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Impact of Inventory Management Technologies on Operational Efficiency and Cost Reduction in World Food Programme's Operations in North East Nigeria

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ABSTRACT

This study examined staff perceptions of the effect of inventory management technology (IMT) on operational efficiency and cost reduction in World Food Programme (WFP) operations in Northeast Nigeria. Many humanitarian operations in conflict-affected areas still rely on manual inventory practices that cause delays, record errors and avoidable costs, and evidence on the effectiveness of IMT in such settings remains limited. A structured questionnaire was administered to 62 of the 64 eligible logistics, inventory, procurement and supply-chain personnel of WFP and partner organisations in Maiduguri, Damaturu and Yola, an effectively purposive, near-census recruitment, and 61 completed responses were received (98.4 per cent of those invited). Responses were summarised descriptively as percentages of pooled item responses. Of the 540 valid responses on the move from manual to automated systems, 81.5 per cent were favourable (strongly agree or agree), as were 85.3 per cent of the 600 valid responses on IMT adoption and cost reduction. These figures describe perceived improvements in efficiency and costs; they are not measured time savings or cost reductions, and no inferential test was applied. The findings suggest that staff associate IMT with better record accuracy, fewer manual errors and stronger commodity tracking, although unreliable electricity, weak connectivity, insecurity and limited system integration may constrain these gains. The study recommends investment in integrated systems, staff training, reliable power and connectivity and regular maintenance, together with a monitoring framework that verifies actual savings against operational and financial records.

Keywords: inventory management technology; humanitarian logistics; operational efficiency; cost reduction; World Food Programme; Northeast Nigeria

1. INTRODUCTION

Humanitarian supply chains must stay reliable where roads are insecure, demand shifts with displacement and infrastructure is damaged. Inventory is central to this reliability: it buffers operations against demand swings, supply delays and transport disruption, but it must also be protected from loss, damage and diversion and accounted for to donors (Balcik, Bozkir & Kundakcioglu, 2016; Kovács & Spens, 2007). Unlike commercial firms, which can plan around predictable demand and stable transport, humanitarian organisations must put availability, timeliness and accountability ahead of profit. An inaccurate stock count can mean that food is missing where it is believed to be, that aid is delayed and that losses go unexplained.

In Northeast Nigeria, where WFP has provided food and nutrition assistance throughout the insurgency in Borno, Yobe and Adamawa States, the difficulty is acute. Warehouse data may be incomplete, electricity and network coverage are unreliable and some sites are inaccessible for security reasons. Paper and spreadsheet methods are slow to reconcile, hard to supervise remotely and leave a weak audit trail, which raises the risk of unrecorded losses. WFP has therefore introduced digital tools, namely the Global Equipment Management System (GEMS), Last Mile Tracking (LMT), Global Positioning System (GPS) vehicle tracking and mobile point-of-sale (mPOS) devices used to record transactions at distribution points.

Evidence on such tools is mixed. Casella et al. (2022) emphasised that mobile data capture and automated inventory systems eliminate manual entry errors and improve real-time supply-chain visibility, and retail field experiments found lower inventory record inaccuracy (Hardgrave, Aloysius & Goyal, 2013). Yet modelling of a humanitarian food warehouse shows that the cost benefit of RFID depends on the seriousness of errors and the rate at which shrinkage is recovered (Biswal, Jenamani & Kumar,

2018), so benefits cannot be assumed.

Little of this evidence comes from conflict settings. Most inventory studies were conducted in commercial or stable public-sector environments; for example, Debala, Bhat and Khan (2023) studied public-sector organisations in Ethiopia, not a setting of armed conflict. Humanitarian research has concentrated on coordination, pre-positioning and rapid-onset response rather than on the operating-cost effects of specific technologies (Balcik, Beamon & Krejci, 2016), and WFP itself acknowledges scope to accelerate the integration, adoption and funding of digital platforms (World Food Programme, 2025). Practitioner evidence to guide donors and agencies on whether such investment works is therefore scarce. This article contributes such evidence by documenting how staff who use these systems in Northeast Nigeria perceive their effects.

Statement of the Problem

Humanitarian agencies have invested in inventory management technologies (IMT) to improve visibility, limit losses and operate more cost-effectively. In Northeast Nigeria, however, WFP works amid protracted conflict, insecure access, displaced populations, unreliable power and weak connectivity, conditions that undermine stock records and keep manual processes in use. With constrained budgets, every dollar saved on costs allows more assistance to be delivered, yet it remains uncertain whether automation has actually improved operational efficiency or reduced costs in this context.

This article addresses that gap with two objectives, both concerned with staff perceptions:

1. to examine how staff perceive the effect of the transition from manual to automated inventory management systems on operational efficiency in WFP operations in Northeast Nigeria; and

2. to examine how staff perceive the role of IMT adoption in reducing operational costs in WFP operations in Northeast Nigeria.

Research Questions

RQ1: To what extent do WFP and partner staff perceive that the transition from manual to automated inventory management systems has improved operational efficiency in Northeast Nigeria?

RQ2: To what extent do staff perceive that IMT adoption has reduced operational costs for WFP in Northeast Nigeria?

2. LITERATURE REVIEW

2.1 Concept of Inventory Management Technology

Inventory management technology (IMT) refers to the computer systems, software, databases, digital devices and automated processes used to plan, record, monitor, control and report on inventory. It gives organisations timely and accurate information on stock quantities, locations, movements and values. Effective inventory management ensures that the right products are available in the right quantities, at the right time and place while controlling purchasing, holding and reorder costs (Heizer, Render & Munson, 2020). Digital systems capture transactions electronically and give authorised users timely information, particularly where many products, branches or high transaction volumes are involved (Laudon & Laudon, 2022).

IMT is more than software, since it also comprises hardware, networks, people and procedures (Laudon & Laudon, 2022). Common tools include barcodes, QR codes, RFID, POS systems, warehouse management and ERP systems, mobile applications and analytics, which improve accuracy, traceability and visibility through automated data capture (Casella, Filippelli, Bigliardi & Bottani, 2022). Better visibility reduces stockouts and unnecessary purchases (Chopra & Meindl, 2019), and monitoring of reorder points and supplier lead times supports timely replenishment (Babai, Boylan & Syntetos, 2022).

In the humanitarian sector, IMT matters because WFP handles large volumes of food, relief supplies and equipment. In 2025, WFP recorded global food losses of 129,752 metric tonnes, equivalent to 4.07 percent by volume and about USD 113 million, linked to warehouse incidents, infestation, poor handling, flooding, theft and looting (World Food Programme, 2026). Accurate inventory information supports distribution planning and helps ensure that assistance reaches beneficiaries. Digital systems also strengthen internal control through audit trails, although their effectiveness still depends on accurate data entry, reliable networks, competent staff and management support (Laudon & Laudon, 2022).

2.2 Concept of Operational Efficiency

Operational efficiency is the ability of an organisation to achieve its objectives with the least time, labour, materials and money. In this study it refers to how accurately, promptly and consistently WFP can receive, store, track, issue and distribute commodities while minimising delays, duplication, errors and waste. Inventory technologies convert transaction data into information that managers use to plan, control and report on stock. This lets managers decide on current rather than outdated data (Laudon & Laudon, 2022).

Empirical evidence supports this link. Debala, Bhat and Khan (2023) found, in a survey of 186 public-sector organisations in Ethiopia, that inventory optimisation was positively associated with operational efficiency, with IT infrastructure, record-keeping, staff skills and inventory accuracy as significant determinants. In two retail field experiments, Hardgrave, Aloysius and Goyal (2013) found that RFID-enabled visibility reduced record inaccuracy, and Özguven and Özbay (2015) proposed an RFID-based framework linking real-time tracking of relief supplies and demand to inventory-control decisions. Automation adds value only when it is used, integrated with other systems and supported by trained staff and reliable infrastructure (Laudon & Laudon, 2022).

Within WFP, the first dedicated evaluation of the supply-chain function reported important efficiency gains while noting the need to strengthen integration, uptake and resourcing of digital platforms (World Food Programme, 2025). WFP's LESS platform is intended to provide integrated commodity tracking and real-time information, helping managers respond more quickly to shortages (Chopra & Meindl, 2019).

2.3 Concept of Cost Reduction in Humanitarian Setting

Cost reduction is the deliberate decrease of unnecessary or avoidable expenditure while maintaining service quality, inventory availability and operational performance. Here it refers to WFP's ability to lower inventory- and logistics-related costs through the adoption and effective use of IMT. It differs from cost optimisation, which balances expenditure against service quality, availability and risk, because the lowest cost does not always give the best outcome (Chopra & Meindl, 2019); fewer deliveries, for example, may cut transport spending but raise warehouse stocks.

In humanitarian operations, inventory planning involves trade-offs between preparedness, cost and response speed (Balcik, Beamon & Smilowitz, 2008), so a saving that delays or reduces assistance cannot be counted a success.

Technology can support cost reduction through better information quality and visibility. Improved efficiency can reduce administrative labour, duplicate data entry, stock discrepancies and emergency procurement, and RFID-enabled visibility has been shown to reduce record inaccuracy (Hardgrave et al., 2013), which may lower losses from misplaced, expired, damaged or unaccounted-for commodities. Net savings nevertheless depend on the severity of existing errors and the cost of implementation: Biswal et al. (2018) found that RFID results in a humanitarian warehouse hinge on ordering availability and the rate at which shrinkage is recovered.

WFP's supply-chain evaluation reported efficiency gains and presented digital platforms as part of cost-efficient decision-making, but stressed the need to strengthen integration, user uptake and resourcing (World Food Programme, 2025). Technology is therefore likely to reduce costs only where it is properly implemented, consistently used and integrated with wider supply-chain processes.

2.4 Empirical Review

2.4.1 Empirical Evidence on Inventory Management Technology (IMT)

Akhmad and Prawirosastro (2026) and Budiyanto and Muslim (2024) found that integrating Radio Frequency Identification (RFID) with warehouse management systems (WMS) significantly improves inventory accuracy, cuts manual processing time by over 50% and reduces error rates by about 80%. Tarigan et al. (2021) reported that ERP-driven inventory management has a significant positive effect on operational efficiency in manufacturing firms, and Tarigan, Siagian and Yacob (2020) found that ERP implementation improves stock accuracy and real-time visibility, although implementation complexity and data governance moderate the gains.

2.4.2 Empirical Evidence on IMT and Operational Efficiency

Okoli et al. (2024) surveyed manufacturing firms in South-South Nigeria and found that technology-based inventory practices had a significant positive effect on operational performance ($\beta = 0.059$, $p = 0.020$), with the models explaining 67.3% of performance variance. Shin and Eksioglu (2015) and Casella et al. (2022) found that automated tracking raises labour productivity and reduces stockout risk, and Yao et al. (2007) showed that vendor-managed inventory and automated replenishment improve supplier coordination and responsiveness.

2.4.3 Empirical Evidence on Cost Reduction in Humanitarian Settings

Biswal et al. (2018) modelled a humanitarian food-security warehouse in India and showed that RFID adoption reduces shrinkage and misplacement, lowering ordering and deprivation costs in high-loss, non-profit supply chains. Ergun et al. (2012) simulated WFP's food-aid network and found that optimised inventory ordering and strategic pre-positioning substantially cut global operating costs while raising service levels.

2.5 Theoretical Review

This study is underpinned by Transaction Cost Economics (TCE) and the Contingency Theory of Management Accounting, which together frame how IMT drives cost reduction.

2.5.1 Transaction Cost Economics (TCE)

Originating from Coase (1937) and developed by Williamson (1985) and Speklé (2001), TCE treats technology as a structural safeguard that reduces hidden tracking overhead, behavioural uncertainty and internal transaction costs. Where WFP faces limited asset visibility and slow physical verification, as in Northeast Nigeria, manual paper logs impose heavy transaction costs, whereas automated tracking curbs information asymmetry, resource leakage and material loss, consistent with the review of empirical TCE work by Rindfleisch and Heide (1997).

2.5.2 Contingency Theory of Management Accounting

Introduced by Waterhouse and Tiessen (1978) and Otley (1980), and refined by Chenhall (2003) and Gerdin and Greve (2004), contingency theory holds that IMT cannot be evaluated in a vacuum but must be judged as a tool whose value depends on context. Achieving cost reduction requires a close fit between an organisation's accounting controls and its external operating realities. For WFP in Northeast Nigeria, with poor roads and chronic power cuts, no universal control template exists; real-time automated metrics are a contingent response that supports an auditable supply chain and lower operating expenses. Chenhall (2003) and Cadez and Guilding (2008) similarly showed that control systems deliver greater efficiency when matched to external turbulence.

Although the Technology–Organisation–Environment (TOE) framework and TCE offer useful baseline perspectives, contingency theory is the primary theory underpinning this study: TOE is a descriptive taxonomy without explicit accounting mechanics, and TCE assumes a universal drive towards transaction minimisation, whereas contingency theory recognises that WFP's cost reduction depends on the fit between its tracking infrastructure and its hostile operating environment.

3. METHODOLOGY

3.1 Population and sample

The population comprised 64 personnel responsible for inventory tracking, logistics, procurement and cost management: 25 in Maiduguri, 14 in Damaturu and 25 partner staff in Yola. Purposive sampling, which deliberately selects participants matching the study's objectives, was employed (Patton, 2002). It suited this study because it selects information-rich cases, here staff with direct working experience of automated inventory systems. Because the population was small, recruitment approached a census of eligible staff rather than a probability sample.

Yamane's (1967) formula was used only as a guide to the number of questionnaires to issue, not as a basis for claiming a probability sample or a fixed margin of error:

$$n = N / (1 + N(e)^2)$$

where n is the sample size, N is the population and e is the margin of error (0.05). Applied within each location, the formula gives:

Maiduguri ($N = 25$): $n = 25 / (1 + 25 \times 0.0025) = 25 / 1.0625 \approx 23.53$, approximately 24

Damaturu ($N = 14$): $n = 14 / (1 + 14 \times 0.0025) = 14 / 1.035 \approx 13.53$, approximately 14

Yola/Partners ($N = 25$): $n = 25 / (1 + 25 \times 0.0025) = 25 / 1.0625 \approx 23.53$, approximately 24

The location figures sum to 62, whereas the pooled formula would give about 55 (n ≈ 55.17). Both figures are close to the population of 64, so in practice almost every eligible person was invited. The number of eligible, invited and responding staff was, respectively, 25, 24 and 24 in Maiduguri; 14, 14 and 14 in Damaturu; and 25, 24 and 23 in Yola, giving 64, 62 and 61 overall. The response rate was therefore 98.4% of those invited and 95.3% of eligible staff. Since respondents were purposively selected rather than drawn at random, no 5% margin of error is claimed for the findings.

3.2 Methods of Data Analysis

Data were analysed using descriptive statistics only. Simple percentages summarised respondents' personal and professional backgrounds. Items were rated on a five-point scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree), and responses were pooled across the items in each block: nine items on the move from manual to automated systems and ten on IMT adoption and cost reduction. Percentages are therefore shares of pooled item responses, not of the 61 individual respondents. Items left blank were treated as missing and excluded from the denominator, so the valid responses in each block fall below the maximum possible (9 × 61 = 549 and 10 × 61 = 610). Respondent-level scores were not computed and no inferential test was applied; the findings describe perceptions and do not test hypotheses.

4. RESULTS

4.1 Respondent characteristics

Table 1: Distribution of Questionnaire

Description	Issued	Retrieved	Percentage
Maiduguri	24	24	39.35
Damaturu	14	14	22.95
Yola (Partners)	24	23	37.70
Total	62	61	100

Source: Field Survey, 2026

Of the 62 questionnaires issued across the three locations, 61 were retrieved and analysed. Valid responses range from 59 to 61 per question because some items were skipped, which is why the totals in Tables 2 to 4 are 59 or 60 rather than 61. Maiduguri and Yola each account for close to two-fifths of the respondents, broadly mirroring the population.

Table 2: Respondents' Educational Qualification

Location	SSCE	Nat'l Diploma	First Degree/HND	Postgraduate	Others	Total	%
Maiduguri	1	1	14	8	0	24	40.7
Damaturu	1	3	5	4	0	13	22.0
Yola (Partners)	3	3	10	4	2	22	37.3
Total	5	7	29	16	2	59	100

Source: Field Survey, 2026

A First Degree or HND was the most common qualification (29 of 59; 49.2%), followed by a postgraduate qualification (16; 27.1%), so the sample is weighted toward tertiary-educated staff, consistent with the technical roles involved.

Table 3: Respondents' Work Experience

Location	Less than 1 yr	1–5 yrs	6–10 yrs	11–20 yrs	21+ yrs	Total	%
Maiduguri	8	10	4	0	1	23	38.3
Damaturu	6	5	2	1	0	14	23.3
Yola (Partners)	9	9	4	1	0	23	38.3
Total	23	24	10	2	1	60	100

Source: Field Survey, 2026

Experience skews early-career: 24 of 60 respondents (40%) had one to five years and 23 (38.3%) less than one year, while only 13 (21.7%) had more than five years, which is common in humanitarian work where turnover is high.

Table 4: Respondents' Current Position

Location	Associate (Entry)	Associate (Support)	Officer	Coordinator	Manager	Total	%
Maiduguri	8	7	5	2	2	24	40.7
Damaturu	4	4	3	2	0	13	22.0
Yola (Partners)	6	7	5	2	2	22	37.3
Total	18	18	13	6	4	59	100

Source: Field Survey, 2026

Most respondents (49 of 59; 83.1%) held Associate or Officer-level positions with day-to-day responsibility for tracking and recording inventory, so the sample concentrates on staff who operate the technologies under study.

4.2 Distribution of responses

Table 5: Manual-to-automated transition and operational efficiency

Block	Valid responses	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Manual-to-automated transition (9 items)	540	250	190	58	24	18
Total	100	46.3%	35.2%	10.7%	4.4%	3.3%

Source: Field Survey, 2026

Table 5 pools 540 valid item responses from nine items, each answered by 59 to 61 respondents. Of these, 81.5% (440 of 540) were favourable, with 46.3% strongly agreeing and 35.2% agreeing that automated systems improve operational workflows; 10.7% were neutral and 7.7% (42 of 540) disagreed or strongly disagreed. These are shares of item responses, not of the 61 staff.

Table 6: Inventory Management Technology Adoption and cost reduction

Block	Valid responses	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
IMT and cost reduction (10 items)	600	312	200	42	29	17
Total	100	52.0%	33.3%	7.0%	4.8%	2.8%

Source: Field Survey, 2026

Table 6 pools 600 valid responses from ten items. Favourable responses made up 85.3% (512 of 600), with 52.0% strongly agreeing and 33.3% agreeing; 7.0% were neutral and 7.7% (46 of 600) disagreed or strongly disagreed. As in Table 5, the percentages refer to item responses, not to individual respondents.

4.3 Interpretation of the survey evidence

The two research questions are answered descriptively. A one-way ANOVA on the response counts is not reported, because the five Likert categories are not independent groups: the counts come from the same respondents answering the same items, so differences between category frequencies cannot show that IMT adoption changes efficiency or costs. Testing such a relationship would require respondent-level scores, separate measures of adoption and outcomes, and a stated unit of observation.

Research Question One: How do staff perceive the transition from manual to automated inventory management systems in relation to operational efficiency?

Staff perceptions were strongly favourable: 81.5% of the 540 valid responses agreed or strongly agreed that automated systems improve operational workflows (Table 5), and only 7.7% disagreed. This points to perceived gains in efficiency among the people who use the systems. It does not measure time saved, errors avoided or delays removed, which would need independent operational records.

Research Question Two: How do staff perceive the role of IMT adoption in reducing operational costs?

Perceptions of cost reduction were similarly favourable: 85.3% of the 600 valid responses agreed or strongly agreed (Table 6), and 7.7% disagreed. This shows that staff believe adoption has lowered costs; it is not evidence of an actual reduction, which would require financial records, such as cost per metric tonne delivered, losses and emergency procurement before and after adoption, net of implementation and maintenance costs.

Table 7: Analysis of Variance (ANOVA)

Sources of Variation	SS	df	MS	F	P-value	F Crit
Between Groups	4949.333	4	1237.333	107.907	0.000	2.605975
Within Groups	458.6667	40	11.46667			
Total	5408	44				

Source: Field Survey, 2026

Table 7 presents the ANOVA on respondents' views of the transition from manual to automated inventory systems. The calculated F-ratio of 107.907 exceeds the critical F-value of 2.605975 at 4 and 40 degrees of freedom, and the p-value of 0.000 is below 0.05. The null hypothesis is therefore rejected: the shift from manual to automated inventory management has a statistically significant effect on operational efficiency in WFP's operations in Northeast Nigeria.

Hypothesis Two: The adoption of IMT has no significant role in reducing operational costs for WFP in Northeast Nigeria

Table 8: Analysis of Variance (ANOVA)

Sources of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4867.257	4	1216.814	313.9201	0.000	2.689628
Within Groups	116.2857	30	3.87619			
Total	4983.543	34				

Source: Field Survey, 2026

Table 8 presents the ANOVA for Hypothesis Two. The calculated F-ratio of 313.9201 exceeds the critical F-value of 2.689628 at 4 and 30 degrees of freedom, and the p-value of 0.000 is below 0.05. The null hypothesis ($H_0 2$) is therefore rejected at the 0.05 level: IMT adoption plays a statistically significant role in reducing operational costs for WFP in Northeast Nigeria.

4.4 Discussion

Respondents overwhelmingly reported that the move from manual to automated systems improved how inventory work is done. This agrees with evidence from public-sector Ethiopia, where record-keeping, IT infrastructure and inventory accuracy were significant predictors of operational efficiency (Debala, Bhat & Khan, 2023), and with field evidence that automatic identification reduces record inaccuracy (Hardgrave et al., 2013). From a transaction-cost perspective, electronic records reduce repeated checking and reconciliation, which is costly when supervisors cannot easily reach remote sites (Williamson, 1985).

The cost-reduction block drew the strongest agreement. Modelling work supports the plausibility of such effects: improved information can raise service levels and lower cost (Ergun et al., 2012), and RFID is valuable where shrinkage is serious (Biswal et al., 2018). The present data cannot separate savings from implementation, maintenance and training costs, and a favourable perception of savings is not a measured saving.

Contingency theory suggests why benefits may differ by site (Chenhall, 2003). Power cuts, weak connectivity and insecurity can force staff back to manual procedures, and the survey does not show whether agreement was equally high at the sites with the weakest infrastructure. Offline functionality and backup power are therefore likely to matter as much as the choice of tool. A further limitation is that the percentages pool item responses and do not link scores to individual respondents, so the study cannot show how many of the 61 staff were favourable overall. Future work should combine respondent-level scores with operational and financial records.

5. SUMMARY AND RECOMMENDATIONS

5.1 Implications

WFP and partners should treat inventory automation as a control and cost programme rather than only an IT project, with minimum standards for digital stock recording and reconciliation. Donors should fund enablers such as offline capability, backup power and training alongside hardware and software.

5.2 Conclusion

Staff of WFP and its partners in Northeast Nigeria overwhelmingly perceived that automated inventory systems have improved operational efficiency (81.5% of 540 valid item responses favourable) and that IMT adoption has reduced operational costs (85.3% of 600 valid item responses favourable). These are perceptions: the survey did not measure actual time savings or cost reductions, and no hypothesis was tested statistically. The findings support continued and selective investment in integrated inventory technology, provided that infrastructure, training and maintenance are funded and that actual savings are verified against operational and financial records.

5.3 Recommendation

WFP Northeast Nigeria should continue, strengthen and selectively expand automated inventory management, supported by offline functionality, backup power, connectivity, training and maintenance. Because staff perceive clear benefits, IMT should be treated as a control and cost-management tool rather than merely an IT investment, with its savings verified rather than assumed.

WFP should also establish a monitoring framework to measure actual savings through indicators such as stock-record accuracy, reconciliation time, inventory losses, emergency procurement and cost per metric tonne delivered, so that perceived benefits become verified improvements.

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