



Perspective

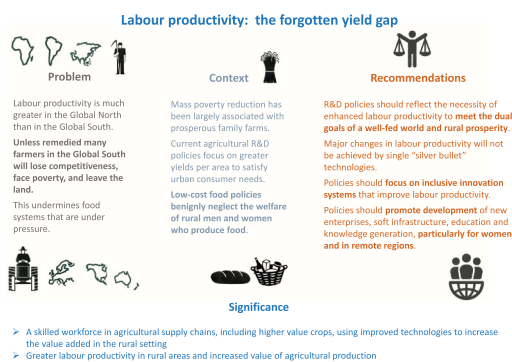
Labour productivity: The forgotten yield gap

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HIGHLIGHTS

- Agricultural labour productivity in the lower income countries is less than that in the higher income countries.
- Agricultural R&D in the Global South emphasizes yield and neglects labour productivity.
- Unless labour productivity increases farmers will be doomed to poverty and food supply will suffer.
- An innovation systems approach is needed to raise labour productivity to ensure rural prosperity and urban food supply.
- Higher value crops are key for increased labour productivity for those with limited access to land.

GRAPHICAL ABSTRACT



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ABSTRACT

Crop yields and labour productivity have increased markedly over the past 70 years. In agriculturally advanced countries, increases in labour productivity – that is, increases in the economic output per unit of labour input – have been several-fold greater than corresponding increases in yield. The gap in labour productivity between the Global North and the Global South is now much greater than the yield gap. This large labour productivity gap, unless remedied, will: (i) condemn many farmers in the Global South to live in poverty; and (ii) make them less competitive and force them to follow the well-established trend of exiting farming altogether, which (iii) will contribute to greater dependence on imported food in many countries.

Despite this situation, agricultural development agencies tend to emphasize biological yield per unit area to satisfy the increasing demand for more nutritious and varied food products. Policies are skewed towards low-cost food for urbanites, often with benign neglect of the welfare of the rural populace, particularly the women who produce the food.

We suggest R&D policies should pay more attention to enhanced labour productivity, while not neglecting increased yield, to meet the dual needs of food for the overall population and prosperity in rural areas. Many technology-based interventions exist to increase labour productivity, nevertheless, single technological fixes are unlikely to bring about major changes. Furthermore, the adoption of new technologies and novel enterprises required to increase labour productivity, particularly those related to high value crops for farmers with limited access to land, depends on an inclusive innovation systems approach. Policies are needed that support the

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development of new enterprises, soft infrastructure, a stronger industrial base and inclusive partnerships with education providers such as universities, research centres, secondary and tertiary education facilities. This is not to say that producers in the Global South should follow the Global North, rather that policy should focus on interventions that improve labour productivity of both women and men tailored to enhance ongoing development within the local context.

1. Introduction

The world needs greater access to healthier, more diverse, and sustainably produced food (Christiaensen et al., 2020). Increased yields have contributed to increased food production over the past seventy years (Fischer et al., 2014). Most public agencies still see increased crop yields or land productivity (Van Ittersum et al., 2013; Fischer and Connor, 2018; Fuglie et al., 2019) as the principal means to meet the demand (see supplementary Information I) with little attention paid to the welfare of the millions who eke out a living from farming.

Labour productivity, defined as the [economic] output per unit of labour input (OECD, 2022), is rarely mentioned as major driver of increased agricultural production even though it has made modern agriculture remarkably efficient (Gallardo and Sauer, 2018). Labour productivity has increased faster than yield in the Global North: from 1911 to 2000, yield in the USA increased fivefold while labour productivity increased fifteenfold (Alston et al., 2009a). The pattern of greater increases in labour productivity than in yield has not occurred in the Global South (Benin and Nin-Pratt, 2016). Labour productivity in the Global South is often an order of magnitude less than in the Global North (Fig. 1).

Greater labour productivity coupled with higher crop yields has contributed to a decline in field crop prices, which fell to 40% of 1949 prices by 2000 (Alston et al., 2009a). The large increases in both labour productivity and yield in the richer countries makes it difficult for many poorer countries to compete in a globalized world (Majid, 2004; Jambor

and Babu, 2016; Supplementary Information III). Thus, Africa which was a major food exporter after the Second World War increasingly relies on food imports.

As a consequence of declining prices of basic staples and commodities and low labour productivity, many farmers or farm workers face lower incomes, become discontented, lose interest in farming and leave for the cities to escape both poverty and drudgery; they look for better opportunities for their children, even if they themselves suffer greatly (see for example Agarwal and Agrawal, 2017; Saunders, 2010; Supplementary information III & V). In those areas where farmers see little future for themselves and their families, there is a clear and present danger that total agriculture production will fall, food security will be compromised, and dependence on imported food will increase. Thus, low labour productivity is a driver of poverty, reduced food production and greater dependence on imported foods. This paper addresses steps required to rethink labour productivity in a context appropriate to better support farmers throughout the Global South.

2. Low labour productivity in the Global South

We begin with the question of whether labour productivity is as low as often reported. It has been suggested that labour productivity is underestimated due to overestimates of time spent on farm work (Christiaensen and Todo, 2014; Fuglie et al., 2019). However, even considering the possible underestimates, farm labour productivity in the poorest countries is at least an order of magnitude less than that of the

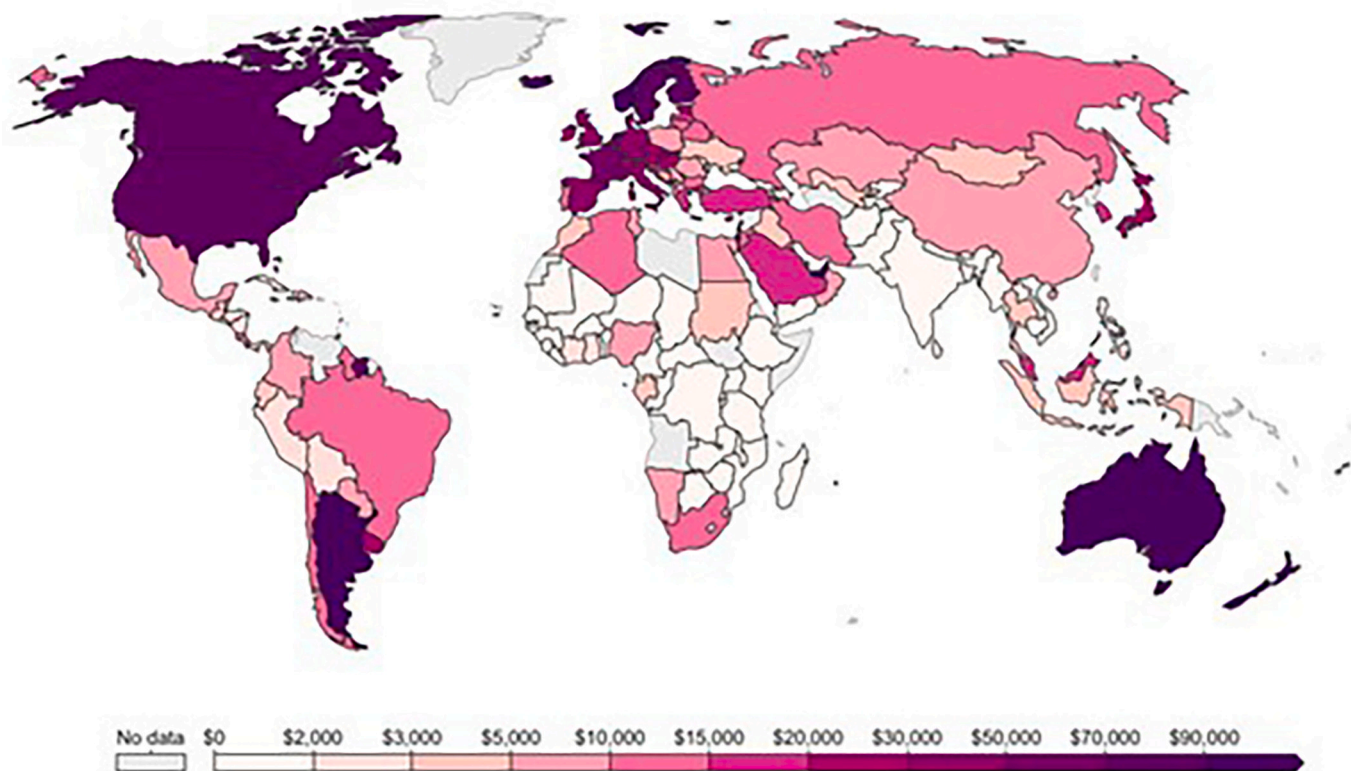


Fig. 1. Labour productivity in 2017 (value added constant 2010 US\$). Original data source World Bank. Map generated in Our World in Data. For dynamic representation from 1991 to 2017 see <https://ourworldindata.org/grapher/agriculture-value-added-per-worker-wdi?time=2017>

richest countries (see Fig. 1).

There is certainly a dearth of labour productivity enhancing technology and related interventions appropriate for the crops and cropping system of the Global South. There are, however, examples of labour productivity improvements in larger more industrialised countries such as China, Brazil, India and South Africa. These countries will likely become an increasing source of context appropriate interventions via South-South exchange of technology and labour productivity innovation. Despite this, lack of skills and capital may reduce farmers' capacity to adopt technologies that might improve labour productivity (Supplementary information VI).

Two contrasting explanations of why labour productivity remains low include the tendency for low biological yields and low value of products in the Global South. While increased yields tend to increase labour productivity this is not a universal truth (Craig et al., 1997; Supplementary Information VII). Wherever rice, wheat, and maize are grown their value is similar in a globalized world: the labour productivity of the top decile countries in income distribution for these crops was 60-fold greater than the lowest decile, whilst yields were only 2–3-fold greater (Gollin et al., 2014). This indicates that labour productivities are inherently low in the low-income countries and are not directly related to either low yields or low value products.

The single factor that best explains the differences between labour productivity of countries and over time is the GDP of the country (deduced from Our World in Data Agriculture value added per worker vs. GDP per capita, 1991 to 2017 (<http://ourworldindata.org>). Farming sustains the livelihoods of a substantial proportion of the population in many countries in the Global South, with the highest proportions generally in the poorer countries. Earnings from farm work will reflect the labour productivity with farmers only working or employing others to work if their labour productivity is sufficiently high to defray labour costs. Thus, faced with declining prices of basic staples and commodities, those who work on farms that produce them will inexorably face declining incomes and less job opportunities unless they are able to increase their labour productivity. This dire prediction is at its worst in the poorest countries of the Global South.

3. Technology and related interventions that could increase labour productivity in the Global South

An array of technologies and interventions exist to improve labour productivity, but they are still largely confined to the Global North or the larger scale farming operations in the Global South. Nevertheless, many of these approaches could be adapted for use in the Global South and coupled with novel value chains and partnerships could augment labour productivity. These opportunities are briefly described:

- (i) **Mechanization, robots and digital technologies.** Currently, under modern mechanized agriculture 2–5 h of farm labour produce the food consumed by a person in a year, whereas non-mechanized systems require approximately 200 times more labour (Ibarrola-Rivas et al., 2016). These massive differences suggest that there are large opportunities for increased labour productivity through mechanization, automation, and use of digital technologies.
- (ii) **Weed Control.** Notwithstanding the environmental concerns, chemical weed control is a crucial pillar of labour productivity: it has spread rapidly in industrialised countries but is still not widespread in many parts of the Global South (Hossain, 2015). The supply of herbicide resistant varieties and highly targeted use of quality agrochemicals in a socially responsible manner that obviates potential negative effects on farmer and environmental health could greatly increase labour productivity. Furthermore, there are exciting new options for automatized control with robots, but some question whether farmers will gain access to these technologies, particularly given that these are capital-intensive

technologies. However, others are optimistic about the future use of robots and other advance technologies in the Global South (Schlogl and Sumner, 2018; Lowenberg-DeBoer et al., 2020).

- (iii) **Agronomic practices.** Agronomic practices can increase labour productivity although they do not necessarily increase yield. Historically, the development of the seed drill was “a stratagem to circumvent an unruly labour force” through increased labour productivity mediated by horse drawn hoeing with near or equivalent yields to traditional systems (Sayre, 2010). As today, there was opposition to labour-saving devices: the seed drill threatened the existence of not just labourers but of yeoman and small tenant farmers (Sayre, 2010). Reduced or minimum tillage frequently produces no gain in yield. However, it increases labour productivity, and, as an added benefit reduces soil erosion and increases soil organic matter (Ekboir, 2003). Transplanting of rice is extremely labour intensive and is increasingly being replaced by direct seeding (Kumar and Ladha, 2011). Despite these opportunities, the agronomic emphasis in poorer countries focusses on closing the yield gap with scant attention to labour productivity.
- (iv) **Crop traits.** Inherent plant traits are rarely discussed in terms of labour productivity. However, they are important. Monogerm seed revolutionized the sugar beet industry reducing labour costs (Harveson, 2015) and, as one of us can attest, ended the mind-numbing drudgery of chopping out beet! Plant breeders could beneficially include labour productivity in their selection criteria (Kholova et al. (2021); Supplementary Information VIII).
- (v) **Yields.** Higher yield per se often increases labour productivity. For example, harvesting is extremely labour intensive in oil palm (Euler et al., 2016) as harvesters walk through the fields at regular intervals identifying and harvesting only the ripe fresh fruit bunches (FFB). As yields increase the time spent searching for bunches relative to the time harvesting them decreases with a consequent increase in labour productivity. Given the vast amount of research addressing improved yield, we do not elaborate here. However, we do suggest that agronomists pay more attention to the potential to increase labour productivity through increased yield.
- (vi) **High value products.** For the small farmers, with limited land area, an attractive means to increase output, in monetary terms, is participation in value chains associated with higher value crops (Muyanga and Jayne, 2014; Supplementary Information IX). We include livestock in high value farm products; unlike most agricultural development programs many livestock programmes in the lower-income countries emphasise income generation (Randolph et al., 2007; Supplementary Information X).

4. Rural prosperity and a well-fed world

In the euphoria of the green revolution, production research was often seen as the mainstay of agricultural development with the maxim “to feed this world” (Wortman and Cummings Jr, 1978). The focus has shifted towards “a well-fed world” with emphasis on both more food and more nutritious food. The tacit role of farming is to ensure “a better fed world” and to act as an employment reserve rather than as a driver of rural prosperity. Policies still envisage the road to the modern world paved with cheap food (Moore, 2010). Nevertheless, it is necessary to consider rural livelihoods. As pointed out by Davis et al. (2022), unless livelihoods are incorporated into approaches to transform food systems there is a major risk of achieving environmental and nutritional objectives on the backs of the rural poor. National leaders seem to be aware of this, especially in Africa, with major directives to improve labour productivity in the policy dialogue (African Union, 2014; Jayne et al., 2021; <https://www.un.org/osaa/> accessed 2020). Despite these directives, agricultural research and development policies and initiatives in the South still focus on increased yields of the staple food crops with

minimal consideration of labour productivity.

Induced innovation is the process in which a change in relative prices of the production factors spurs invention of specific technologies. In the richer countries, labour-saving technology has largely been developed by the private sector through induced innovation (Hayami and Ruttan, 1971). However, only 5% of global private R&D takes place within the developing countries (Alston et al., 2009a). This limits their capacity to develop appropriate labour productivity enhancing opportunities. Hence, there is an urgent need for policies that focus on inclusive innovation systems that improve local labour productivity. Furthermore, soft infrastructure, including universities, research centres, secondary and tertiary education facilities, and an industrial base that are necessary to foster and sustain induced innovation (Terluin, 2003) are lacking, especially for women and in the smaller and poorer countries. Hence, even if there is an induced demand for innovations that increase labour productivity, the capacity to answer the demand is fragile in much of the developing world (Supplementary Information XII).

5. What is needed to improve labour productivity?

The first step on the road to increased labour productivity is the recognition of its importance as a driver of inclusive agricultural transformation. A fundamental policy change is needed to emphasise inclusive rural prosperity per se, rather than seeing the rural population as a residual source of cheap labour that produces cheap food.

These policy changes should be reflected in programmes that support labour productivity improving technologies and interventions. Within this framework, labour productivity of women should be emphasised as it is frequently much lower than that of men in farming (see for example: Palacios-López and López, 2015). Changes will require more and refocused research and development with an emphasis on the distinct contexts of the Global South, improved hard and soft infrastructure, an industrial base to facilitate greater endogenous development, and the establishment of value chains for a diverse range of higher value products. Endogenous development is preferred as it provides solutions adapted to local circumstances and fosters local industries and services. These local services and industries will not only support agriculture but will also contribute to increased local employment and acquisition of new skills, defraying to some extent loss of employment that results from increased labour productivity.

The need to increase labour productivity is most urgent in the poorest countries of the Global South where many people depend on the land and land holdings are small. In these instances, a shift to higher value products is surely the most effective means to increase labour productivity and improve rural welfare (Supplementary Information IX). Research and development efforts to link the small farm to both local and international markets is essential (Jayne et al., 2010). These linkages include organizational arrangements, such as cooperatives, availability of capital and inputs, and overall infrastructure along the supply chain (see for example Hellin et al., 2009; BIRTHAL et al., 2012).

A shift to high value crops has implications for production of staples. Efficient production of staples is a critical pillar of food security in the Global South. Widespread increases in both land and labour productivity on the larger holdings can contribute to overall food security and at the same time release labour and capital from staple crop production to produce higher value crops (Jayne et al., 2010). Thus, we suggest international and national agencies should pay greater attention to high value crops which are currently neglected (Supplementary Information XI). The greater emphasis on high value crops should go hand in hand with increased land and labour productivity of the basic food crops with policies supporting improvements in both, rather than one at the expense of the other.

A source of contention around improvements in labour productivity is that such improvements will lead to less employment on farm. Such concerns must be nuanced, as the total value of production per unit land area with high value crops can provide more gainful and rewarding on-

farm employment per unit land area than staples while providing job opportunities throughout the value chain, extending beyond the rural sector (Christiaensen et al., 2021). Some may pessimistically argue that if small scale farmers move into higher value crops, they will once again be on the treadmill of declining prices. This seems unlikely as the price of specialty crops, including vegetables and fruits, has only declined by 5.3% from 1949 to 2004 (Alston et al., 2009a, 2009b). Furthermore, there are many examples that indicate it is possible to continually differentiate products and maintain the high value status.

Any intervention used to increase labour productivity and improve rural livelihoods must be considered within the context of the local food system and should not be implemented in isolation. For technology to be adopted and have the desired impact, a series of innovation-related components must come together in a “perfect storm” (Clarke et al., 2018; see XII Perfect Storm). The World Bank (2006) was early to recognize that to foster development innovation systems must embrace not only research organizations, but the also the multiple interactions among actors involved in innovation. An inclusive innovation systems approach that is accompanied by improvements in both hard and soft infrastructures is necessary to foment the “perfect storms” that lead to increased labour productivity, of both women and men, and to foster inclusive agricultural development which redresses the rural-urban balance (IFAD, 2022).

In this communication we do not attempt to provide prescriptive details for policy components that need to be adopted to leverage increased labour productivity to provide farmers and farm laborers with greater prosperity. We simply point out that current policies stress cheap food for the urban masses while themes addressing the welfare of farmers and their workers are largely a sidebar in the global agricultural research for development agenda. Unhappy, farmers, irrespective of their gender, are unlikely to fulfil the policy functions tacitly assigned to them by policy makers and development agencies. International support and public sector investment beyond simply addressing technological issues kept rice farmers happy in the green revolution (Supplementary Information XIII and XI): similar multifaceted aid and assistance must be directed towards labour productivity.

We realize that fostering a happy rural population and improving their welfare includes many components above and beyond increasing income. The “living wage” concept tackles this head-on and focuses on the monetary value a household would need to live decently irrespective of whether it is in the physical form of food, labour or money (van de Ven et al., 2021). The living wage concept is likely to account for more much of the hidden work done by women, which is often not considered in estimates of labour productivity. Given little information is available on the elements suggested for the living wage and as monetary income represents a clear, albeit incomplete, gauge of farmer wellbeing, we use it as the starting point for dialogue. Future analysis should incorporate the living wage concept and other elements including health, drudgery, and general job satisfaction.

6. Final reflection

Since 1700, mass poverty reduction is largely associated with increased income due to higher productivity on small family farms (Lipton, 2003). We will surely be criticized for promoting increased labour productivity that leads to less employment and the demise of the small farmer. However, if small farmers move into higher value crops and adopt labour productivity improving technology, then history can repeat itself with greater income for skilled farm workers, farmers, and those involved in increasingly sophisticated off farm aspects of agri-food systems. We expect less drudgery, more rewarding work, and greater job satisfaction in ancillary support services along the supply chain, offering opportunities for meaningful rural employment especially for women. For this to occur, support for small farmers will have to shift to value chains and those who farm will need to employ context appropriate technologies that maximise labour productivity. This will also require

strong policy support for education and knowledge generation, particularly in the more remote, rural regions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.agssystem.2022.103452>.

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