

Are We Ready for 3D Printing? Additive Manufacturing and Food Security in Africa

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ABSTRACT

Africa faces a deepening food security crisis driven by climate change, armed conflict, economic fragility and global shocks. More than one in five Africans experienced hunger in 2024, and the continent is projected to host most of the world's undernourished people by 2030. Three-dimensional (3D) printing is often presented as a Fourth Industrial Revolution answer to this crisis, yet claims about its promise rarely ask whether African food systems are ready to absorb it. This paper asks how ready African food systems are to adopt 3D printing in response to food insecurity driven by escalating human security threats. It combines a structured review of literature published between 2010 and 2025 with six semi-structured interviews with experts in agricultural economics, food science, law, public policy, development practice and technology. It develops a readiness framework drawn from the UNCTAD Frontier Technology Readiness Index and the technology, organisation and environment model, and applies it across six dimensions. The analysis distinguishes between two technologies that the literature often conflates, namely 3D food printing and 3D printing of agricultural hardware, such as spare parts, tools, and sensors. The paper finds that Africa is largely unready for 3D food printing, which remains costly, small-scale, weakly regulated, and culturally contested. Readiness for printing agricultural hardware is uneven but real, anchored in South African industrial capacity and a growing network of fab labs and social enterprises. The paper argues that 3D printing is a partial tool for resilience rather than a solution to hunger, and that policy should prioritise distributed hardware production over printed food.

Keywords: 3D printing, additive manufacturing, food security, human security, technology readiness, Africa, smallholder agriculture.

INTRODUCTION

Food security remains one of the most pressing challenges facing Africa. The continent now carries the heaviest burden of hunger in the world. More than 20 per cent of Africa's population, about 307 million people, faced hunger in 2024, and almost 60 per cent of the 512 million people projected to be chronically undernourished in 2030 are expected to live in Africa (FAO et al., 2025). Child undernutrition is equally severe. A pooled analysis of survey data from 35 sub-Saharan African countries estimated that about 35 per cent of children aged 6 to 59 months were stunted (Takele et al., 2022). The COVID-19 pandemic deepened these patterns, pushing more African children into hunger through lost incomes and disrupted food supply (Aborode et al., 2021).

These figures leave Africa far from achieving Sustainable Development Goal 2, which commits to ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture by 2030 (United Nations, 2015). They also sit uneasily with the African Union's Agenda 2063, which envisions African citizens who are healthy and well nourished (African Union Commission, 2015). Population growth adds pressure. Africa's population is projected to reach about 2.5 billion by 2050 (United Nations Department of Economic and Social Affairs, 2022), and a young and urbanising population will demand more food and more diverse diets.

Food insecurity in Africa is not only a problem of production. It is bound up with a wider set of human security threats. Conflict disrupts planting, markets and humanitarian access (Delgado et al., 2023). Climate change erodes the productivity of rain-fed farming on which most rural households depend (Pearson & Newman, 2019). Economic fragility and weak governance limit the capacity of states to respond (Wudil et al., 2022). These threats compound one another, so that households exposed to both conflict and climate shocks suffer the steepest losses (Muriuki et al., 2023).

In this context, technologies associated with the Fourth Industrial Revolution are often promoted as a way to leapfrog structural constraints. Three-dimensional (3D) printing, also known as additive manufacturing, is prominent among them. It builds objects layer by layer from digital files and can produce food items, agricultural tools, spare parts and sensors close to where they are needed (Otcu et al., 2019). Advocates suggest that 3D printing could personalise nutrition, upcycle food waste, lower the cost of farm equipment and shorten fragile supply chains (Zhong et al., 2023).

The literature on 3D printing and food security has two weaknesses. Much of it describes technical possibility rather than adoption. Studies of printed foods are dominated by laboratory work in China, the United States, Australia, Europe, and Africa, which contributed only 19 of 800 documents in one global bibliometric review (Fasogbon & Adebo, 2022). The literature also merges two distinct technologies. Printing food and agricultural hardware differ in cost, users, regulation, and social meaning, yet they are frequently discussed as a single solution. Claims that 3D printing could transform African food systems, therefore, rest on thin evidence and blurred categories.

This paper addresses these gaps through a single central research question. How ready are African food systems to adopt 3D printing in response to food insecurity driven by escalating human security threats? The paper answers the question through a readiness framework applied to a structured review of the literature and six expert interviews. It makes two contributions. First, it separates 3D food printing from 3D printing of agricultural hardware and shows that African readiness differs sharply between them. Second, it frames the debate through a human security lens, which asks whether a technology reduces the vulnerability of the people most exposed to hunger, rather than whether it is technically impressive.

CONCEPTUAL FRAMEWORK

Human Security and Food Security

The concept of human security shifted the focus of security from protecting states to protecting people. The United Nations Development Programme framed it as freedom from fear and freedom from want and identified food security as one of its seven components (UNDP, 1994). A human security lens matters in this paper because it focuses on the people who face the greatest risk. A technology that improves food supply for affluent urban consumers may be valuable, but it does little for human security if it does not reach displaced households, smallholder farmers or children at risk of stunting.

Food security is commonly defined as a condition in which all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life (Babu et al., 2014). Four dimensions have long anchored the concept. Availability refers to the physical supply of food through production, trade and stocks. Access refers to the economic and physical ability of households to obtain food, which depends on incomes, prices and market infrastructure. Utilisation refers to the nutritional quality of diets, food safety and the health conditions that shape how the body uses nutrients. Stability refers to the ability of the other three dimensions to hold over time in the face of shocks (Hendriks & Babu, 2024).

The High Level Panel of Experts on Food Security and Nutrition added two further dimensions. Agency refers to the capacity of individuals and communities to make choices about what they eat and how their food is produced. Sustainability refers to food system practices that protect the ability of future generations to meet their own needs (HLPE, 2020). These six dimensions provide a useful test for any technology. A

credible contribution to food security should improve at least one dimension for vulnerable groups without weakening the others.

Technology Readiness

Readiness is the degree to which a society, sector or organisation has the conditions needed to adopt and benefit from a technology. At the national level, UNCTAD's Frontier Technology Readiness Index measures readiness across five building blocks. These are information and communication technology deployment, skills, research and development activity, industrial activity and access to finance (UNCTAD, 2023). The 2023 index covered 166 economies and found that countries in sub-Saharan Africa were among the least ready to use, adopt and adapt frontier technologies (UNCTAD, 2023).

At the organisational level, the technology, organisation and environment model explains adoption through three sets of conditions. These are the characteristics of the technology itself, the resources and structure of the adopting organisation and the external environment of markets, regulation and support institutions (Tornatzky & Fleischer, 1990). The model is useful here because it highlights regulation and social context, which national indices tend to downplay.

This paper combines the two approaches into a framework with six dimensions. The first is infrastructure and energy, covering electricity, connectivity and physical premises. The second is skills and research capacity. The third is the industrial and market base, meaning the firms, workshops and demand that can sustain use. The fourth is finance and cost, covering both capital outlays and running costs. The fifth is regulation, food safety and intellectual property. The sixth is social acceptance, meaning whether users and consumers regard the technology and its products as legitimate. Each dimension is assessed separately for 3D food printing and for 3D printing of agricultural hardware.

Food insecurity in Africa as a human security problem

Climate Change

Most African farming is rain-fed and highly sensitive to shifts in rainfall and temperature. Crop modelling for sub-Saharan Africa projects substantial losses in rain-fed cereal yields under climate change unless farmers adapt planting dates, varieties and inputs (Alimagham et al., 2024). In West Africa, simulations for smallholder systems in Ghana and Senegal show that climate change reduces maize and other cereal yields under a range of future production systems (MacCarthy et al., 2021). In Ethiopia, changes in precipitation and temperature have reduced staple crop yields, with sorghum and barley most affected (Bouteska et al., 2024). In Southern Africa, reduced and more variable rainfall threatens both water resources and agricultural productivity, particularly in the drier western parts of the region (Nhemachena et al., 2020). These trends undermine availability and stability and fall hardest on households with the least capacity to adapt.

Conflict and Political Instability

Conflict damages every dimension of food security. In the Tigray region of Ethiopia, a household survey during the war found that 77.38 per cent of households were food insecure, with many in crisis phases (Araya & Lee, 2024). In Nigeria, conflict-induced food price shocks have reduced calorie intake and dietary diversity (Adekunle et al., 2024). In Burkina Faso, armed conflict has displaced large populations and cut them off from land and markets (Lusiani & Nisadina, 2024). In Ghana, farmer-herder conflicts have reduced crop and livestock production (Otu et al., 2024). Evidence from Ethiopia and Malawi shows that exposure to violent conflict lowers household food consumption scores, and that the effect is larger when conflict coincides with natural shocks (Muriuki et al., 2023). Conflict also disrupts the supply of imported equipment and spare parts, a point that becomes important when the potential of 3D printing is assessed.

Economic and Governance Constraints

Weak and uneven economic growth, high inflation and poor infrastructure limit access to food across sub-

Saharan Africa (Wudil et al., 2022). Cross-country evidence suggests that demographic change drives economic transformation, which in turn shapes the stability of food systems, so that food security policy must address production, trade, population growth and urbanisation together (Guliyev et al., 2024). Governance failures, including corruption and weak implementation capacity, blunt the effect of food security policies (Wudil et al., 2022). A rights-based perspective holds that food insecurity in Africa reflects political choices about resource distribution as much as technical shortfalls (Abubakar, 2023). Smallholder farmers, who produce much of the continent's food, face persistent barriers to access to inputs, equipment, and finance (Langyintuo, 2020).

Global Shocks

Africa's food systems are also exposed to shocks that originate elsewhere. Lockdowns during the COVID-19 pandemic disrupted food supply chains and incomes, increasing food insecurity across the continent (Oluoko-Odingo et al., 2024). The war in Ukraine raised global food and fertiliser prices and exposed the dependence of many African states on imported grain (Hussein & Knol, 2023). A systematic review of the war's effects found that higher prices, inflation and disrupted trade reduced food access for poor households in import-dependent countries (El Bilali & Ben Hassen, 2024). These shocks show that stability, the fourth dimension of food security, is increasingly shaped by global supply chains over which African states have little control. The appeal of 3D printing lies partly in its promise to localise some of that production.

METHODOLOGY

The study used a qualitative design that combined a structured literature review with semi-structured expert interviews. The two components were chosen because evidence on 3D printing in African food systems remains limited. Published studies describe technical possibilities and international experience, while expert interviews provide insight into how those possibilities align with African institutional, economic, and cultural conditions.

The literature review searched Google Scholar, JSTOR and ScienceDirect for academic articles, reports and case studies published between 2010 and 2025. Search strings combined terms for 3D printing and additive manufacturing with terms for food security, food printing, agriculture, spare parts and Africa. Sources were included when they addressed the application of 3D printing to food, agriculture, or manufacturing capacity, or when they provided evidence on the human security drivers of food insecurity in Africa. Priority was given to peer-reviewed studies and to evidence from Africa. Grey literature from United Nations agencies was used for continental statistics and readiness indicators. Studies on 3D printing outside Africa were retained as international reference points where they documented actual use rather than technical potential alone.

Six experts were interviewed. They were purposively selected for their expertise in fields relevant to the adoption of 3D printing in food systems. The participants were an agricultural economist (P1), a food scientist (P2), a legal expert specialising in intellectual property (P3), a public policy expert (P4), a development practitioner (P5), and a technology expert (P6). Interviews followed a guide covering the potential uses of 3D printing in food systems, costs, scalability, consumer acceptance, regulation and intellectual property. Participation was voluntary and informed consent was obtained from all participants. Participants are identified by role and code to protect their anonymity.

Interview notes and transcripts were analysed thematically following the six phases described by Braun and Clarke (2006). Initial codes were generated inductively and then organised under the six readiness dimensions of the conceptual framework. The literature evidence was coded using the same dimensions, allowing the interview data and the published evidence to be compared directly. Readiness on each dimension was then judged as low, low-to-moderate, moderate, or high for each of the two technologies.

The study has limitations. Six interviews cannot represent the views of all relevant stakeholders, and the sample did not include farmers, food processors or consumers. The readiness judgements are qualitative and

are intended to structure debate rather than to provide a quantitative index. The evidence base on 3D printing in African agriculture is small, which is itself a finding of the study.

FINDINGS

Two Technologies, Not One

The first finding is conceptual. The literature on 3D printing and food security combines two technologies that should be analysed separately. The first is 3D food printing, in which edible pastes, powders or gels are deposited layer by layer to form food products. Its main claimed benefits are personalised nutrition, texture modification for people with swallowing difficulties, the use of alternative proteins and the upcycling of food by-products (Dancausa Millán & Millán Vázquez de la Torre, 2024; Hamilton et al., 2024). The second is 3D printing of agricultural hardware, in which plastics, metals or composites are printed to produce tools, spare parts, irrigation fittings and sensors (Agron & Kim, 2024; Kataev et al., 2023).

The distinction matters because the two technologies relate to food security in different ways. Food printing primarily acts on utilisation by changing the form and composition of existing food. It does not produce new calories and depends on ingredients that must still be grown, processed and transported. Hardware printing primarily affects availability and stability by keeping farm equipment running and reducing dependence on imported parts. The two technologies also serve different users. Food printers are used by restaurants, hospitals, military caterers and research laboratories, while printed hardware can serve smallholder farmers, repair workshops and extension services. The sections that follow, therefore, assess each technology separately.

International Reference Points

The countries most often cited as leaders show what 3D food printing can do and also how far it remains from mass use. China is the leading producer of research on 3D food printing, accounting for 219 of 800 documents in a global bibliometric review (Fasogbon & Adebo, 2022). Much of this work concerns the formulation of printable materials, including protein-based inks for extrusion printing (Guo et al., 2022). Earlier work by Sun et al. (2015) mapped the main printing techniques, including extrusion, selective sintering, binder jetting and inkjet printing, and noted that most were suited to small volumes and specialised products.

In the Netherlands, 3D food printing has been tested in a real military setting. Caulier et al. (2020) provided customisable 3D printed snack bars to 12 soldiers at a Dutch army base over four weeks. Attitudes improved with repeated consumption, but conventional snacks were still preferred, and the printers could personalise only the sensory qualities of the bars rather than their nutritional profile. Dutch research has also developed machine vision systems to monitor print quality and adapt printing in real time (Ma, 2024), while research on firms in the Netherlands and Belgium shows that adoption of additive manufacturing depends on deliberate business strategies rather than on the technology alone (Martens et al., 2022).

In Canada, strategic foresight research on the firm Structur3D concluded that the future of printed food depended on consumer demand, regulation and business models as much as on engineering (Charlebois & Juhasz, 2018). Canadian consumer research found that participants rated 3D printed foods lower than conventional equivalents, with the least interested group regarding printed foods as unnatural or unsafe (Manstan & McSweeney, 2020).

Three lessons follow. First, even in wealthy countries with strong research systems, 3D food printing remains confined to laboratories, pilot projects, and niche markets because printers operate slowly and produce in small batches (Ramundo et al., 2020). Second, the benefits most clearly demonstrated, such as texture-modified meals for patients and personalised snacks for soldiers, address the needs of specific institutional users rather than the food-insecure poor. Third, consumer acceptance cannot be assumed even in high-income settings.

The evidence on agricultural hardware is different. Studies from Russia document the use of 3D printing and 3D scanning to manufacture and repair components of agricultural machinery, reducing downtime when replacement parts are scarce (Kataev et al., 2023). Printed sensors have been developed to monitor soil, plant health and food contamination at low cost (Agron & Kim, 2024). Work on 3D printing for development argues that distributed manufacturing could allow communities in the Global South to produce locally needed goods, while warning that the technology does not remove the need for skills, materials and supportive institutions (Birtchnell & Hoyle, 2014). These uses are less visible than printed food, but they speak more directly to the constraints facing African farmers.

The African Evidence Base

Evidence from Africa on 3D food printing is sparse. Africa contributed only 19 of 800 documents in the global bibliometric review, with Egypt producing eight, Morocco four, Ethiopia three and Ghana two, while Nigeria, South Africa, Tanzania and Namibia produced one each. The first African publication on the subject appeared in 2016, about a decade after the field emerged elsewhere (Fasogbon & Adebo, 2022). The authors called for greater collaboration with researchers abroad and for increased public funding (Fasogbon & Adebo, 2022).

The evidence on additive manufacturing in Africa, more broadly, is stronger. South Africa accounts for more than 60 per cent of African publications on additive manufacturing, has a national additive manufacturing roadmap and hosts a centre of competence at the Council for Scientific and Industrial Research, whose Aeroswift project developed large-scale metal printing for aerospace (Klenam et al., 2025). Nigeria, Kenya and Egypt are emerging adopters, with applications in automotive parts, dentistry, prosthetics, construction and education (Klenam et al., 2025). The same review notes that additive manufacturing can supply customised tools and spare parts for farming, but it identifies unreliable energy supply, high capital costs, skills shortages, underdeveloped regulation and weak supply chains as barriers across the continent (Klenam et al., 2025).

Grassroots use is also growing. A study of eight fab labs and several social enterprises in South Africa and Kenya found that Kenyan entrepreneurs were printing customised shoes for people with foot deformities, headlamps for fishermen, medical equipment parts and low-cost 3D printers built from electronic waste (Schonwetter & Van Wiele, 2020). Most of these entrepreneurs did not rely on Fab Lab printers but bought or built their own open-source machines. Access to fab labs was limited by transport costs, fees, unfamiliar university settings and the stigma attached to some locations (Schonwetter & Van Wiele, 2020). The study did not identify any agricultural applications, indicating that the potential of hardware printing for farming remains largely untested in African settings.

Evidence on African consumers is emerging. A survey of 355 South African consumers found that positive attitudes towards 3D-printed food were strongest among respondents who recognised its convenience and health benefits, and that understanding of its safety and usefulness shaped acceptance (Cunningham & Adebo, 2025). Evidence on related novel foods suggests caution. In a study of more than 12,000 educated, mostly urban respondents across 12 African countries, only 8.9 per cent expressed a definite willingness to try artificial meat. Respondents cited the product's unnaturalness, safety concerns, possible harm to local farmers and an unwillingness to pay more than for conventional meat (Kombolo Ngah et al., 2023).

Readiness by Dimension

Table 1 summarises readiness on each dimension. The discussion that follows explains each judgement.

Table 1. Readiness of African food systems for two forms of 3D printing

Dimension	3D food printing	3D printing of agricultural hardware
Infrastructure	Low. Food printers need reliable power,	Low to moderate. Desktop printers need

and energy	hygienic premises and supply of processed ingredients	modest power and can be located in towns, colleges and workshops
Skills and research	Low. Africa produced 19 of the 800 documents in the field	Moderate in South Africa and emerging in Kenya, Nigeria and Egypt
Industrial and market base	Low. Demand is concentrated in niche urban and institutional markets	Low to moderate. Fab labs and social enterprises already print functional parts
Finance and cost	Low. Printers and consumables are costly and output is small	Moderate. Open source printers built from electronic waste lower entry costs
Regulation, safety and IP	Low. No dedicated rules on safety, hygiene or labelling of printed food	Low to moderate. General product rules apply, but the status of shared design files is unclear
Social acceptance	Low to uncertain. Scepticism towards novel foods is widespread	Moderate to high. Farmers judge a part by whether it works

Source. Author's assessment based on the reviewed literature and interview data.

Infrastructure and Energy

Additive manufacturing depends on stable electricity, connectivity for design files and suitable premises. Unreliable energy supply is one of the main barriers to additive manufacturing across Africa (Klenam et al., 2025), and sub-Saharan Africa scores poorly on the infrastructure components of frontier technology readiness (UNCTAD, 2023). Food printing is more demanding than hardware printing because it also requires hygienic food-preparation areas, refrigeration, and a steady supply of processed ingredients. Hardware printing is less demanding. A desktop printer can operate in a college workshop or district office where power is reasonably reliable, and a printed part can then travel to rural users.

The interviewees saw community institutions as possible hosts for the technology. The agricultural economist argued that local involvement would matter more than the machines themselves.

Empowering local communities through access to 3D printing technology can promote innovation and entrepreneurship, leading to job creation and improved livelihoods. Involving community members in the 3D production process can enhance local ownership of food systems and promote food sovereignty. (P1, agricultural economist)

This view links readiness to the agency dimension of food security. The evidence from Kenyan and South African fab labs, however, suggests that hosting a printer in a public institution does not guarantee community use, because transport costs, fees, and unfamiliar settings keep poorer users away (Schonwetter & Van Wiele, 2020). Community hubs would need to be located and run with those barriers in mind.

Skills and Research Capacity

Skills are a binding constraint. African output in 3D food printing research is very small, and much of it is concentrated in North Africa (Fasogbon & Adebo, 2022). Skills shortages are also identified as a general barrier to additive manufacturing on the continent (Klenam et al., 2025). South Africa is the clear exception, with established research centres and a national roadmap, offering a base from which regional training could be built (Klenam et al., 2025). The technical skills needed to print spare parts, including computer-aided design, printer maintenance and material selection, overlap with existing engineering and vocational curricula. The skills needed to formulate printable foods that are safe, nutritious and culturally acceptable are more specialised and scarcer. The wider lesson is that Fourth Industrial Revolution tools are adopted only where curricula are deliberately redesigned to accommodate them, as Masunda (2024) argues, proposing a curriculum framework that builds African capabilities for the technologies of the Fourth Industrial Revolution rather than leaving their adoption to imported expertise.

Industrial and Market Base

The market for 3D printed food in Africa is thin and concentrated in niche segments. The agricultural economist saw a commercial opportunity, but in markets far removed from the food-insecure.

The ability to produce customised food products can create new market opportunities, particularly in niche markets such as personalised nutrition and plant-based foods. (P1, agricultural economist)

Such markets could increase consumer engagement and producers' margins (Dabbene et al., 2018), but they are unlikely to reach displaced households or rural children at risk of stunting. The market for printed hardware is more promising. Imported agricultural tools and spare parts are expensive and slow to reach remote areas, and delays at planting or harvest can cost a season's output. Local printing of simple parts could reduce transport costs and protect farmers from supply chain disruptions caused by conflict or global shocks. The Kenyan social enterprises that already print functional products show that a small industrial base exists (Schonwetter & Van Wiele, 2020), even if it has not yet turned to agriculture.

Finance and Cost

Cost is the most frequently cited barrier to 3D food printing. The high purchase price of food printers and their maintenance costs make them unaffordable for most small and medium enterprises (Niyet et al., 2024). Automation can reduce labour costs, which is the main economic case for the technology in countries with labour shortages (Niyet et al., 2024), but that case carries little weight in African economies where labour is abundant and capital is scarce. The agricultural economist identified consumables as a further obstacle.

Integrating 3D food printing into existing supply chains requires overcoming barriers such as the cost of consumables and the complexity of the technology. (P1, agricultural economist)

Such barriers are more severe in areas with less developed infrastructure (Verma et al., 2022).

3D printing allows for the utilisation of alternative protein sources, such as insects and plant-based materials, which are more sustainable and cost-effective compared to traditional livestock. The production of 3D-printed food using these alternative sources can lower overall costs for consumers, making nutritious food more accessible to vulnerable populations. (P2, food scientist)

Research supports the view that printing can help convert insect protein into acceptable products, thereby strengthening circular insect supply chains (Chaimung & Liou, 2024). The cost advantage, however, lies in the protein source rather than in the printing process. Insects are already eaten in many African communities without any printing, and printing adds capital and energy costs to a product whose main virtue is cheapness. For hardware, the cost picture is different. Open-source printers built from electronic waste show that entry costs can be low (Schonwetter & Van Wiele, 2020), and the savings from a printed part are easy to measure against the price and delay of an imported part.

Regulation, Food Safety and Intellectual Property

No African country appears to have regulations designed for 3D printed food. Printed foods raise new safety questions because the printing process creates complex structures and brings food into contact with hard-to-clean machine parts (Hamilton et al., 2024; Tran, 2019). The food scientist stressed hygiene.

Hygiene and cleanability are also critical. The cleanliness of 3D printing machines is crucial to prevent contamination. Regulations should mandate regular maintenance and cleaning protocols to ensure machine hygiene, essential for safe food production. (P2, food scientist)

Labelling would also be needed so that consumers know the ingredients and nutritional content of printed products (Tran, 2019). Environmental rules matter for both technologies, since many printing materials are

plastics and printing uses significant energy (Baiano, 2022). The public policy expert called for regulation that steers the choice of materials.

Regulations should encourage the use of biodegradable or recyclable materials to minimise environmental harm. (P4, public policy expert)

Intellectual property is a more complex issue for hardware. The legal expert emphasised protection for designers.

Intellectual property (IP) rights are necessary in protecting the designs and innovations associated with 3D printing. This includes ensuring that creators can secure patents for their designs, which is essential for fostering innovation and investment in the technology. (P3, legal expert)

Digital design files can be easily copied and shared, which makes enforcement difficult and raises questions about liability for faulty printed parts (Li, 2016). Strong protection can also restrict access, since food security depends on the diffusion of useful technologies and overly strict intellectual property rules can limit access to agricultural innovations in developing countries (Haugen et al., 2010). The Kenyan social entrepreneurs studied by Schonwetter and Van Wiele (2020) shared designs freely and saw sharing as essential to product development. A regime that protects original designers while allowing open sharing of designs for basic agricultural parts would suit African conditions better than one modelled solely on commercial patent protection.

Social Acceptance

Social acceptance is the dimension on which the two technologies differ most. Printed food is a novel food, and novel foods face scepticism. Consumers associate them with unnaturalness, which can trigger food neophobia and disgust (Frewer, 1998; Siegrist & Hartmann, 2020). The development practitioner framed this as a question of cultural fit.

Integrating new technologies must respect and align with cultural norms to gain acceptance. Consumers often associate novel food technologies with unnaturalness, which can trigger food neophobia and disgust, hindering acceptance. (P5, development practitioner)

The food scientist linked acceptance to regulation and collaboration.

Consumer perception and regulatory frameworks are critical to scaling 3D food printing. Acceptance of 3D-printed food products and establishing clear regulations are necessary to facilitate market entry and expansion. Moreover, collaboration between technology developers, food scientists, and regulatory bodies will be essential to address these challenges and promote innovation in this emerging field. (P2, food scientist)

The African evidence supports this caution. The low willingness to try artificial meat among educated urban Africans and their concern for local farmers suggest that printed foods will face similar resistance (Kombolo Ngah et al., 2023). The South African survey offers a more hopeful signal, since consumers who saw convenience and health benefits were open to printed food (Cunningham & Adebo, 2025), although those respondents were urban consumers familiar with the concept rather than the rural poor. Printed hardware raises no comparable problem of acceptance. A farmer judges a printed pump fitting or plough component by whether it works and how long it lasts.

DISCUSSION

The findings answer the research question with a differentiated verdict. Africa is largely unready for 3D food printing and unevenly but increasingly ready for 3D printing of agricultural hardware. On every dimension of the framework, food printing scores low. It demands infrastructure that is scarce, skills that are rare, capital that is expensive, regulation that does not exist and consumer trust that has not been earned.

Hardware printing scores higher on most dimensions because its requirements are lighter, its benefits are easier to measure and it builds on an existing industrial and grassroots base.

The human security lens sharpens this verdict. Food printing acts mainly on utilisation and serves institutional and affluent users. Its strongest demonstrated applications, such as texture-modified meals and personalised snacks, do little to help households facing hunger due to conflict, drought or price shocks. Hardware printing, in contrast, acts on availability and stability. A spare part printed in a district town can keep an irrigation pump or a grinding mill working when conflict or a global shock has cut the supply of imported parts. This is a modest contribution, but it reaches the people and the vulnerabilities that human security concerns.

The findings also qualify the leapfrogging narrative that surrounds Fourth Industrial Revolution technologies. International benchmarks indicate that 3D food printing has not transformed food systems, even in wealthy countries. It would be unrealistic to expect it to do so in countries that rank among the least ready for frontier technologies (UNCTAD, 2023). The literature's tendency to merge food printing and hardware printing has lent the former a promise that belongs more properly to the latter.

These conclusions carry implications for policy. Governments and development partners should prioritise distributed hardware production, supported by vocational training, open design repositories for common agricultural parts and partnerships with existing fab labs and social enterprises. Public investment in food printing should be limited to research and niche uses with clear benefits, such as clinical nutrition. Regulators should prepare food safety, hygiene and labelling rules before printed foods reach the market, and intellectual property policy should balance protection for designers with open access to basic agricultural designs.

The study also points to an agenda for research. The absence of documented agricultural uses of 3D printing in African fab labs is striking and deserves direct investigation. Field studies are needed that track the cost, durability and uptake of printed parts among smallholder farmers and repair workshops, and consumer research on printed food should extend beyond urban respondents.

CONCLUSION

This paper examined how ready African food systems are to adopt 3D printing in response to food insecurity driven by escalating human security threats. The question matters because Africa now carries the world's heaviest burden of hunger, and because 3D printing is often presented as a technology that could help the continent leap past its structural constraints. Using a readiness framework with six dimensions, drawn from the UNCTAD Frontier Technology Readiness Index and the technology, organisation and environment model, the paper applied that framework to a structured review of the literature and to six expert interviews. Its central finding is that readiness depends on which technology is meant.

Africa is largely unready for 3D food printing. The technology remains confined to laboratories, pilot projects and niche markets, even in China, the Netherlands and Canada. In Africa, it faces an unreliable energy supply, scarce specialised skills, high capital and consumable costs, a lack of dedicated regulation, and widespread scepticism towards novel foods. Its main benefits act on utilisation for institutional and affluent users rather than on availability and access for the hungry.

Africa is more ready for 3D printing of agricultural hardware, although this readiness is uneven. South Africa has a national roadmap, established research centres, and industrial capacity; Kenya, Nigeria, and Egypt are emerging adopters; and a grassroots network of fab labs and social enterprises already prints functional products on low-cost, open-source machines. A locally printed spare part can keep farm equipment working when conflict or a global shock disrupts imports, which strengthens the availability and stability of food supply.

The paper, therefore, concludes that 3D printing is a partial tool for resilience rather than a solution to hunger in Africa. It cannot replace investment in agricultural productivity, rural infrastructure, social protection, peacebuilding and climate adaptation. Within those limits, it can make a real contribution if policy is directed at the right form of the technology.

Three priorities follow. Governments and development partners should support distributed production of agricultural hardware through vocational training, open design libraries and existing fab labs. Public spending on 3D food printing should be confined to research and to niche uses with clear benefits. Regulators should develop rules on the safety, hygiene and labelling of printed food, while keeping basic agricultural designs open.

Future research should test these conclusions in the field, following printed parts from design to use on smallholder farms and including farmers, processors and extension officers as participants. The answer to the question in this paper's title is therefore neither yes nor no. Africa is not ready for printed food, but it is becoming ready to print the tools that grow it.

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