UFZ HELMHOLTZ Centre for Environmental Research

Policy brief

Rethinking agricultural productivity: more than yield and land

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MAIN MESSAGES

- The prevailing paradigm of agricultural productivity – increasing yields and optimizing them in relation to input costs – often overlooks the environmental consequences of energy-intensive practices.
- Shifting the focus to include energy productivity – measuring production output per unit of energy input – is crucial for reducing the environmental footprint of agriculture.
- Policymakers can play a vital role in promoting energy-efficient agricultural practices through targeted incentives, regulations and research funding.

Introduction

Food systems are responsible for a third of global anthropogenic greenhouse gas (GHG) emissions. As the global population grows, so too will the demand for food and, with it, GHG emissions, unless there are substantial changes in global food systems (including agricultural practices). Improving agricultural efficiency is paramount in mitigating climate change. Traditionally, agricultural productivity has been evaluated as yield per unit of land. However, this approach is no longer sufficient given the urgency of climate change, resource limitations and environmental impacts.

This policy brief redefines agricultural productivity as a multifaceted concept that extends beyond area-based yield. A key metric for evaluating the sustainability of agricultural systems is energy productivity. This refers to the amount of agricultural output generated per unit of energy input. However, a reduction in energy inputs could potentially lead to increased demand for land. The challenge is to produce sufficient food while simultaneously reducing negative environmental impacts, given that food production is limited by land availability as well as energy, human resources and technology; while the former is finite, the latter three have the potential to increase with innovation.

Multiple objectives

Solutions to providing all people with access to a healthy and adequate diet, while decreasing the impact of agriculture and food supply require a balance of multiple, sometimes competing, objectives, including production of sufficient healthy food; input use efficiency, including reduction of fossil fuel use and (thus) GHG emissions; farmers' incomes; biodiversity; and other ecosystem services (e.g. water retention/storage and flood protection).

Finite space

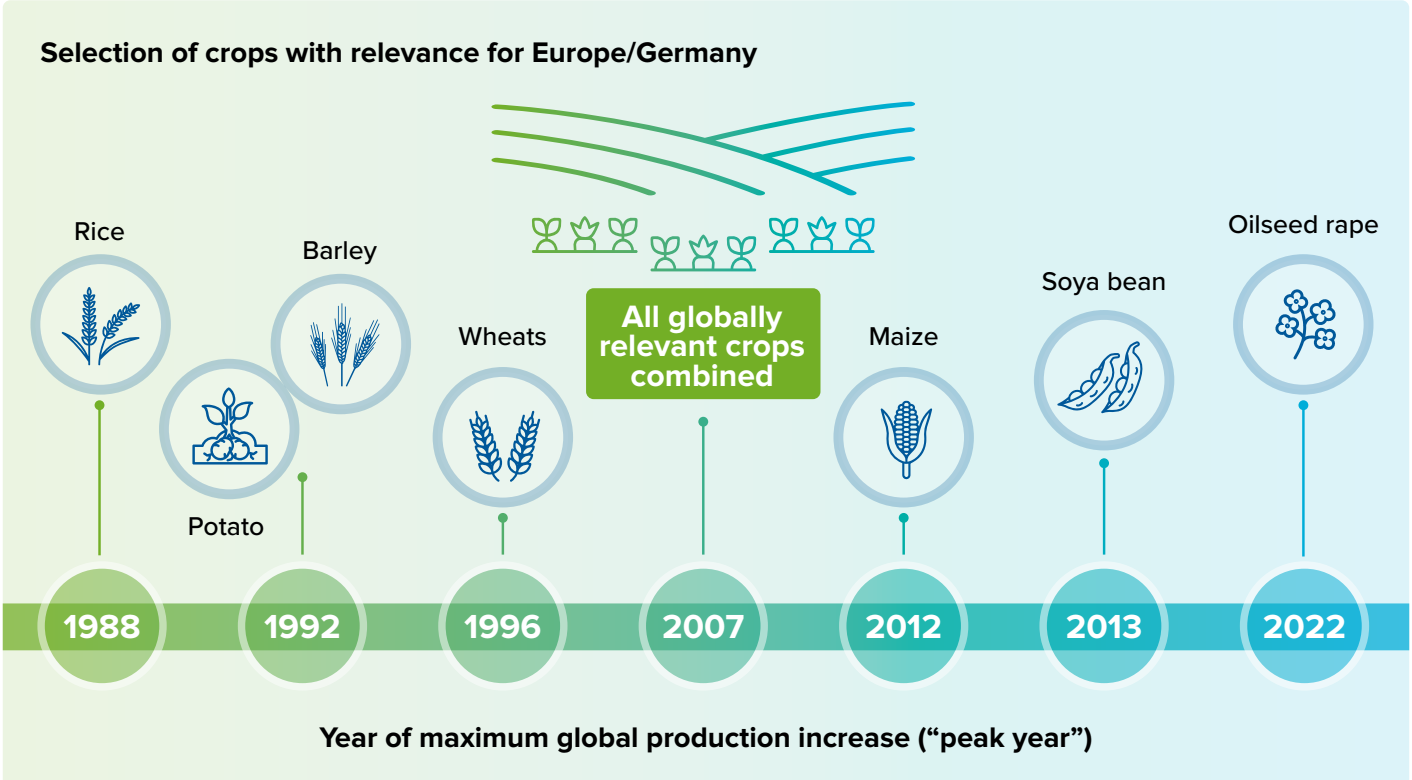
Globally, growth in crop yields is slowing, stagnating or, in some cases, reversing – at least in part because of environmental damage caused by unsustainable farming practices. On a global scale, there are huge gaps between crop yield potential (as achieved on model farms, in research plots or demonstrated via computer models) and yields farmers actually achieve on their farms – especially acute in rain-fed farming systems in Africa, but not so much in high-intensity European systems.

The European (and German) picture is complex as it is diverse. Yield growth has slowed since 2002. Land rent has increased through competition with solar farms and biofuels, which achieve substantially higher incomes. Meanwhile, in parts of Europe land abandonment is an issue, driven by economics (high cost, low profit), demographic changes (rural depopulation, ageing farming population), policy and market conditions (e.g. the EU Common Agricultural Policy, subsidies), biophysical factors (poor soil quality, unfavourable climate), structural issues (fragmented land ownership and small farms), and geopolitical changes (Cold War legacies).

Concurrently, Europe drives indirect land use change in other parts of the world. For example, pig farming (for meat) is big business in the EU, led by Germany and Spain. The demand for soya to feed these pigs drives deforestation in the major exporting countries of Brazil and Argentina. Only about 24% of soya used in livestock feed in Europe is certified 'deforestation-free'. Clearance of forests and other natural vegetation leads to further environmental degradation and loss of biodiversity. In many cases, bringing such land under cultivation is expensive in terms of GHG emissions – for example, chainsaws and transport trucks used in forest clearance both run on fossil fuels.

While there has long been a market for produce from diverse agricultural systems, 'conventional' farmers claim that environment-friendly farming systems produce lower yields than systems based on the use of mineral fertilizers and synthetic pesticides. This perception does indeed seem to be correct, with global meta-analyses confirming the lower (and more variable) crop yields of organic systems, but also confirming their superiority in terms of environmental richness and stability.

However, diversified agriculture does enhance yield stability, resilience to climate change and other factors.

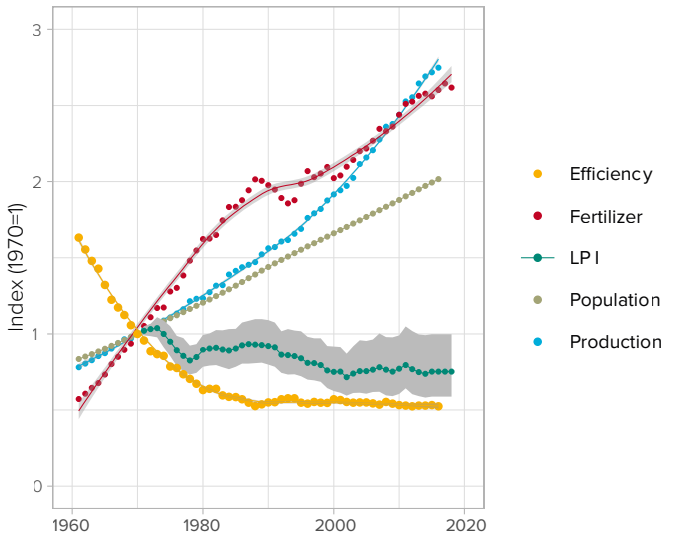


Year-on-year production increases have been the norm for decades if not centuries for most crops globally; however, the rate of increase of production of many crops has peaked over the past 40 years. Contributing factors to the subsequent decline in rate of increase include land scarcity and degradation and nearing the biological potential of some crop plants.

Finite energy

Modern agriculture is energy-intensive – high-tech equipment, pumped irrigation, fertilizers, pesticides, etc., all drive up the carbon footprint of agriculture because of their dependence on fossil fuels.

Despite increasing energy input, productivity per unit of energy has decreased in recent decades. Moreover, the 'wasted' energy (often in the form of surplus nitrogen) is directly responsible for acidification and eutrophication.



Since 1970, global agricultural production (green) has increased more than 2.8-fold, the global population has doubled (brown), and the amount of mineral and organic N applied worldwide increased more than 2.5-fold (red). The ratio of goods produced per amount of fertilizer used ('efficiency', yellow) has fallen continuously, together with the Living Planet Index (LPI, dark green), an indicator of the state of global biodiversity.

The impact of reducing the total energy use in a farming system – in terms of lower yields – depends on the system inputs. For example, reducing energy inputs (e.g. by reducing fertilizer and pesticide use) in high-input systems prevalent in Europe would have considerably less impact on production than a similar reduction in low-input systems (typical of developing countries). In the latter context, and specifically in the context of monocrops, reducing energy input would likely reduce yield and therefore increase the need for more land, assuming total production needs to stay the same. This would then perpetuate a vicious cycle.

Reducing inputs with enough food for all?

At a global scale, there is enough food produced to feed everyone on the planet, but there is a huge four-fold gap between the average daily food consumption in rich and poor counties. Key issues for global food security include the following.

- Socioeconomic inequalities: Both 'rich' and 'poor' countries display huge gaps between their wealthiest and poorest citizens – and globally, 1.1% of the population holds 45.8% of the world's wealth.
- Population growth and dietary shifts: In general, developing economies have higher population growth rates than developed economies; however, as incomes and wealth increase, people everywhere tend to adopt protein-rich diets, especially animal-based protein (meat and dairy products) – animal production typically requires more space and inputs than crop production.
- Distribution inefficiencies: Urban populations are almost always at an advantage when it comes to accessing diverse nutritious food at affordable prices, because of the economies of bulk transport and the fact that urban centres are usually better served with transport links. Conversely, some rural populations are more or less isolated during certain seasons of the year.
- Loss of production occurs in-field, during harvesting and post-harvest transport and processing, and food waste is rife (especially in developed economies) at retail and consumer levels. Such losses account for around a third of agricultural production.

Policy recommendations

- Promote agricultural diversification via crop diversification and farming on the basis of agroecological principles,[1] including a move away from high dependence on mineral fertilizers and pesticides. In the short term, this may mean offering financial incentives for farmers, and implementing regulations that limit the use of agro-chemicals.
- This will require research into diversified farming systems and their energy-saving potential, including alternative fertilizers and farm management techniques. Research and development is also needed for energy-efficient agricultural technologies, including climate-smart resource-use-efficient varieties and breeds, renewable energy for agricultural use, and the development and adoption of precision agricultural technologies that optimize resource use – these will all require support, funding and, once developed, promotion.

1 'Farming on the basis of agroecological principles' is used as an umbrella terms for various farming systems and techniques that have been adopted to combat the use of synthetic chemicals in agriculture and move towards improved human and environmental health and animal welfare. These include (but are not limited to): agroecology farming; conservation agriculture; organic farming; permaculture; and regenerative farming.

- Invest in knowledge-sharing, extension services and capacity-building by expanding extension services to provide training, developing educational materials, and supporting farmer-to-farmer learning networks.
- For lower-energy farming to become both profitable and sustainable, consumers' awareness will need to be raised on the benefits (e.g. both personal and environmental health) of new products from diversified farming systems.
- It may well be necessary to tackle the few retail companies that have come to dominate the supply chain from farm to consumer. Large retailers (e.g. Walmart, Aldi, Carrefour, Tesco and Nestlé) have expanded their businesses back down the value chain, frequently all the way to the farm. They have their own processing plants and distribution networks, so they can dictate to both farmers and consumers what should be produced and how and what is available for consumption. This creates a challenging environment for farmers, traditional processors and distributors, and alters the competitive dynamics of the retail sector.

FURTHER READING

This brief draws on data and discussions in over 30 source documents. For an annotated list of these documents, see here.

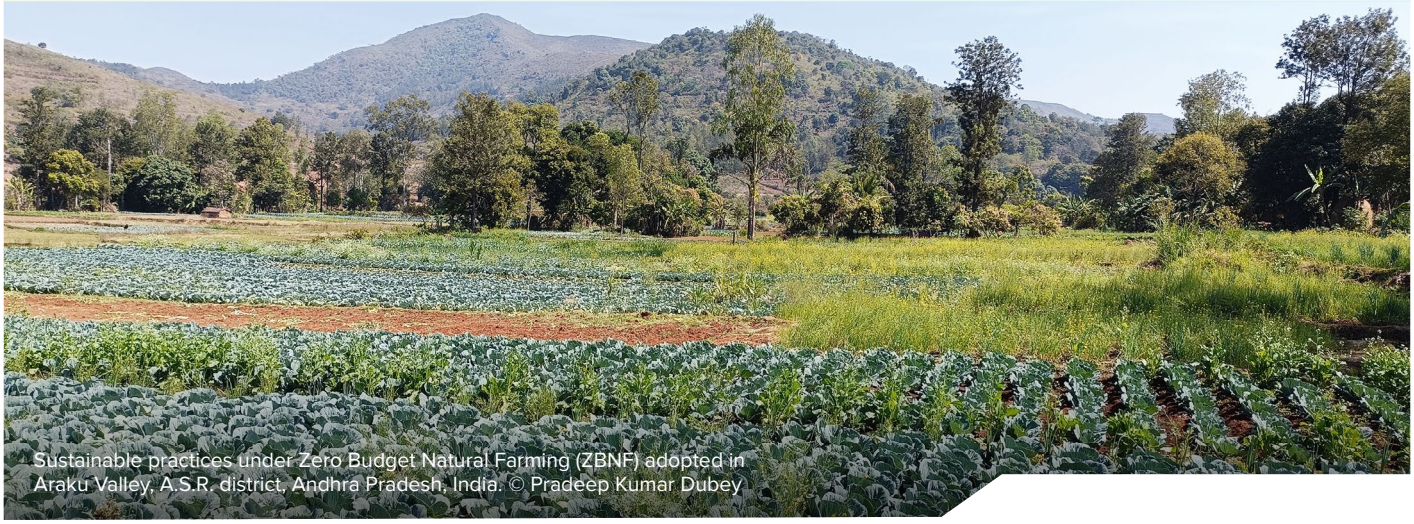
CASE STUDY

Zero Budget Natural Farming in Andhra Pradesh

The Zero Budget Natural Farming (ZBNF) approach emphasizes the use of natural inputs and traditional farming techniques to reduce reliance on chemical fertilizers and pesticides. The goal is to create a more sustainable and environmentally friendly agricultural system that mimics nature, minimizes GHG emissions, and promotes soil health and local biodiversity.

ZBNF has gained significant traction in Andhra Pradesh, India, with many farming communities adopting these methods to improve crop yields and reduce water use and costs. ZBNF is having a positive impact on both the environment and the livelihoods of farmers. Practised on 0.1 million hectares in 2021, it is targeted to cover 8 Mha (currently under conventional farming) in 2027. While rice and wheat yield declines have been reported upon ZBNF scaling, only area-based performance has been measured.

> *"Our guiding question is no longer how much rice or corn we harvest per growing season, but how long we can produce green growth and diverse crops over 365 days."*
>
> *Vijay Kumar Thallam, Rythu Sadhikara Samstha (RySS) and former long-serving government official*



Sustainable practices under Zero Budget Natural Farming (ZBNF) adopted in Araku Valley, A.S.R. district, Andhra Pradesh, India. © Pradeep Kumar Dubey

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