

Sustainable intensification of African agriculture: a necessity, but not yet a reality

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After decades of well-intentioned and professional research for development, agriculture in sub-Saharan Africa is still dominated by low-input, subsistence food crop production on small, rainfed land holdings using hand labor. What are the drivers and constraints to development in African agriculture, and how can the region intensify farming in economical and environmentally sustainable ways to satisfy its rapidly rising and shifting food demands?

Looking at the evolution of global agriculture over the past 60 years^[1], one cannot miss the striking differences between continents, regions and countries. Agriculture in developed countries followed the path begun during the industrial revolution in England more than 250 years ago, benefiting from agrochemicals and mechanization. Emerging countries in Asia and Latin America efficiently caught up during the Green Revolution of the mid- twentieth century^[2,3]. Worldwide, farm output has met the growing demand for food from rapidly expanding populations (Fig. 1(a,b)) and, more recently, for animal products in developed and emerging economies. This did not happen without unintended effects on social equity or the environment and natural resources.

Still, although for many the challenge is to produce more and better food with fewer resources, one region—sub-Saharan Africa—has not shifted gears in productivity or escaped subsistence farming. It urgently needs to do so^[4].

1 Worrying indicators

Agriculture intensification indicators^[1] such as yield, mechanization, and agriculture land use since 1960 show sub-Saharan Africa lagging far behind the rest of the world (Fig. 1). With few exceptions, there has been little positive transformation and few signs of needed intensification. In contrast, African rural landscapes are most often poverty traps for unlucky inhabitants, who depend almost exclusively on low-yield agriculture for food security and livelihoods. Africa has generally addressed increasing food demand by putting more land under low-input, labor-intensive farming (Fig. 1(c,d)). While providing some livelihood options, this has not set the continent on a positive development pathway, triggered development of secondary and tertiary sectors to process and sell farm products, nor led to fewer people in rural areas (Fig. 1(e)). Farmland expansion has led to less productive and marginal land, causing deforestation, loss of wildlife habitats and an overall erosion of once plentiful land resources. African agriculture is actually in a downward spiral, ever more vulnerable to climate change, degrading soils, erratic rainfall, droughts, destructive pests and crop diseases. Barring immediate large and well-conceived development investments, the region will suffer severe crises from agriculture system failures in coming decades.

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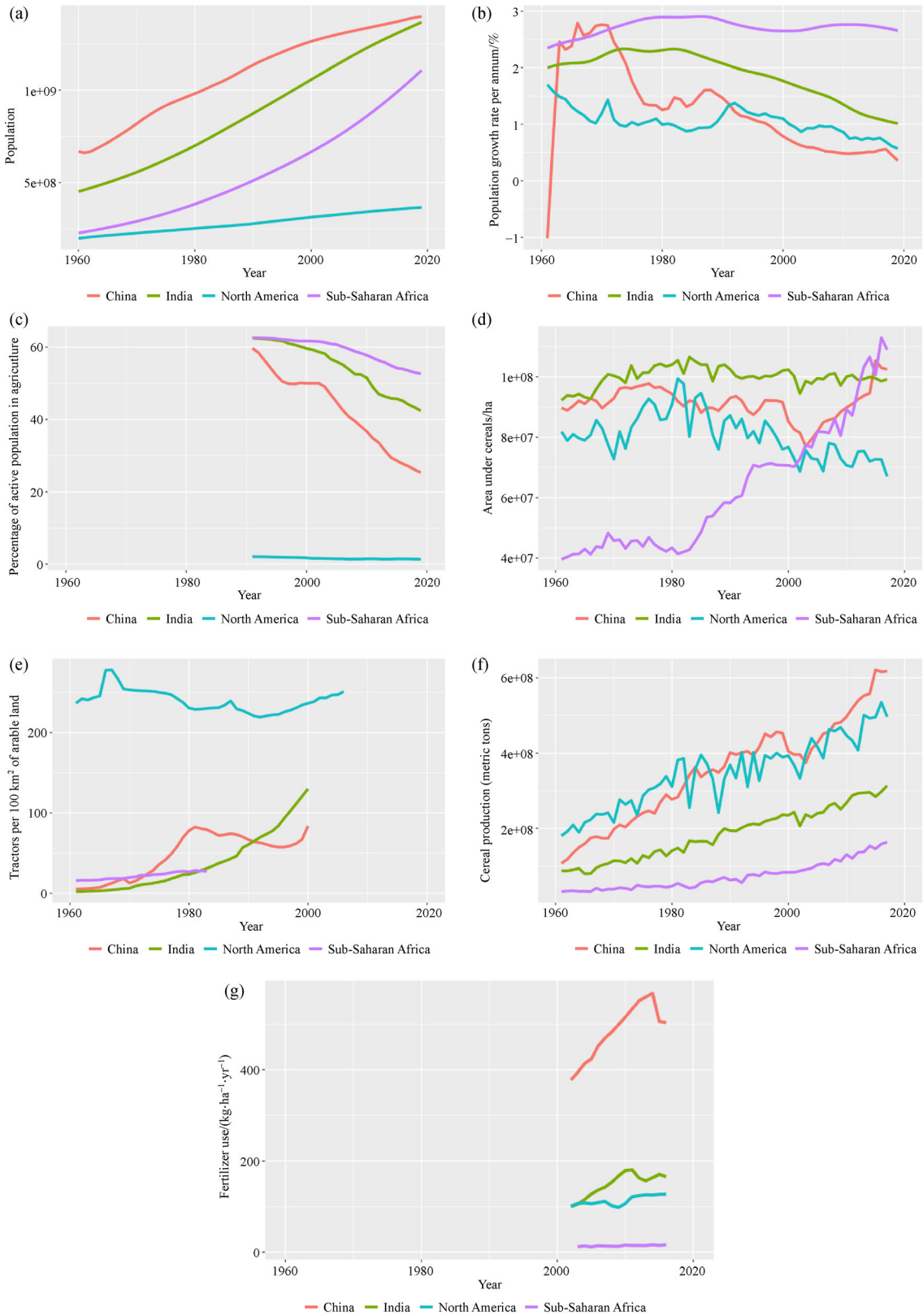


Fig. 1 Evolution of World Bank indicators for a subset of countries and regions since 1960. (a) Population; (b) population growth rate; (c) percentage of active population in agriculture; (d) area under cereals; (e) tractors per unit area of arable land; (f) cereal production; and (g) fertilizer use. Data source: World Bank.

2 Low adoption of intensification measures by smallholder farmers

Why is African agriculture creating more poverty than wealth? Most answers to that question lie outside the agriculture sector. Technologies, improved seeds and better agronomic practices developed in Africa or elsewhere have shown their potential largely to reduce yield gaps and agricultural risks but, outside of research-for-development projects, adoption remains relatively low. There are many reasons: lack of knowledge, lack of access to inputs or to cash/credit to buy them, lack of input and output markets, limited financial incentives for enhanced productivity, risk aversion, and uncertain land tenure and land endowment; finally, extension and scaling approaches have fallen short in Africa^[5,6].

3 Can the land support a fast-growing rural population?

An eye-opening study by Harris and Orr^[7] concluded that, because rainfed farms in sub-Saharan Africa are so small (80% are less than 2 ha), even the best yield improvement practices will not provide enough revenue to lift farmers and their families out of poverty¹.

Rapid demographic growth and the scarcity of livelihood options outside of farming will exacerbate rural land fragmentation, further reducing average farm size and the ability to make a living through farming alone. Off-farm agricultural labor or jobs outside the farm sector, along with transfers and remittances, may support some^[8] but will seldom provide significant economic advancement. If the massive clearing of natural habitats for farming is to be avoided, while maintaining the current 80% food self-sufficiency as food demand triples over the next 30 years, van Ittersum et al.^[4] suggest the need to transform agriculture, adding irrigation and practicing double cropping.

4 Low productivity of rural labor

The low total-factor productivity of African farms derives in large part from the absence of mechanization (Fig. 1(e)). Labor may appear abundant in the region, but shortages at periods of peak demand (sowing and weeding) delay operations and reduce yields^[9–11], and farm labor entails considerable drudgery, especially for women and children. State-led efforts in several African countries to mechanize agriculture mostly failed, due to their governance models, lack of proper use and maintenance, and the type of equipment selected^[12]. Recent interest in mechanization for the region is building on lessons from the success of scale-appropriate mechanization in Asia^[13]. Alternate cropping practices that feature reduced tillage require smaller, less powerful, more affordable tractors — including two-wheel tractors — and are suited for small farms^[14]. Even so, mechanization will prove expensive for individual farmers, so public-private partnerships and mechanization service provision models, whereby machine owners contract their services to farmers, will be required^[15].

5 Agricultural inputs

Use of agrochemicals, such as mineral fertilizers (Fig. 1(g)), herbicides and pesticides, underpinned agricultural intensification in other regions but has not been widely adopted by African smallholders. Their use and abuse are at the core of current debates and reflections regarding sustainable intensification versus agroecological approaches. The two paradigms largely overlap in aiming to increase resource use efficiencies but differ regarding the use of external inputs. Agroecological approaches do not totally reject use of external inputs but favor capitalizing on endemic resources and aiming for high cycling and recycling efficiencies. In contrast, most proponents of sustainable intensification approaches for Africa cite the lack of plant nutrients applied in a balanced way as the chief constraint, along with a lack of water in the arid and semiarid regions, and believe that nutrient cycling alone will not be enough to boost productivity in the region's soils. The agroecological push in Europe reflects a reality where lands are rich in nutrients, external inputs have long been applied in excess, and the decoupling of crop and livestock production has generated major nitrogen pollution. In contrast, in African farming systems, recycling solutions without external inputs have often shown their limits and have a

¹There may be reason for slight optimism; Harris and Orr did not include livestock in their analysis, even though farm animals are strategically important for human and plant nutrition, farm power, income generation and coping with risk, on African farms.

low factor productivity/higher labor demand. The debate should be about whether low-input agriculture will feed a rapidly growing population and provide decent living conditions, health, and education for farmers and their families. Today African farmers are not agroecological by choice but for lack of viable intensification options. Their constraints are for the most part not technical but socioeconomic and due to the absence of an enabling environment.

There are technical issues. Poor soil fertility has been amply documented as the main cause of large yield gaps throughout sub-Saharan Africa^[16]. Other causes for stagnant or declining yields include a lack of quality seed, poor management practices, lack of crop protection, poor or delayed weeding, erratic rainfall, dry spells and drought^[4,17]. Understanding these agronomic problems is an important first step but deploying solutions at scale has been much more challenging. Clear, long-term, integrated approaches are needed and must include improved policies, functional markets, socioeconomic analysis, and strong, coordinated public and private support.

6 Detrimental economic policies

Beginning in the 1960s, improving agriculture in Africa was seen as a stepwise exercise, first to fix the most critical constraint, soil fertility, by easing access to mineral fertilizer through Input Subsidy Programs (ISPs). Two decades of such programs achieved mixed results and much less impact on land productivity than expected^[18]. To continue receiving World Bank loans in the 1980s and 1990s, many countries pursued structural adjustment programs to reduce government spending and promote free trade, leading to the suspension of ISPs. Structural adjustment programs are now widely recognized as unsuccessful, failing to contribute to sustainability goals, poverty reduction or increased wealth. Economic policies under those programs did little to further agricultural development but rather weakened African agricultural research capacity. A second generation of ISPs, labeled as smart subsidies, were implemented in several African countries. They gave lower returns than expected^[19] but at least demonstrated that access to fertilizer did boost productivity at scale, as seen in Malawi (Fig. 2).

7 Fertilizer alone will not do the job

Ethiopia provides a striking example of strong public support for agriculture. Cereal yields have doubled there over the past 15 years with a relatively low use (around 20 kg·ha⁻¹·yr⁻¹) of fertilizer. One important lesson learned from the ISPs was that the lower than expected returns on fertilizer investments^[19] were largely due to farmers not applying better crop management practices (timely weeding, optimum planting density, crop protection and use of quality seeds) in conjunction with fertilizer. In addition, large areas of crop land in sub-Saharan Africa have low inherent fertility, are physically and chemically degraded from long use under low-input farming, and have low organic matter content, making them unresponsive to fertilizer^[20]. So, it appears that farmers need to apply a suite of improved technologies and practices, to get the best return on their investments in fertilizer. Moreover, a sequential adoption over years of improved management practices, starting with use of small quantities of mineral fertilizer^[21], might not be the best strategy in many contexts.

8 An underfunded public sector and a growing but timid private agrifood sector engagement

In Maputo, Mozambique, in 2003, the African Union (AU) Summit made the first declaration regarding a Comprehensive Africa Agriculture Development Programme (CAADP), as an integral part of the New Partnership for Africa's Development. The CAADP is an African policy framework for agricultural transformation, wealth creation, food security and nutrition, economic growth and prosperity for all. At the time, two broad targets were set: 6% annual growth in agricultural GDP and an allocation of at least 10% of public expenditures to the agricultural sector. Main objectives included developing a continent-wide framework to boost job creation and increase employment opportunities, especially for women and youth, as well as guaranteeing food security and improved nutrition and strengthening resilience. The importance of a cross-sector approach was also explicit. In 2014, during an AU summit in Equatorial Guinea, African heads of state and governments repledged to the Malabo declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods, restating that agriculture should remain high on the agenda for the development of the continent and is a critical policy initiative for African economic growth and poverty

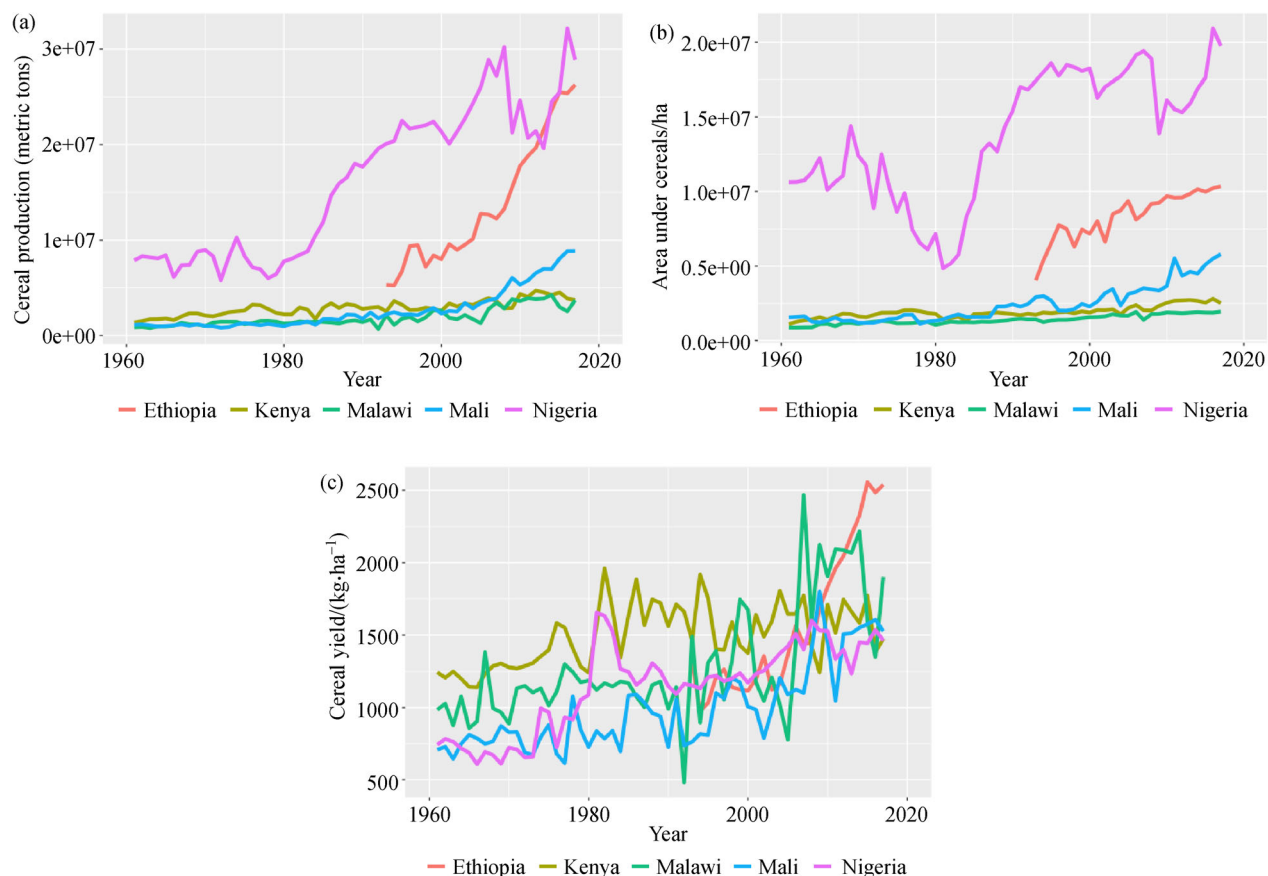


Fig. 2 Evolution of World Bank indicators for a subset of African countries. (a) Cereal production; (b) area under cereals; and (c) cereal yield. Data source: World Bank.

reduction. The declaration set a series of ambitious goals to be achieved by 2025 through concrete and targeted actions. Facing strong budgetary challenges, many countries failed to fund agriculture at the levels originally envisaged by CAADP^[22] and, according to macro-level indicators, most countries are far from achieving the 2025 targets.

Many consider the private sector as an important, potential driver for agricultural development in Africa. Private growth and engagement, including those of small- and medium-scale regional and national enterprises, have grown steadily but remain relatively low. Governments and societies must foster an enabling environment through larger incentives, supportive policies and adequate infrastructure, to capture private sector investments and lift agriculture.

9 Agricultural research is much needed to guide development

The diversity of biophysical, socioeconomic and market conditions across the vast African continent demands agricultural solutions tailored for specific environments. As part of a sustainable intensification framework, research must embrace a multi-criteria approach including social, economic and environmental components and across multiple levels and scales. It must also be multidisciplinary to reflect past tradeoffs and synergies, address current realities, and come up with integrated solutions in context. Biological, environmental and human science knowledge should be integrated to develop relevant solutions. Also, only strong coordination between research, policy and development will improve the likelihood of development investments being designed, targeted, and implemented to provide the desired return on investment.

Most critical crop and livestock production and marketing decisions are taken at the farm level, so understanding and supporting farm-level decision making is key to improving agricultural productivity and rural livelihoods. Information technologies are already providing site-specific support to millions of farmers in other

regions, and will be apt for African farmers with mobile phones. Research should also have a larger role in monitoring and critically evaluating development investments, to better steer and improve development approaches.

Integrated methods are essential but still need to be built around strong disciplinary science, such as field agronomy and breeding. Breeding must in turn expand its focus beyond mere yield enhancement to include yield stability, resistance or tolerance to biotic and abiotic stresses, and nutritional quality.

Agricultural research in Africa is underfunded^[19,23] and increasingly fragmented, being supported from relatively small and short projects and various funding agencies, sometimes with differing demands and criteria^[6]. This prevents a more coherent programmatic approach which is needed to increase ROI of research funding and impact at scale. The current CGIAR reform, if well designed and implemented, should provide such a research-for-development environment where national agricultural research systems, advanced research institutes, international research centers, and funding and development agencies collaborate in a coherent and aligned manner.

Compliance with ethics guidelines Bruno Gérard declare that he has no conflicts of interest or financial conflicts to disclose. The views expressed here are those of the author and do not necessarily represent or reflect the views of CIMMYT.

References

1. World Bank. World development indicators. 2020. Available at World Bank website on July 30, 2020
2. Evenson R E, Gollin D. Assessing the impact of the green revolution, 1960 to 2000. *Science*, 2003, **300**(5620): 758–762
3. Pingali P L. Green revolution: impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences of the United States of America*, 2012, **109**(31): 12302–12308
4. van Ittersum M K, van Bussel L G J, Wolf J, Grassini P, van Wart J, Guilpart N, Claessens L, de Groot H, Wiebe K, Mason-D’Croz D, Yang H, Boogaard H, van Oort P A J, van Loon M P, Saito K, Adimo O, Adjei-Nsiah S, Agali A, Bala A, Chikowo R, Kaizzi K, Kouressy M, Makoi J H J R, Ouattara K, Tesfaye K, Cassman K G. Can sub-Saharan Africa feed itself? *Proceedings of the National Academy of Sciences*, 2016, **113**(52): 14964–14969
5. Glover D, Sumberg J, Andersson J A. The adoption problem; or why we still understand so little about technological change in African agriculture. *Outlook on Agriculture*, 2016, **45**(1): 3–6
6. Woltering L, Fehlenberg K, Gerard B, Ubels J, Cooley L. Scaling – from “reaching many” to sustainable systems change at scale: a critical shift in mindset. *Agricultural Systems*, 2019, **176**: 102652
7. Harris D, Orr A. Is rainfed agriculture really a pathway from poverty? *Agricultural Systems*, 2014, **123**: 84–96
8. Rapsomanikis G. The economic lives of smallholder farmers: an analysis based on household data from nine countries. Rome: *Food and Agriculture Organization of the United Nations (FAO)*, 2015
9. Baudron F, Misiko M, Getnet B, Nazare R, Sariah J, Kaumbutho P. A farm-level assessment of labor and mechanization in Eastern and Southern Africa. *Agronomy for Sustainable Development*, 2019, **39**(2): 17
10. Baudron F, Sims B, Justice S, Kahan D G, Rose R, Mkomwa S, Kaumbutho P, Sariah J, Nazare R, Moges G, Gerard B. Re-examining appropriate mechanization in Eastern and Southern Africa: two-wheel tractors, conservation agriculture, and private sector involvement. *Food Security*, 2015, **7**(4): 889–904
11. Silva J V, Baudron F, Reidsma P, Giller K E. Is labour a major determinant of yield gaps in sub-Saharan Africa? A study of cereal-based production systems in Southern Ethiopia. *Agricultural Systems*, 2019, **174**: 39–51
12. Daum T, Birner R. African agricultural mechanization: myths, realities and an emerging research agenda. Working Papers 298420. Bonn, Germany: *Center for Development Research (ZEF), University of Bonn*, 2019
13. van Loon J, Woltering L, Krupnik T J, Baudron F, Boa M, Govaerts B. Scaling agricultural mechanization services in smallholder farming systems: case studies from sub-Saharan Africa, South Asia, and Latin America. *Agricultural Systems*, 2020, **180**: 102792
14. Jaleta M, Baudron F, Krivokapic-Skoko B, Erenstein O. Agricultural mechanization and reduced tillage: antagonism or synergy? *International Journal of Agricultural Sustainability*, 2019, **17**(3): 219–230
15. Kahan D, Bymolt R, Zaal F. Thinking outside the plot: insights on small-scale mechanisation from case studies in East Africa. *Journal of Development Studies*, 2018, **54**(11): 1939–1954
16. Sanchez P A. Ecology. Soil fertility and hunger in Africa. *Science*, 2002, **295**(5562): 2019–2020
17. Beza E, Silva J V, Kooistra L, Reidsma P. Review of yield gap explaining factors and opportunities for alternative data collection approaches. *European Journal of Agronomy*, 2017, **82**: 206–222
18. Baltzer K T, Hansen H. Agricultural input subsidies in sub-Saharan Africa. Denmark: *Ministry of Foreign Affairs of Denmark, Danida*, 2011
19. Jayne T S, Mason N M, Burke W J, Ariga J. Review: taking stock of Africa’s second-generation agricultural input subsidy programs. *Food Policy*, 2018, **75**: 1–14

20. Vanlauwe B, Kihara J, Chivenge P, Pypers P, Coe R, Six J. Agronomic use efficiency of N fertilizer in maize-based systems in sub-Saharan Africa within the context of integrated soil fertility management. *Plant and Soil*, 2011, **339**(1–2): 35–50
21. Aune J B, Bationo A. Agricultural intensification in the Sahel — The ladder approach. *Agricultural Systems*, 2008, **98**(2): 119–125
22. Fontan Sers C, Mughal M. From Maputo to Malabo: public agricultural spending and food security in Africa. *Applied Economics*, 2019, **51**(46): 5045–5062
23. Lynam J, Beintema N M, Roseboom J, Badiane O. Agricultural research in Africa: investing in future harvests. *International Food Policy Research Institute*, 2016