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The Digital Transformation of Indigenous Food Processing and Preservation Practices in Sierra Leone: Opportunities, Challenges and Implications for Food Security

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Abstract: Sierra Leone food system contains a large body of practical knowledge developed through rice parboiling, cassava fermentation, fish smoking, sun drying, oil extraction and other household or small-enterprise techniques. These practices remain important to food availability, taste, identity and income, yet they operate within value chains marked by post-harvest loss, variable quality, weak market information and limited access to suitable processing equipment. This critical narrative review examines how digital technologies could strengthen, document and responsibly modernise indigenous food processing and preservation without displacing the knowledge holders on whom the system depends. Evidence was synthesised from peer-reviewed research and policy or institutional publications on Sierra Leone, West Africa and comparable smallholder food systems. The review identifies six practical pathways: digital documentation of local knowledge; mobile and multimedia training; low-cost sensing and decision support; digital quality assurance and traceability; market, payment and logistics platforms; and data-enabled coordination of processors, extension services and public institutions. These pathways can reduce avoidable loss, improve food safety, widen market access, support women- and youth-led enterprises and make local foods more visible within national food-security programmes. However, technology is not automatically inclusive. Unreliable electricity and connectivity, device and data costs, limited digital literacy, gendered control of assets, weak standards, cybersecurity risks and the extraction of community knowledge without consent may reproduce existing inequalities. The article proposes a human-centred "document validate adapt connect govern" framework and argues for phased pilots built around familiar foods, local languages, offline functionality and measurable food-security outcomes. Digital transformation should therefore be understood as a partnership between indigenous expertise and appropriate technology, not as the replacement of traditional practice by imported systems.

Keywords: *Indigenous Knowledge; Food Processing; Food Preservation; Digital Agriculture; Post-Harvest Loss; Food Security; Sierra Leone.*

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I. INTRODUCTION

Food security in Sierra Leone is often discussed as a production problem, but what happens after harvest is equally decisive. Food can be grown or landed and still fail to nourish people if it spoils, loses quality, becomes unsafe, or cannot reach a buyer at the right time. The February 2024 Food Security Monitoring System reported that 82% of the population was food insecure and that 68% of surveyed households spent more than three quarters of total expenditure on food (World Food Programme [WFP], 2024). More recent national reporting points to improvements, but the continuing pressure on household diets shows why food availability, affordability, safety and resilience must be addressed together rather than as separate policy concerns.

Indigenous processing and preservation sit at the centre of this problem and its possible solutions. Across Sierra Leone, households and microenterprises transform rice, cassava, fish, palm produce, vegetables, fruits, spices and

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other foods using combinations of cleaning, soaking, fermentation, parboiling, pounding, grating, pressing, smoking, drying, roasting and milling. The techniques differ by food, locality and intended use. They are not merely remnants of an earlier production system. They are living technologies that extend shelf life, make raw materials edible, create preferred flavours, support trading and preserve cultural memory. They are also heavily dependent on experience: the processor often judges readiness by texture, colour, aroma, sound, weather and the behaviour of the fire.

At the same time, traditional does not mean risk-free or unchangeable. Inadequate control of moisture, temperature, smoke, hygiene, storage time and packaging can produce uneven quality or expose food to mould, insects, contaminants and re-wetting. An early Sierra Leonean investigation of smoke dried bonga fish, for example, found mycotoxigenic fungi and toxins in mouldy samples, while properly preserved samples showed no fungal contamination (Jonsyn & Lahai, 1992). The lasting lesson is not that smoking should be abandoned; it is that process control and timely quality checks matter.

Digital transformation offers a new set of supporting tools. A smartphone can carry a local-language video on safe smoking or cassava fermentation. A low-cost sensor can warn that grain moisture is too high for storage. A QR code can connect a packaged product to its processor, batch and handling record. Mobile money can shorten payment cycles, while a digital marketplace can reveal demand beyond the immediate community. At a wider scale, interoperable data can help extension officers, laboratories, aggregators and regulators identify where losses or safety problems recur. Sierra Leone's Feed Salone Strategy already brings together aggregation, processing, marketing, agricultural technology, climate-smart agriculture, and the empowerment of women and youth (Ministry of Agriculture and Food Security [MAFS], 2023). The Sierra Leone Digital Transformation Project likewise prioritises broadband access, digital skills and inclusive digital services (SLDTP, 2026). The policy space for convergence therefore exists.

The central question is how that convergence should be designed. Much digital-agriculture literature concentrates on production and farm-level advisory services. Less attention is paid to household and small-enterprise processing, where Home Economics, food safety, livelihoods, culture and information systems meet. This article addresses that gap by examining how digital tools could strengthen indigenous food processing and preservation in Sierra Leone; the benefits that may follow for food security and enterprise development; the barriers and ethical risks that must be anticipated; and the governance principles required for locally legitimate innovation.

II. REVIEW APPROACH

The article uses a critical narrative review. This approach was selected because Sierra Leone-specific empirical literature on the digitalisation of indigenous food processing is still limited and the relevant evidence is spread across food science, post-harvest management, information systems, gender studies and policy documents. Rather than pretending that these different sources answer one narrowly defined intervention question, the review brings them into a structured interdisciplinary argument.

A targeted search was undertaken for English-language material published mainly from 2018 to August 2026, supplemented by older Sierra Leone-specific evidence where it remained directly relevant. Search combinations covered digital agriculture, indigenous knowledge, food processing, food preservation, post-harvest loss, traceability, smallholder value chains, women processors, Sierra Leone and West Africa. Peer reviewed reviews and empirical studies were considered alongside official publications from the Government of Sierra Leone, FAO, WFP, the World Bank and related development institutions. Sources were retained when they contributed to at least one of four analytical areas: the condition of Sierra Leone's food system; the role and risks of indigenous processing; a credible digital application; or the institutional conditions affecting adoption. The synthesis was thematic and interpretive. It does not estimate a pooled effect and should not be read as a systematic review of every available technology.

III. INDIGENOUS PROCESSING AS A FOOD-SYSTEM ASSET

- *More than a Set of Recipes*

Indigenous food-processing knowledge is distributed across people, routines and places. Some of it is explicit and can be stated as a sequence; much of it is tacit and becomes visible only while work is being done. A processor may know the correct consistency of fermented cassava dough by touch, the strength of a smoking fire by observing the colour and movement of smoke, or the suitability of grain for storage by biting or shaking it. Such judgement is accumulated through repetition and social learning. Digital documentation that captures only ingredient lists and nominal processing times will therefore miss the very knowledge that makes the practice reliable.

The knowledge is also economically organised. Women frequently occupy labour-intensive processing and retail roles, while access to equipment, transport, finance and formal markets may be controlled elsewhere in the value chain. A digital intervention that improves record-keeping but ignores who owns the phone, receives payment or authorises investment can increase visibility without increasing decision-making power. Reviews of ICT use in West African agriculture similarly show that women's lower income and constrained control over household resources can limit their ability to act on digital advice (Adzawla et al., 2022). For this reason, digital inclusion must be assessed

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through effective use and benefit, not registration numbers alone.

➢ *Why Preservation Quality Matters*

Post-harvest loss includes more than food that is physically discarded. Quality can decline through discoloration, insect damage, mould, odour, nutrient loss or contamination that is not immediately visible. Affognon et al. (2015) and Stathers et al. (2020) caution that estimates vary with commodity and measurement method, while Sheahan and Barrett (2017) show that evidence must distinguish measured loss from broad assumptions. More recent economic analysis stresses that hidden quality loss may have greater food-safety and nutrition consequences than the quantity loss most easily counted (Hoffmann et al., 2022). This distinction is important for Sierra Leone: a digital scale can record weight, but safer food may require moisture, temperature, hygiene and storage information as well.

Processing also affects the stability of national value chains. The Feed Salone agenda seeks stronger aggregation, processing and market linkages, including expanded milling and greater commercial use of cassava and other priority commodities (FAO Investment Centre, 2025). These targets depend on consistent raw material, dependable processing, packaging, standards and buyer confidence. Indigenous methods can contribute to that expansion if their strengths are retained and their variable points are better controlled.

IV. DIGITAL PATHWAYS FOR RESPONSIBLE TRANSFORMATION

Digitalisation should begin with the problem experienced by processors, not with the novelty of a device. Table 1 maps common food-system needs to technologies that are plausible under Sierra Leonean conditions. The emphasis is deliberately on combinations of simple and advanced tools. Artificial intelligence and the Internet of Things may be useful, but an offline audio guide, an SMS alert or a shared digital weighing record may solve a more urgent constraint at lower cost.

Table 1. Practical Digital Pathways for Indigenous Food Processing and Preservation

Food-System Need	Suitable Digital Application	Expected Value	Safeguard
Loss of tacit knowledge	Local-language audio/video archives; community-controlled recipe and process records	Preserves technique, supports intergenerational learning and training	Prior consent, attribution, access rules and benefit-sharing
Uneven drying, smoking or storage	Low-cost moisture/temperature sensors; timer alerts; simple decision-support thresholds	Improves consistency and reduces spoilage or unsafe batches	Local calibration, maintenance plan and non-digital fallback
Weak quality records	Mobile batch log, digital weighing, photo records and laboratory-result linkage	Supports corrective action, certification and buyer confidence	Minimal data collection, secure storage and clear ownership
Limited market information	USSD/SMS prices, mobile marketplaces, demand forecasts and digital payments	Reduces information gaps and widens market reach	Transparent fees, fraud controls and assisted access
Fragmented transport and cold chain	Pickup scheduling, route coordination, shared cold-room booking and alert systems	Reduces delays, re-wetting and temperature abuse	Reliable power, service accountability and contingency plans
Low visibility of local foods	Digital catalogues, nutrition content, origin stories and institutional procurement portals	Builds demand and links processors to schools, retailers and hospitality buyers	Evidence-based claims and respectful cultural representation

➢ *Documenting Knowledge Without Extracting It*

Digital archives can protect knowledge that is vulnerable to migration, changing diets and the ageing of experienced processors. Achieng (2022) argues that digitalisation can support the preservation and dissemination of indigenous agricultural knowledge in Africa, while also noting that such work remains underdeveloped. For Sierra Leone, documentation could include short videos, narrated process maps, local names, seasonal variations, sensory indicators and explanations of why a step is performed. Community radio, WhatsApp audio and offline media libraries may reach users whom text-heavy platforms exclude.

Yet documentation can also become extraction. Once a community technique is recorded, outsiders may package or commercialise it without recognition or return. Responsible documentation requires free, prior and informed consent; named attribution where desired; the right to restrict sensitive knowledge; and an agreed approach to commercial benefit. The data model should recognise communities and practitioner groups as knowledge holders rather than treating their contributions as unowned raw data.

➢ *Process Monitoring and Decision Support*

Simple sensing is one of the clearest links between information technology and preservation. Moisture meters

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can support decisions about when rice, maize, cassava products or dried spices are safe to bag. Temperature probes and timed alerts can improve repeatability in smoking, drying or cooling. In storage spaces, sensors can flag rising humidity or temperature before visible deterioration occurs. Where smartphones are available, a basic application can translate readings into an action: continue drying, cool before packaging, separate the batch, or request inspection.

The important word is support. A sensor reading should not erase sensory judgement or assume that a threshold validated elsewhere applies unchanged to every local product. Devices need calibration against the commodity, packaging, climate and intended shelf life. Processors should be involved in testing alerts and explaining false alarms. The system must also work when batteries fail, networks drop or replacement parts are unavailable. Appropriate digitalisation increases local control; it does not create dependence on a device that only an external technician can repair.

- *Quality Assurance, Traceability and Consumer Trust*

Small processors often know where a product came from but cannot demonstrate that history to a distant buyer. Lightweight traceability can bridge that gap. A batch identifier may connect the source community, processing date, key control checks, packaging and destination. QR codes are useful for smartphone users, but printed batch numbers and USSD or SMS verification may be more inclusive. The purpose should be proportionate: a community gari processor does not need the same architecture as an export fish plant, but both benefit from records that allow a complaint or unsafe batch to be traced and corrected.

Traceability becomes valuable when it is connected to genuine quality assurance rather than marketing theatre. Clark and Hobbs (2018) show that credible signalling and quality mechanisms can help address sourcing, market size and consumer trust in African complementary-food chains. In Sierra Leone, digital records could support laboratory referrals, certification, institutional procurement and stronger branding of locally processed foods. However, claims such as “organic,” “fortified,” “traditional” or “safe” must be verified. Otherwise, digital labels merely give weak practice a modern appearance.

- *Markets, Payments and Logistics*

Processors lose value when they sell under pressure, lack reliable price information, cannot aggregate enough product, or face delayed payment. Mobile platforms can display indicative prices, match supply with buyers, coordinate aggregation and record orders. Digital payments can reduce cash-handling risk and create a transaction history that may help an enterprise demonstrate turnover. Reviews across low- and middle-income countries find that digital agricultural services most commonly improve access to information, advice and markets, although evidence of sustained income effects remains uneven (Tsan et al., 2019; Porciello et al., 2022).

Market access should not be confused with platform access. If commission charges, data costs, ranking systems or delivery obligations are unclear, processors may assume new risks. Platforms should publish fees in plain language, provide assisted registration, allow complaints, protect users against impersonation and avoid exclusivity arrangements that weaken bargaining power. Where digital finance is involved, cybersecurity and fraud awareness must be part of training rather than an afterthought.

- *Artificial Intelligence as a Bounded Tool*

Artificial intelligence can add value where sufficient and reliable data exist. Computer vision may help classify colour or visible defects; forecasting models may estimate demand; speech systems may deliver guidance in accessible formats; and anomaly detection may flag unusual storage conditions. These are promising applications, but they are not yet a substitute for foundational infrastructure, good records, food-science validation and accountable institutions. A model trained on images from another country may misclassify local products, processing stages or packaging. Poor data can therefore automate error with unwarranted confidence.

A realistic sequence is to digitise basic records, establish quality definitions, test sensors and build representative local datasets before deploying higher-risk automated decisions. Human review should remain mandatory where a recommendation could affect food safety, income or market exclusion. The question is not whether an AI tool is technically impressive, but whether it improves a decision that matters to processors and consumers.

V. IMPLICATIONS FOR FOOD SECURITY AND LIVELIHOODS

- *Availability and Stability*

Better control of drying, smoking, fermentation, cooling and storage can keep more food usable between seasons and during transport. Digital alerts and coordinated logistics may reduce delays that expose fish, vegetables or prepared foods to spoilage. At system level, batch and inventory data can help aggregators and public programmes see where stocks exist and where bottlenecks are emerging. This supports availability, but only when digital information is matched by physical infrastructure such as clean water, improved ovens, dryers, stores, roads, packaging and reliable energy.

- *Access, Income and Enterprise Growth*

Processing converts perishable or bulky raw materials into products with longer selling periods and, often, higher unit value. When digital tools improve costing, demand information, payments and buyer discovery, they may strengthen enterprise income and household purchasing power. The potential is particularly important for women and young people whom national policy identifies as priority participants in agricultural transformation (MAFS, 2023). World Bank experience in Sierra Leone also indicates that organised support to women farmers can improve income, assets and household food security, although access to finance and productive resources remains decisive (World Bank, 2023).

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Digital records may also make small enterprises more legible to lenders and institutional buyers. This can be beneficial, but formalisation must be gradual and supportive. Imposing complex compliance systems on enterprises before they have equipment, working capital or stable demand may push the smallest operators out of the market. A tiered pathway from basic hygiene and batch records to verified standards and larger contracts is more equitable than a single high entry threshold.

- *Utilisation, Nutrition and Safety*

Food security includes the ability to consume safe and nutritionally adequate food. Digital training can explain hygiene, contamination risks, storage limits and nutrient-sensitive processing in formats that can be replayed during work. Traceability and test results can strengthen confidence in local complementary foods and other products intended for vulnerable groups. Sierra Leone's planned expansion of locally produced fortified complementary foods and processing facilities shows the growing importance of reliable local processing capacity (WFP, 2026). The same quality culture can extend to smaller enterprises if standards are translated into workable steps and supported by laboratories and extension services.

- *Cultural Continuity and Dietary Diversity*

Digital media can raise the visibility of local foods, record preparation knowledge and connect younger consumers with products that may otherwise decline. This matters because the erosion of neglected and underutilised crops narrows dietary and agricultural diversity (Foday et al., 2025). However, preservation should not freeze food culture into a museum display. Communities continually adapt recipes, tools and markets. The goal is to keep knowledge usable and valued while allowing practitioners to decide how it evolves.

VI. RISKS, CONSTRAINTS AND UNRESOLVED TENSIONS

- *Infrastructure and Affordability*

Connectivity, electricity, device cost, repair services and data affordability remain foundational constraints. The Sierra Leone Digital Transformation Project is investing in broadband, skills and public digital infrastructure, especially for underserved areas (SLDTP, 2026), but coverage does not guarantee reliable use at a processing site. Shared devices, solar charging, offline-first applications, SMS/USSD options and local maintenance arrangements are therefore not secondary design features; they determine whether an intervention survives beyond a pilot.

- *Digital Capability and Language*

Digital literacy is not a single skill. A user may confidently send voice notes but struggle with passwords, spreadsheets or online forms. Training should be organised around actual tasks recording a batch, reading a sensor, checking a payment or reporting a fault and delivered in familiar language. Scoping reviews of digitalisation among smallholders in sub-Saharan Africa repeatedly identify limited connectivity, affordability, literacy and infrastructure as barriers, with gender disparities shaping who benefits (Agyekumhene et al., 2024; Mkhize, 2024). Training that ends when equipment is handed over is unlikely to change practice.

- *Data Protection, Cybersecurity and Platform Power*

Processing records can reveal suppliers, volumes, prices, customers and production cycles. These data have commercial value. Systems must specify who owns them, who may access them, how long they are retained, and whether they may be used to train algorithms or profile enterprises. Users need meaningful consent and the ability to correct inaccurate records. Basic controls unique accounts, secure backups, role-based access, fraud reporting and minimal data collection are more important than complex features that no local institution can govern.

Platform power is another concern. A marketplace or traceability provider may become the gatekeeper between processors and formal buyers. If its scoring model is opaque, an enterprise can be downgraded without understanding why. Public procurement and donor-supported platforms should therefore require transparent rules, data portability, accessible appeals and interoperability. Digital transformation should reduce dependency within the value chain, not simply replace one intermediary with another.

- *Standardisation Versus Diversity*

Quality improvement often requires repeatable processes, but indigenous foods legitimately vary by locality, season and consumer preference. Excessive standardisation can erase distinctive qualities or privilege the version easiest for industry to measure. Standards should separate non-negotiable safety requirements from acceptable cultural and sensory variation. Co-design with processors, food scientists, Home Economics specialists, consumers and regulators can identify which steps must be controlled and which should remain flexible.

VII. A HUMAN-CENTRED FRAMEWORK FOR SIERRA LEONE

The review proposes a five-stage framework: document, validate, adapt, connect and govern. It is intended as an iterative cycle rather than a one-way technology rollout.

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Table 2. Proposed Framework for Digitally Strengthening Indigenous Food Processing

Stage	Core question	Priority actions	Evidence of progress
1. Document	Whose knowledge and problem are being addressed?	Map practices with processors; record local terms, sensory indicators, seasonal variation and ownership expectations.	Knowledge holders approve records and define access.
2. Validate	Which practices are effective and where are the safety or loss points?	Combine practitioner judgement with moisture, temperature, microbiological or shelf-life checks.	Critical control points and acceptable variation are agreed.
3. Adapt	What is the simplest workable digital support?	Co-design offline and local-language tools; test usability, repair and non-digital fallback.	Processors use the tool correctly without continuous external support.
4. Connect	Which services must work together?	Link processors with extension, laboratories, finance, logistics, buyers and institutional procurement.	Faster decisions, fewer rejected batches and improved market access.
5. Govern	Who controls data, standards and benefit?	Set consent, security, interoperability, appeals, attribution and benefit-sharing rules.	Users can access, correct and transfer their data; grievances are resolved.

➢ *Principles for Implementation*

First, begin with one value chain and one measurable bottleneck. A pilot might focus on moisture control in stored rice, safe smoking and packaging of fish, or consistency in cassava fermentation and drying. Second, choose mixed indicators. Technology uptake alone is inadequate; evaluation should include spoilage or rejection rates, food-safety compliance, shelf life, processor time, income, women's control over proceeds, affordability and user trust. Third, build institutional ownership from the start. Freetown Polytechnic, Njala University, SLARI, extension services, standards and food-safety bodies, processor associations and technology firms each have complementary roles. Fourth, budget for maintenance, replacement, connectivity and training after the demonstration period. Finally, retain non-digital procedures so that safety and livelihoods are not suspended by a system failure.

VIII. POLICY, PRACTICE AND RESEARCH RECOMMENDATIONS

➢ *Policy and Institutional Action*

The Government should explicitly connect Feed Salone's processing and AgTech pillars through a national programme for digitally enabled post-harvest quality. The programme should fund small, commodity-specific pilots; publish open technical guidance; and require inclusion, data protection and interoperability plans. Digital infrastructure investments should identify processing clusters, landing sites, markets and aggregation centres as productive-use locations, not only as places of general connectivity.

Standards and food-safety agencies should translate formal requirements into tiered checklists and local-language multimedia guidance for micro and small processors. Laboratories and extension services should provide referral pathways when digital records indicate a possible safety problem. Institutional buyers, including school-feeding programmes, can create demand for verified local products, but procurement requirements should be phased so smaller enterprises receive support to qualify rather than being excluded immediately.

➢ *Education and Enterprise Support*

Home Economics and ICT departments are well placed to lead interdisciplinary applied work. Training should combine processing science, nutrition, hygiene, costing, digital record-keeping, cybersecurity and platform marketing. Student and staff teams can work with processor groups to document practices, prototype simple tools and test usability. This makes the polytechnic a neutral bridge between community knowledge and technical design while ensuring that digital solutions are assessed in the setting where they will be used.

Enterprise support should prioritise shared assets where individual ownership is unrealistic: solar dryers, improved smoking facilities, cold rooms, quality-testing kits, packaging equipment, charging points and assisted digital service desks. Financial products should recognise the seasonal cash flow of processors. Women's inclusion should be measured through access to devices, training completion, control of accounts and income, representation in platform governance and influence over investment decisions.

➢ *Research Priorities*

Sierra Leone needs baseline evidence on indigenous processing practices, their critical control points, post-harvest quality loss and the digital capabilities of processor groups. Future studies should compare sensor-supported and existing practices under real operating conditions; examine whether digital traceability changes buyer trust and prices; assess the cost-effectiveness of offline versus smartphone services; and investigate who gains or loses when a value chain becomes data-driven. Participatory action research is especially

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appropriate because processors can help define outcomes and refine interventions across production cycles.

Longitudinal research is also necessary. Many pilots report registration, training attendance or initial use, yet food-security benefits depend on sustained adoption, maintenance and market response. Studies should follow enterprises beyond the funded pilot and report disaggregated results by gender, age, location, enterprise size and disability. Qualitative evidence should accompany quantitative measures so that changes in autonomy, cultural ownership and trust are not hidden behind average adoption rates.

IX. CONCLUSION

Indigenous food processing and preservation in Sierra Leone are not obstacles waiting to be replaced by modern technology. They are a practical foundation for food availability, enterprise, identity and resilience. Their weaknesses variable process control, avoidable loss, limited records and restricted market reach are real, but so are their strengths: local materials, accumulated judgement, cultural acceptance and livelihood value.

Digital tools can strengthen this foundation when they are selected for a clear processing problem and embedded in physical infrastructure, food-science validation and accountable institutions. Local-language media can preserve and transmit knowledge; sensors can make hidden risks visible; traceability can support quality and trust; and platforms can connect processors to services and markets. None of these benefits is automatic. Poor design may deepen gender gaps, expose commercial data, impose unsuitable standards or transfer control away from knowledge holders.

The appropriate direction for Sierra Leone is therefore a human-centred and phased digital transformation: document knowledge with consent, validate it with practitioners and science, adapt technology to local conditions, connect the institutions needed for value creation, and govern data and standards transparently. If pursued in this way, digitalisation can help the country retain more of the food it produces, strengthen local enterprises and advance the food-sovereignty ambitions of Feed Salone without sacrificing the knowledge and cultural diversity that make its food system distinctly Sierra Leonean.

DECLARATIONS

- *Authors' Contributions*

Fatmata Fauziatu Vincent conceptualised the Home Economics, indigenous food processing, nutrition and household food security dimensions of the article and contributed to the critical interpretation of the literature. Hamza Amin Kargbo conceptualised the information technology, digital systems, data governance and implementation dimensions and contributed to the literature synthesis. Both authors developed the interdisciplinary framework, reviewed the manuscript critically, and approved the final version.

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- *Conflict of Interest*

The authors declare no conflict of interest.

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