



# Dramatically increased accessibility and decreased cost-per-person impacts are needed for scaling IPM in Africa

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While traditional scaling for integrated pest management (IPM) in Africa requires the movement of expert trainers from village to village, these efforts are often costly, time-inefficient, hampered by distance, and became impossible under COVID-19's movement restrictions (despite tremendously increased public need for IPM-scaling knowledge). One solution to this dilemma is IPM-scaling, usable by a diversity of development actors expending limited or few resources, to deliver critical information to large numbers of people with systems-approach information and communication technologies. This paper describes one such systems-approach scaling platform, Scientific Animations Without Borders, which effectively elicited end-user solution-adoption and decreased unit costs over increasing scales in three African countries during COVID-19. How to scale game-changing IPM insights 'off the shelf' and 'into people's hands in the field' is also discussed.

## Addresses

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## Introduction

While agricultural productivity in Africa must be able to feed its current and future populations [1], most African governments and international development partners agree that this will require sustainable intensification of agriculture [2–4••]. However, biotic risks (including insect pests and diseases) are some of the most serious threats to agricultural intensification (e.g. rice-cropping systems during the Green Revolution in Asia [5]). In Africa, agricultural insect pests are already causing 60% yield losses and encouraging the use of harmful synthetic pesticides [6•].

While integrated pest management (IPM) can potentially curb pesticide misuse, it also suffers from significant logistical limitations [7••,8•]. Realizing IPM's promise for low-resource farmers requires information campaigns to support behavior change, locally sourcing materials/items, using plant extracts, and selective use of second-generation pesticides (or a combination thereof) [8•–10••]. Such approaches increase crop yields and incomes while reducing farmer costs and impacts on their health and environment [10••,11].

However, many African farmers are often primarily fluent in local languages only (or are low-literate learners in national languages) [8•,12] and in remote areas infrequently visited where traditional/government-extension agents. The higher costs and lower accessibility of these issues limit the reach of new IPM-knowledge solutions to lower-resource farmers in Africa [13]. Consequently, shortfalls of farmer knowledge about synthetic pesticide dangers still require better information campaigns to mitigate or eliminate those dangers [6•,8•,9,14,15].

## Game-changing ideas

The above motivates this paper's proposal to dramatically increase farmer accessibility to IPM agricultural-intensification information while decreasing the costs of delivery. However, scalability is defined or measured [16–18], it always must address the increasing costs for extending an intervention's reach [19–21]. Fortunately, the history of science provides an exemplar of this paper's proposal.

In 1953, Watson and Crick released their game-changing idea of DNA as the basis for heredity. With decades of other innovations to follow (e.g. Sanger's sequencing of genetic materials, Polymerase Chain Reaction (PCR) technologies), the largest impacts from this game-changing idea were most felt (among scientists and the general public) with the advent of genomics [22]. Two main drivers of the genomics revolution included (1) exponential decreases in the costs of sequencing genetic materials (and the supporting technologies) and (2) exponential increases in sequencing speed [22] (including 'big data' advancements using artificial intelligence [23]).

More generally, a productive potential becomes better realized when dramatically lower-cost, more accessible technologies and infrastructures to support productivity emerge — for example, steam engines and the telegraph for the Industrial Revolution [24], or now-ubiquitous, comparatively low-cost mobile phones and Internet in the Information Age [25•,26]. Over the past half-century, many stakeholders — including national agricultural research programs, Consultative Group for International Agricultural Research (CGIAR) centers, universities, nongovernmental organizations (NGOs), and individual change agents — have joined forces with international development agencies to research, develop, and distribute game-changing ideas for transforming the lives of socioeconomically marginalized people, particularly in Africa [27–29]. While these efforts were not always successful and sometimes had adverse social outcomes [30–33•], from a technical standpoint, too many of these game-changing IPM innovations (which easily could have been applied at little to no cost) 'languished on the shelf' without reaching those beneficiaries. Of the innovations disseminated, only a handful have been scaled to their maximum reach [34].

#### **Additional challenges: COVID-19, climate change**

Accordingly, dramatically increased informational access at dramatically decreased cost-per-person delivery is needed. While information and communication technologies (ICTs) represent a potential pathway for such delivery, game-changing support emerged recently, when cellphones became the primary digital-access device globally (and in Africa specifically by mid-2017) [25•]. Against too much enthusiasm for this promise — and with due caveats for culturally different uses of cellphones, especially between men and women [35–39••]— COVID-19 has radically set back progress and exposed many knowledge and work gaps even for international development stakeholders [40,41].

Food security especially has been hard-hit. During COVID-19, some humanitarian efforts ground to a halt (even after the lifting of movement restrictions) [42•,43], others have dramatically shifted prioritization of limited

resources [44,45]. Aid earmarked for food security and other Sustainable Development Goals (SDG) goals was redirected to emergency pandemic relief [45,46], while farmers who leveraged agricultural-intensification improvements found that they could not take their increased yields to markets (due to curfews and movement restrictions) [47,48]. In this context, improved IPM postharvest-storage innovations became a critical input for supporting food security during the still-ongoing pandemic [49].

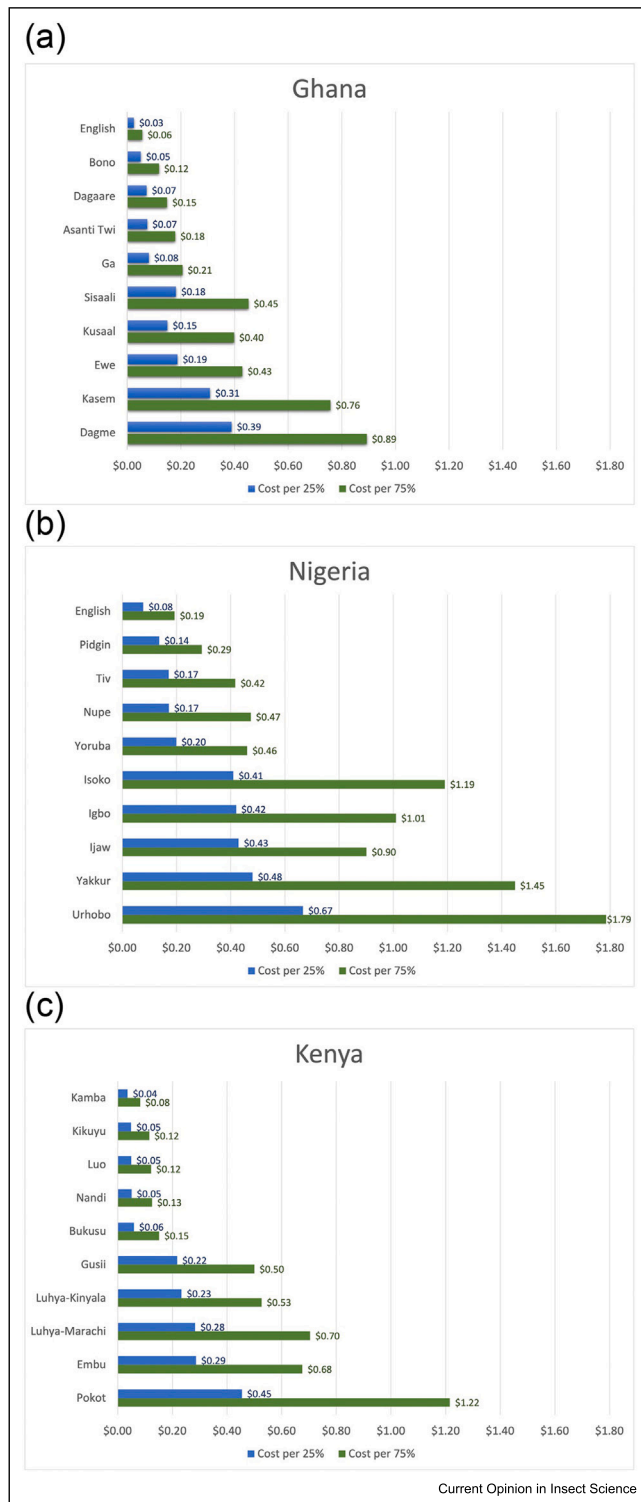
In general, these impacts prompt a rethink around how development work will achieve food security going forward [50,51]. Curfewed mobility among global development stakeholders during peak-COVID-19 exposed cracks in traditional work methods for large development organizations [42•,46,50,52,53]. Climate change as well makes traditional travel (for face-to-face work) problematic and contributed to vastly increased use of remote technologies (such as WhatsApp and Zoom), undermining the conventional rationale for in-person interactions and introducing new technological problems and stressors [54]. Taken in total, these many changes invite reconsideration of "digital" international development work and work products generally.

#### **Systems approaches are needed for scaling integrated pest management information**

Game-changing moments rarely occur only through increased donor spending — especially now, given the massive diversion of funds to mitigate COVID-19 [55] — and more typically by reconfiguring the social realities that afford them (for the present paper, a radically increased information accessibility at reduced per-unit costs). Over the last decade — which crosses the 2015–2017 tipping point when cellphones became the primary digital-access device type [25•], globally — efforts have focused on developing global systems approaches for informal education that leverage digital accessibility for IPM messaging. One such systems approach is Scientific Animations Without Borders (SAWBO) (described below), whose educational videos have demonstrated mass-scaled accessibility and solution adopt at reduced-cost scalability.

At a time when digital solutions still face rural infrastructure obstacles (even in the third wealthiest country in Africa, South Africa) [56,57], mobile phones have a capacity to overcome those limitations [58] even without electricity (if solar recharging stations are available). As part of the effort to leverage this capacity, SAWBO embeds scientifically grounded research for development innovations produced by others in an educational animation format then useable by anyone for scalable training (including on IPM topics). Importantly, SAWBO does not independently produce and deploy

Figure 1



YouTube GoogleAd campaigns for jerrican videos across (a) Ghana, (b) Nigeria, and (c) Kenya. The average costs to have one person watch 25% (exposure to the problem and solution) and 75% (majority of content of the video minus end credits) of the video. Note that only the five most and five least cost-effective campaigns are shown for each country, in order to show the range of costs across languages.

animated video content but produces it (on demand, when funded) toward whatever use or implementation the video commissioner desires.

From SAWBO's inception in 2011 through 2019, these educational animations (covering more than 140 topic areas translated into more than 280 languages and dialects) have reached at least 50 million people through numerous ICT channels. Besides any use of these animations by those who commissioned them, all videos are freely available on a systems platform for anyone to download and utilize for educational purposes.

These same animations have also been used as research tools for determining the potential for cost-effective IPM-scaling using ICTs across a multiplicity of languages, literacy levels, and cultures. Recent research (much of it focused on IPM specifically) has empirically demonstrated the multicultural acceptability of these linguistically adapted educational animations [59,60], greater learning gains and knowledge transfer compared with traditional extension teaching [61,62], high solution uptake, adoption [63,64], and behavior change in communities [65–67], as well as local add-on innovations [68]. Demonstrable advantages arising from this comprehensive (systems) framework approach have included high learning gain scores [61,69], an 89% solution-adoption rate (measured at a two-year follow-up) for an improved postharvest bean-storage IPM strategy [63], and promotion of local adaptations of innovations [38,65]. To the authors' knowledge, direct investigations of the research construct of *IPM-scaling using ICTs in Africa* are virtually nonexistent outside of SAWBO (based on our literature review of this research construct). This paucity of research echoes the literature review by Sartas et al. [70] that found no comprehensive framework for R4D scaling practices [82].

Nevertheless, genuinely new innovations rarely appear *ex nihilo* but involve a novel (re)configuration of existing materials and techniques. As antecedents to integrated pest control (IPC)-scaling using ICTs in Africa, for example, animated educational video has engaged [71–73] and locally translated [58,73–75] ICT-deliverable educational content [38,76–78] archived through App-available or online digital repositories [12,79,80]. Placing this research under a comprehensive framework makes the next (game-changing) step forward visible for further research and works to dramatically increase access while *decreasing* the unit costs per person impacted.

#### A need to explore strategies for mass-scaling of integrated pest management videos

Mocumbe [81] documents a multiyear USAID-funded study in Gurùè District, Mozambique, that identified a critical gap (and developed an 8-step animated educational IPM video) for improved postharvest food security

storage using locally available jerricans [82]. Developed initially with expert input from stored-product entomologists and local community focal groups, pre- and postintervention learning gain studies then documented high knowledge-retention and solution-adoption at two-year follow-up [63,65].

The increased stress placed on global food security by COVID-19 [83] mandates these types of improved postharvest storage [84]. Accordingly, USAID committed to a one-year investment in SAWBO *RAPID* (described below), which focused on decreasing the delivery costs for animated video education while dramatically increasing the scalability of that knowledge in four countries (Ghana, Nigeria, Kenya, and Bangladesh). As one component of this USAID program, SAWBO *RAPID* translated an animation into an additional 100 languages (spoken in the four countries), which USAID then disseminated using YouTube GoogleAds in Ghana, Nigeria, and Kenya, WhatsApp networks in Kenya, and national TV stations in Nigeria and Kenya, reaching more than 10 million people. Because the visuals for the animation used already existed, the scalability costs for these 100 language variants only required generating a new translation and re-overdubbing it onto the video.

For brevity, we report in this article only on scalability costs for the video in Ghana, Nigeria, and Kenya. While pushing videos across countries as part of YouTube advertisements is a rapid way to scale such content, Figure 1 (below) summarizes the reach-costs for those campaigns (across the numerous language used). This provides proof-of-concept for increased scaling at decreasing costs, however, AI optimization for delivery should further decrease these costs. For example, viewership can be increased by preselecting the most appropriate regional-language variant and adjusting campaign spending to capture system fluctuations (e.g. changes in content interests over time).

Besides YouTube pushes, a Kenyan NGO, Kataru Concepts, used WhatsApp networks to deliver content to all 47 of Kenya's counties. By enabling local actors to use their phones to show content to those without phones, this also afforded a decreasing-cost approach for scaling. In particular, network participants could share relevant language variants and videos, which local deployers could further select for their various target audiences.

## Conclusion

Impacts from COVID-19, emergent food-shortage crises, supply-chain disruptions, and climate-change issues make scaling food-security IPM solutions in Africa an urgent need. As farmers are empowered and benefit from pest-control knowledge, using tools and solutions

that are practical and economically viable, delivery of such IPM information in a scalably cost-effective manner, at the right time and place, and in the language of local target populations, better assures solution-adoption and the movement of game-changing IPM ideas 'off the shelf' and 'into people's hands'. Looming climate impacts, potential future pandemics, and as-yet unforeseeable globally disruptive events no longer afford letting life-saving ideas not reach those who would benefit from them — especially when the game-changing capacities of digital education on cellphones are widely available.

## Conflict of interest statement

N. Peter Reeves is the owner of Sumaq Life LLC. Otherwise, the authors declare no conflicts of interest in the production of this work.

## Data Availability

No data were used for the research described in the article.

## Acknowledgements

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## References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
  - of outstanding interest
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  3. Grzebisz W, Łukowiak R: **Nitrogen gap amelioration is a core for sustainable intensification of agriculture—a concept**. *Agronomy* 2021, **11**:1-23.
  4. Kuyah S, et al.: **Innovative agronomic practices for sustainable intensification in sub-Saharan Africa. A review**. *Agron Sustain Dev* 2021, **41**:1-21.

This study reviews some of the currently most promising sustainable intensification approaches (for agriculture in Africa). These approaches significantly and empirically contribute to the socioeconomic pillars of sustainability (sustainably increased crop production) without compromising the environmental pillar. These approaches include cereal-legume doubling up and intercropping, conservation agriculture, improved crop yields through simultaneous agroforestry practices, the use of planting basins, micro-dosing with fertilizer and manure, and push-pull approaches (using silverleaf or greenleaf desmodium with Napier grass or brachiaria to control pests). Despite empirical successes

with push-pull, the expense of desmodium seeds and a lack of farmer information limit the reach of this very successful technique. This again points to a need for successful message campaigning to farmers.

5. Pimentel D: **Green revolution agriculture and chemical hazards.** *Sci Total Environ* 1996, **188**:S86-S98.

6. Sarkar S, et al.: **The use of Pesticides in Developing Countries and their Impact on Health and the Right to Food.** European Union; 2021.

This study is significant for its discussion of 'rationales' for continuing to export synthetic pesticides prohibited in Europe to developing nations. In particular, this links to the change of attitude called for in the 'decolonization' recommended by Murrey & Jackson (2020) and the broader critique of eurocentrism in Oloruntoba (2020). It is characteristic of colonialism to prohibit locally what one practices abroad, and the export of banned pesticides is a good exemplar. The institutional recommends here must stand against already existing institutions that certain stakeholders are ignoring.

7. Deguine J, Ferron P, Russell D: **Integrated pest management: good intentions, hard realities. A review.** *Agron Sustain Dev* 2021, **41**:38.

This study historically surveys the discourse and implementation of IPM presuppositions, practices, and approaches. A major criticism raised is that despite decades of efforts to curtail synthetic pesticide use, it not only remains the norm in most places, considerable efforts have also been made to 'spin' IPM in favor of synthetic pesticides (including no consensus on definitions, permissible practices, and so forth). Outside of industry and institutional inertia, entrenched in existing (synthetic) pesticide interests, the authors highlight that farmers do not engage IPM practices in part due to a lack of basic understanding behind more environmentally sustainable ecological principles and rationales. This again underscores the critical need for dramatically scalable information campaign approaches with minimal costs for delivery.

8. Wyckhuys K, et al.: **Ecological illiteracy can deepen farmers' pesticide dependency.** *Environ Res Lett* 2019, **14**:093004.

This study examines the impacts of farmer illiteracy (or simply a general lack of information) about the dangers and consequences of synthetic pesticides. The key finding that a lack of pesticide knowledge can deepen farmer dependency on synthetic pesticides is an important one but relatively narrow in scope. Self-evidently, (bi-directional) information campaigns can help to close this gap. Still, researchers must treat referring to farmers as 'illiterate' with care since most are quite fluent in their mother-tongues, which may or may not have print-versions in the first place. It is questionable whether an inability to read warning labels in a language one has never learned to read deserves to be framed as a problem of 'illiteracy'; it is equally an industry problem that fails to place warnings in languages that people can understand. This article correctly emphasizes that ineffective communications (whether due to poor labeling or a lack of educational access to languages that the warning labels are printed in) must be overcome by more effective communications generally.

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10. Gwada RO, Bett HK, Sibiko KW: **Effect of integrated pest management technology on the livelihoods of small-scale maize producers.** *Rev Agric Appl Econ* 2021, **14**:37-55.

This study examines the impacts and factors encouraging farmer use of push-pull (IPM) technologies (PPT) among maize producers in Homa Bay County, Kenya. Age, land tenure and total land owned, perception of pest severity positively associated with PPT adoption, as did level of education, with a recommendation by the authors for increased literacy development. This reprises, but with granular specifics, the through-line of a need for information campaigns for international development projects generally, but specifically for any effort to dramatically scale-up distribution while driving down costs.

11. Clausen AS, et al.: **Effect of integrated pest management training on Ugandan small-scale farmers.** *Environ Health Insights* 2017, **11**:1178630217703391.

12. Bello-Bravo J, et al.: **A case study of social-technical systems approaches and education video animations (health care/ international).** In *Systems Thinking for Instructional Designers: Catalyzing Organizational Change*. Edited by Bond MA, et al.. Routledge; 2021:159-169.

13. Waddington H, White H: **Farmer Field Schools: From Agricultural Extension to Adult Education (3IE Systematic Review Summary 1).** International Initiative for Impact Evaluation; 2014.

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23. Valuates Reports: **Precision medicine market size to reach USD 206320 Million by 2027 at a CAGR of 9.6%.** 2022 25 May 2022; Available from: (<https://www.prnewswire.com/news-releases/precision-medicine-market-size-to-reach-usd-206320-million-by-2027-at-a-cagr-of-9-6-valuates-reports-301418467.html>).

24. Williams R: **Television and Cultural Form.** Schocken; 1974.

25. Bello-Bravo J, et al.: **Breaking out: the turning point in learning using mobile technology.** *Heliyon* 2021, **7**:e06595.

This study marks the historically significant moment, per each global region between 2015 and 2017, when mobile phones surpassed all other digital information access devices. Globally (and particularly in Africa, which was the first region to pass this tipping point), this means that to reach the widest demographics possible worldwide, mobile telephones are the most likely and technologically familiar form of digital access for a majority of ICT-enabled populations.

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32. Murrey A, Jackson NA: **A decolonial critique of the racialized "Localwashing" of extraction in Central Africa.** *Ann Am Assoc Geogr* 2020, **110**:917-940.

This study examines the ways that the discourse around international development functions to create problems (or undermine) development goals. The issues undertaken by development (including the distribution of IPM strategies) are not 'technical only' (even when treated as such). Against every 'progressive' effort to being genuine solutions to Africa, 'regressive' actors are looking for workarounds or ways simply to ignore such efforts to maintain a status quo now recognized as unsustainable. While this article presents a very high-level critique of industry efforts, it exemplifies the need for a change in attitude and stance by those who genuinely seek to bring solutions to Africa.

33. Oloruntoba SO: **The politics of paternalism and implications of global governance on Africa: a critique of the sustainable development goals.** In *Pan Africanism, Regional Integration and Development in Africa*. Edited by Oloruntoba SO. Springer; 2020:165-179.

This study echoes and expands Murrey & Jackson (2020), as a critique of certain kinds of international development activity in Africa, especially with regard to attaining the SDGs. While Murrey & Jackson (2020) describe ways that elites and nonlocal actors control local discourse through proxies, Oloruntoba is here emphasizing how local voices and values are not being attended to. Solutions are being 'given' to people rather than developed in collaboration with and this results in project failures, irrelevance, or even socioeconomic and ecological harm. This again points to a need for a change in attitude or stance by international development actors toward those it seeks to help. Sometimes local actors truly are unaware 'of the issues' but this is true of international 'experts' as well. This underscores how Education for Sustainable development is bi-directional, such that all stakeholders are at times teachers and at other times learners.

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This study examines patterns of differential mobile phone use among male and female youth, and especially how mobile phones impact female social activity. It powerfully demonstrates that mobile phone technology is not 'gender neutral'. For example, among the women participants, there was little evidence that mobile phones were empowering or productive for positive transformative change. This issue is not that mobile phones do not work for women but that they do work, in ways different than for men, and with consequences potentially opposite of empowerment and positive transformative change for men. This demonstration that technology is not gender neutral is a very strong corrective to assume otherwise. Given the need to extend IPM awareness and solution-adoption to all farmers in Africa, regardless of gender, the mobile phone is well-positioned as a teaching device, but extending its benefits post-teaching requires further built-in affordances to that teaching.

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Although this report specifically draws on data from Colombia, Myanmar, Nigeria, South Sudan, and Yemen, it outlines elements of the change in attitude or stance that (1) COVID19 has brought to the fore, and (2) emphasized in other studies in this note, especially Murrey & Jackson (2020) and Oloruntoba (2020). While restrictions on travel due to COVID19 made it factually impossible for humanitarian stakeholders to intervene (or continue to intervene), other macroscale economic reversals (decreased budgeting or capacity for international aid) also closed the gates of assistance in ways not consistent with the Grand Bargain of the 2016 World Humanitarian Summit. As such, the shift toward local actors as primary is a result of pandemic logistics but also not following through on the Grand Bargain. Recommendations relevant to this change in stance or attitude include revisiting the standard humanitarian response, recommitting to the Grand Bargain with tangible system-wide steps for addressing inequalities across international and local service providers (especially by poetizing the needs of the most vulnerable), improving the provision of equitable duty of care or 'occupational safety and health' for all personnel, regardless of nationality or contract status, prioritizing protection activities related to sexual and gender-based violence, building a coherent, multiscale approach to risk (for all stakeholders, not just providers), looking for opportunities in crisis (without benefiting from the crisis), and investing more in information campaigns. As already noted, such information (learning) campaigns must be bi-directional, such that the role of teacher and learner can switch. Failing this will help to reproduce the status quo and reprise objections raised by Murrey & Jackson (2020), Oloruntoba (2020), and Deguine et al (2021).

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