11.3	–150 million
Afforestation	0.5–8.9	–100 million
Reforestation	1.5–10	
Forest management (avoided degradation and deforestation, active management)	1.48–10.08	100 million
Agroforestry	0.11–5.68	1.3 billion
Pasture management	0.33–2.82	1 billion
Soil management in croplands	0.28–7.49	60–225 million

Source: OXFAM International[4].
Note: Minus sign indicates the number of individuals estimated to potentially be harmed by the strategy.

Switching to more ecologically sustainable agricultural practices can help build climate resilience and sustain agricultural productivity while reducing land degradation and enhancing carbon sequestration in the soil.

Agroforestry being the combined production of trees and agricultural species on the same land is a multifunctional form of agriculture that can enhance food security while meeting climate commitments.

Recent evidence suggests that agroforestry systems can sequester 10–20% more soil carbon compared to arable lands that do not have trees[7]. In all, the system has the potential to sequester up to 5.7 $GtCO_2$ eq/yr apart from ensuring food security to around 1.3 billion people globally (Table 1)[4].

Despite its significant role in addressing the twin crises of food insecurity and climate change, agroforestry adoption in India has been limited, though it has been promoted in recent times. Constraints of adopting tree-based farming are generally governed by market and regulations relating to felling and transporting of farm-grown timber. This calls for provisioning the objectives of the National Agroforestry Policy (2014) by establishing an independent National Agroforestry Board to enable backward and forward market linkages through a single window system. The agroforestry producers also deserve praise for their mitigation role that has a bearing on the carbon credit and market systems. It is time to integrate as many woody perennials both in arable and non-arable green spaces in India for an anticipatory net-zero emission.

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COMMENTARY

Revisiting the science of agronomy: crop production versus crop management

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Addressing the emerging challenges of agriculture demands reorienting the agricultural education in general and agronomy education in particular. Crop husbandry has been evolving constantly, although academically and, for different operational purposes, agronomy science and academia have remained far more static than they should have been. This note emphasizes that the science of agronomy must include all the important aspects of crop management so that agronomists/students can attain better comprehension in wider perspective so that the goal of agronomy can be realized in the current context of changing crop husbandry.

Indian agriculture contributes to about 8% of the global agricultural gross domestic product (GDP) to support 18% of the world's population on only 11.3% of arable land and 2.3% of geographical area. Attainment of food security has been the major objective of Indian agriculturists since independence. India successfully achieved this goal by adopting green revolution technologies (GRTs). The country has attained more than a fivefold increase (50–265 million tonnes (Mt)) in food grain production, against a three and a half-fold rise in human population (360–1250 million) with per capita availability of food grains from 395 g/day in 1950 to 450 g/day in 2012. The gross irrigated area also increased from 22.5 to 91.5 million hectares during this period. Likewise, fertilizer consumption has increased several-fold since independence.

Consequently, India emerged as the second largest producer of food grains in world and has the potential to become the world leader, if the emerging challenges of agriculture are addressed through the reorientation of agricultural education in general and agronomy education in particular. On-farm crop husbandry has also experienced dynamic evolution, but academically the science and academics of agronomy have remained largely unadapted. Therefore, here we argue for revisiting the academic and functional parlance of agronomy in the context of the functional repercussions of modern agricultural technologies.

Challenges of modern agriculture

Though GRTs helped India become food secure, they are also blamed for severely damaging farm production resources. The degradation of natural resources like land and water has now become the key constraint in augmenting agricultural production. The yield plateaus and new-generation problems of soils are considered the silent ill-effects of overexploiting the resources. The soil has become sick for sustaining food production and the environment has turned unsafe for human health. The widely emerging problems in agriculture have been empirically documented and discussed at several forums. Some of the more notable ones are listed below for a better understanding and to help us realign our mindset to achieve the future goals.

- The soil quality is poor with multiple nutrient deficiencies and low organic carbon content due to intensive cultivation and use of indiscriminate amounts of fertilizers.
- The water table is critical in most irrigated lands, and water quality is also deteriorating due to the leaching of salts and pollutants.
- The overexploitation of irrigation water has lowered the depth of the water table.
- The indiscriminate use of insecticides has caused a resurgence with no satisfactory control of pests; for instance, *Helicoverpa armigera* on cotton and pigeon pea, and tolerance to the chemical toxicity of the herbicide isoproturon on the wheat weed *Phalaris minor* and butachlor on wrinkle grass in rice.
- Chemical residues in food have increased the incidence of several diseases/disorders among farmers in particular and consumers in general.

Apart from the above, there is growing concern about the consequences of climate change for food security, as projections indicate that the demand for food grains will increase to 345 Mt by 2030, for which food grain production has to be increased at a rate of 5.5 Mt annually. There are several other examples also which challenge the