



**ASSESSMENT OF FARM MACHINERY UTILIZATION AND TURNOVER RATIO
PATTERN IN IRRIGATION SCHEMES OF KWARA AND KOGI STATES (A Case of
Lower Niger River Basin Development Authority, Nigeria)**

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ABSTRACT

The optimum utilisation of farm machinery and good turnover pattern constitute strategic management procedure for transforming public agricultural mechanisation from accelerated system to active commercial activities to promote food sufficiency and reduce rate of unemployment in Nigeria. This study investigated the systemic operational and institutional factors responsible for underutilisation and poor financial turnover patterns in five prominent public irrigation schemes operated by Lower Niger River Basin Development Authority (LNRBDA) across Kwara and Kogi State, Nigeria: Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan. Primary data were obtained through the administration of 105 structures questionnaires to technical and administrative personnel, coupled with secondary financial institutional records extracted from internal requisition log-books and financial year booklets spanning 2012 – 2024 for cross validation. Empirical evaluation focused on the relationship between annual farm machinery utilisation hours, operation and maintenance, failure rates and technical literacy as the independent variables and Total Asset Turnover (TAT) ratios as the dependent variables, establishing predictive models using linear regression analysis. The findings indicate that peak utilisation hours across all schemes ranged from a minimum of 211.70 hours in Patigi to maximum of 768.8 hours in Ejiba fall drastically short of the internationally recommended standard of 1000 hours of optimum utilisation hours per annum. Mean asset turnover ratios remained chronically suppressed across all studied areas: Tada-Shonga (0.53), Patigi (0.53), Oke-Oyi (0.62), Ejiba (0.46) and Giriyan (0.60). The uniform under-performance highlights a structural crisis driven by extreme budgetary imbalances (where operations and maintenance funding was strictly pegged at 2.50% of capital allocations), low technical literacy among operators, and a reliance on corrective breakdown maintenance rather than proactive management. Linear regression models validate that operational utilisation hours, operation and maintenance, failure rates and technical literacy serve a statistically robust predictor of investment sustainability. Specifically, this research provides private investors and public agricultural sectors with an empirical framework to correlate machinery utilisation index and financial turnover driving strategies to promote mechanisation and Sustainable Development Goals (SDGs) in public agricultural investments.

Keywords: Farm machinery utilisation, utilisation hour, technical literacy, asset turnover patterns, linear regression, investment sustainability,

INTRODUCTION

The optimum utilisation of farm machinery and good turnover pattern is a strategic management procedure for transformation of active commercial agricultural activities to promote food sufficiency and reduce rate of unemployment in Nigeria (Peng *et al.*, 2022). In a real-time investment, profit values and effective turnover ratio serve as bedrock for agricultural mechanisation investment. Odey and Uzowulu (2019) and Kefas *et al.* (2024) emphasised that scaling up a country's mechanisation activities is key to fulfilling related Sustainable Development Goals (SDGs).

According to Emmanuel (2015) and Ahiakwo and Isirima (2023), the standard utilisation hour of farm machinery should be 1000 hours per annum for effective productivity that yields good turnover pattern for investment sustainability. The sensitisation programme for proper utilisation of farm machinery was carried out in the three regions of Nigeria to strengthen the relationship between total asset utilisation and total turnover pattern for re-investment among the small scale farmers in the country. This objective failed due to poor utilisation of farm machinery, lack of loyalties in handling government investment and poor maintenance activities (Ntagu *et al.*, 2022; Ale *et al.*, 2024).

Pandey and Bhat (2015) and Tetteh *et al.* (2023) asserted that turnover pattern is an index used to determine the efficiency of an investment. This indicator can be used to convert assets of an investment to revenue generation and it is a starting point for investors in forecasting and planning procedures of an investment. Therefore, continuous investment in agricultural machinery for stable food and economic sustainability in Nigeria requires efficient operational management and good financial performance (Ale *et al.*, 2024). Langemeier and Ibendahi (2020) carried out a research work on crop machinery investment per acre and machinery cost per acre related to the total asset turnover and also observed that the negative values indicate an inverse relationship between the machinery cost per acre and its asset turnover, this implies that as investment in machinery increases, its asset turnover efficiency decreases and established a benchmark of 65% as the stable turnover for reinvestment.

The previous studies highlighted some factors that were responsible for underutilisation of farm machinery in Nigeria such as low profit margin, lack of technical and managerial competence to handle maintenance activities. Moreover, lack of technical know-how at the point of acquisition and the high cost of operation and maintenance of farm machinery make it difficult for average Nigerian farmers to privately own heavy-duty farm machinery that could enhance agricultural

mechanisation and sustainability in Nigeria (Dauda *et al.*, 2010; Ale *et al.*, 2024). It is important to ascertain the various key parameters associated with the cost of owning and operating farm machinery to enable the investors determine the level of its effective utilisation for profit maximization (Oduma *et al.* 2023).

According to Simon-Ilogho (2025), the determination of turnover pattern is a major problem in public and private agricultural sectors in Nigeria which hindered profit maximisation and reduce the investment sustainability of farm machinery. Adequate knowledge of the performance data of the available farm machinery to create relationship between total asset utilisation and total turnover pattern is required to promote agricultural mechanisation system in Nigeria (Simon-Ilogho, 2025). Meanwhile, various authors have carried out studies on tractor utilisation in Nigeria, but there is no established study on relationship between machinery utilisation hours and financial asset turnover in public irrigation schemes. Therefore, this study established the relationship between farm machinery utilisation and turnover pattern in public agricultural irrigation schemes in Lower Niger River Basin Development Authority (LNRBDA), Nigeria to improve investment sustainability in agricultural machinery management.

METHODOLOGY

Study Area

The research work was conducted in five viable irrigation schemes. These include: Tada-Shonga, Patigi, Oke-Oyi irrigation schemes in Edu, Patigi and Ilorin-East Local Government Areas of Kwara State, respectively. The other schemes are Ejiba and Giriyan in Yagba-West and Kotonkarfe Local Government Areas of Kogi State, respectively. Table 1 shows the Longitude and Latitude of the study area with a total land area between 500 – 5000 ha (LNRBDA Planning Directorate, 2015).

The rainfall patterns of the schemes are bimodal with the cropping pattern of wet and dry season and the annual rainfall ranges between 1500 – 2200 mm. The annual temperature ranges between 25 – 33°C and the area consists of upland and *fadama* which are suitable for the cultivation of crops such as maize, guinea-corn, rice, vegetables and sugarcane. Figure 1 illustrates the map of the study area which is on a scale of 1:50,000 as produced in 2015.

Table 1: Latitude and Longitude of the study area

S/N	Scheme	L.G.A	Latitude	Longitude	Area (ha)
1	Tada-Shonga	Edu	9.02°N	5.15 °E	5000
2	Patigi	Edu	8.73 °N	5.76 °E	500
3	Oke-Oyi	Ilorin-East	8.58 °N	4.72 °E	500
4	Ejiba	Yagba-West	8.30 °N	5.63 °E	4500

Source: LNRBDA, Planning and Design Unit (2015)

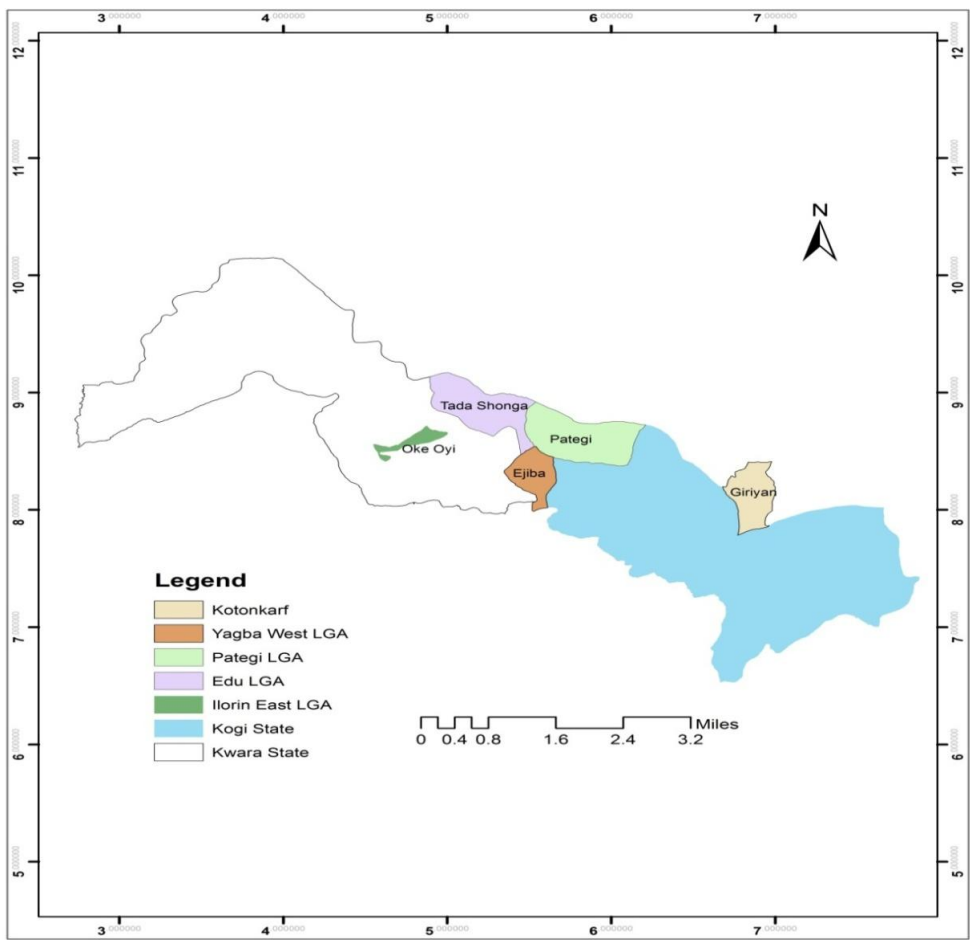


Figure 1: Map of the study area

Source: LNRBDA Planning Directorate, (2015)

Sampling Procedures and Data Collection

This study used a mixed-methods research design. Primary data were obtained using structured questionnaires targeting scheme participants, technical personnel and engineers in the schemes. The sample size determination was calculated using proportional allocation (N_n) formula developed by De Vera *et al.* (2022) as presented in Equation 1 and one hundred and five (105) questionnaires were administered to the relevant personnel and the participants in the selected schemes. This procedure was carried out to collect relevant information on educational level, demographic status, maintenance culture in various schemes as a qualitative insights data.

$$N_n = \frac{N_h}{N} \tag{1}$$

where:

N_n : proportional allocation

N_h = baseline population within specific irrigation scheme (h)

N = cumulative baseline population across the entire LNRBDA scheme ($N = 345$)

The baseline population distribution (T_n) was derived in the schemes as presented in Equation 2

$$T_n = N_1 + N_2 + N_3 + N_4 + N_5 \tag{2}$$

where N_1, N_2, N_3, N_4, N_5 are the population at Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan schemes with corresponding population values of 73, 30, 69, 124 and 49 and a total population of the five schemes to be 345 respectively. Thus, the calculated samples using Equations 1 and 2 were presented in Table 2.

Table 2: Proportion allocation of questionnaires distributed in the irrigation schemes

Irrigation scheme	Baseline Population (N_h)	Stakeholder	Calculated sample	Distributed questionnaires
Tada-Shonga	73		22.20	22
Patigi	30		9.10	9
Oke-Oyi	69		21.00	21
Ejiba	124		37.80	38
Giriyan	49		14.90	15
Total	345		105	105

Data Source Allocation and Memory-Bias Mitigation

To ensure strict econometric validity and eliminate retrospective recall bias (respondent memory decay over 13-year timeline), a rigorous data source allocation was enforced. Specifically, no operational or financial indicators ranging the 2012-2024 panel longitudinal frameworks were generated through unstructured historical memory reconstruction. However, variables were strictly allocated to their primary institutional and physical source origins as follows:

- i. Institutional Financial Variables (TAT and Operation and Maintenance, O&M): continuous annual time –series observations for Annual Revenue Generated (ARG), initial machinery procurement costs, annual average operating expenses and localised operation and maintenance budgetary pools were extracted directly from the audited LNRBDA financial year booklets and official financial ledgers published at the close of each respective fiscal cycle between 2012 and 2024.
- ii. Physical Machinery Run-Times (U_{hr}): continuous machine operational data were compiled directly from physical, on-site mechanical

tachometer readings and daily operator logbooks maintained by the scheme engineering departments. The structured questionnaires distributed to technical personnel were restricted to validating current operational capacities, cross-checking specific historical data points and categorizing qualitative management frameworks.

iii. Mechanical Reliability Indicators such as Failure Rate (FR), Mean Time Before Failure (MTBF) and Mean Time To Repair (MTTR): Machinery failure rates and breakdown histories were extracted directly from institutional workshop requisition ledgers, job cards and spare parts replacement records kept by the central workshop and engineering maintenance units.

iv. Demographic and Human Capital Metrics ($Lit_{i,t}$): The technical literacy index of the active workspace was the primary variable captured directly from the current structured questionnaire responses (N=105) which recorded verified educational qualifications (certificates, technical school diplomas and formalized mechanical training records) of active scheme personnel. Moreover, to resolve minor discrepancies between field questionnaires and administrative ledgers, an ex-post data triangulation matrix was applied within $\pm 5\%$ using Equation 3 (Olayanju *et al.*, 2022).

$$D_v = \frac{V_s - V_a}{V_a} \times 100 \quad (3)$$

where:

D_v = Relative variance index

V_s = Field Survey questionnaires variable

V_a = Audited archive financial year booklets or workshop requisition logs

Secondary Institutional Validation Data

To cross validate the primary survey responses, secondary institutional data were extracted directly from internal requisition log-books, technical repair registers and audited financial year booklet covering 2012 – 2024 operating years. These datasets provided comprehensive records of annual capital budget appropriations, operation and maintenance disbursements, physical asset machinery records and Annual Revenue Generated (ARG). To quantify the empirical impact of field operations on financial performance, an OLS linear regression analysis was conducted utilizing the aggregated 13 year datasets from LNRBDA schemes. The final OLS estimation model was constructed based on the a total of 65 distinct data observations, derived from the evaluation of five separate schemes across the 13 years study period (5 schemes x 13 years = 65).

Mathematical Modeling of Engineering and Financial Performance Variables

To evaluate the operational efficiency and economic viability of the studied, a structured mathematical modeling was established. This approach allows for the quantification of technical

engineering capacities alongside financial performance index, translating physical field data into actionable indicators. The engineering performance in the schemes operations primarily relates to capacity utilisation, degree of mechanisation and structural distribution across the schemes. Moreover, to compliment the technical engineering variables, financial performance models are also integrated to assess the economic sustainability of the irrigation schemes.

Determination of percentage of farm machinery in the irrigation schemes

Total percentage of farm machinery in each irrigation scheme was obtained using Equation developed by Olayanju *et al.* (2022) as presented in Equation 4.

$$M_{\%} = \frac{N_m}{T_m} \times 100\% \quad (4)$$

where:

$M_{\%}$ = percentage of farm machinery

N_m = number of machinery

T_m = total number of farm machinery

Determination of degree of mechanisation

The Equation established by Adetarami *et al.* (2025) was used to determine degree of mechanisation as illustrated in Equation 5.

$$MD = \frac{S_k}{T_s} \quad (5)$$

where:

MD = degree of mechanization

S_k = area under mechanized operations (ha)

T_s = total commanded area (ha).

Determination of utilisation and capacity utilisation indices

The utilisation index (UI) was also determined using Equation 6 as developed by Al-Suhail and Al-Sabah (2024).

$$UI = \frac{M_1 - M_2}{M_1} \times 100 \text{ per operation} \quad (6)$$

Where:

M_1 = maximum operating hours / day

M_2 = minimum operating hours / day

Khan *et al.* (2015) defined capacity utilisation index (CUI) of farm machinery as the ratio of total numbers of hectare of land cultivated per year (ha/yr) as shown in Equation 7:

$$CUI = \frac{\text{Total hectares}}{\text{Year}} \quad (7)$$

The Equation 9 was re-modified to monthly data as presented in Equation 8 to determine CUI.

$$CUI = \frac{\text{Total hectares}}{\text{Month}} \quad (8)$$

Determination of failure rate

Mkalaf (2015) developed Equation for determination of failure rate as presented in Equation 9

$$F_r = \frac{1000 * F_n}{U_p} \quad (9)$$

where:

F_r = failure rate

F_n = number of failures

U_p = total operating time per years

Determination of meantime between failures

$$MTBF = \frac{U_p}{F_n} \quad \text{Ahmad and Khan (2015)} \quad (10)$$

where:

$MTBF$ = meantime between failure

U_p = utilisation period

F_n = number of failures

Determination of meantime to repair

$$MTTR = \frac{R_t}{F_n} \quad \text{Sanga et al. (2015)} \quad (11)$$

where:

$MTTR$ = meantime between failure

R_t = repair time

F_n = number of failures

Determination of total asset turnover ratio

The Total Asset Turnover (TAT) is an indicator to assess the efficiency and economic sustainability of the investment. Thus, Equation 12 was used to determine TAT ratio in the irrigation schemes as developed by Pandey and Bhat (2015) and Luu Thu (2023).

$$TAT = \frac{A_{RG}}{C_m + A_{AOE}} \quad (12)$$

where:

A_{RG} = annual revenue generated

C_m = cost of machinery

A_{AOE} = average annual operating expenses

Predictive Linear Regression Modeling

To replace traditional descriptive trends with a verifiable framework, this study used a Ordinary Least Squares (OLS) linear regression model. The 13 year dataset (5 schemes over 13 years, creating n = 65 observations) was used to analyse how primary operational field parameters and secondary budget structures determine economic output (TAT). This model treats TAT as the dependent financial variables, driven by annual farm machinery utilisation hours (U_{hr}), operation

and maintenance ($OM_{i,t}$), failure rate ($FR_{i,t}$) and technical literacy ($Lit_{i,t}$) as the primary independent predictor as presented in Equation 13.

$$TAT = B_0 + B_1U_{hr} + B_2(OM_{i,t}) + B_3(FR_{i,t}) + B_4(Lit_{i,t}) + \phi \quad (13)$$

where:

B_0 = intercept parameter representing the theoretical asset turnover when utilisation hours are zero

B_1, B_2, B_3, B_4 = regression coefficient quantifying the expected change in TAT for additional hour of machinery operation

U_{hr} = annual utilisation runtime of farm machinery (h/yr)

$OM_{i,t}$ = ratio of operational maintenance funding capital allocation calculated from financial booklets

$FR_{i,t}$ = mean machinery failure rate (%) calculated from technical field performance data.

$Lit_{i,t}$ = stakeholder technical literacy index, measured as the percentage of the scheme participants possessing secondary or higher formal education degrees from the questionnaire data

Φ = stochastic error term capturing unexplained field variance

RESULTS AND DISCUSSION

Response Indicator

Table 3 presents the responses from the structured questionnaires for the irrigation schemes considered in this study. A total number of 105 questionnaires were distributed and 93 were received amounting to 89% of response. Tada-Shonga and Ejiba irrigation are the major schemes among the other irrigation schemes selected for this study. Oke-Oyi and Ejiba irrigation schemes received the highest number of administered questionnaires and the total percentage of responses was 93% and the lowest number of questionnaires administered was obtained from Giriyan irrigation scheme with 73% of responses.

Table 4 illustrates the socio-economic characteristics of the participants with respect to level of education. The interval 0, 1- 6, 7-12, 12-20 represent the educational level of all the stakeholders in the schemes ranging from 0 as illiterates, 1- 6 (primary school level), 7-12 (secondary level) and 12-20 (Higher degrees). Table 4 also revealed that 53% of the respondents are illiterates and has no educational qualification. These illiterates are actively involved in the farming activities, while respondents with primary and secondary school certificate possessed 13.6% and 14.8%, respectively. The participants with primary school certificate were the major technical personnel found in the operation and maintenance activities in the irrigation schemes. The low level of their education has contributed to inadequate understanding of technicality and basic process of operation incorporated in the operator's manual attached to the farm machinery which served as a guide for standard operation and optimum utilisation capacity of farm machinery. Moreover,

the low level of their education is associated with the serious setback in adopting high-tech and made most of the technical personnel to rely more on the traditional approach rather than modern-tech solution for the maintenance and utilisation of farm machinery. Other factors such as poor troubleshooting and inefficient resource management and poor record keeping of the previous repair and maintenance due to their low level of education are also responsible for the failure to achieve optimum utilisation of farm machinery in the schemes.

Table 3. Responses from questionnaires distributed for each project.

Project	Location (LGA)	Questionnaires Distributed (No.)	No. of Response (No.)	Rate of Response (%)
Tada-Shonga	Edu	22	20	90
Patigi	Patigi	9	8	87
Oke-Oyi	Ilorin-East	21	20	93
Ejiba	Yagba-West	38	35	93
Giriyari	Koto-karifi	15	11	73
Total		105	93	89

Table 4. Stratified educational level of scheme workforces

Project	Total No. of Participants	Educational Level			
		No formal certificate (0)	Primary level (1 – 6)	Secondary level (7 – 12)	Higher Degree level (12 – 20)
Tada-Shonga	73	45	6	9	13
Patigi	30	17	4	5	4
Oke-Oyi	69	30	13	12	14
Ejiba	124	65	15	19	25
Giriyari	49	25	9	6	9
Ground Total	345	182	47	51	65
Total Percentage		52.80%	13.60%	14.80%	18.80%

The managerial coordinators which form 18.8% of the respondents in the irrigation schemes possess academic qualifications of HND and M.Sc. degree. Farm machinery utilisation required high skilled handling and proper scheduling. The low percentage of managerial coordinators causes operator-abuse overrunning the engines more than the schedule period of maintenance and forcing the engine to untimely breakdown which leads to under utilisation of farm machinery

in the schemes. The lack of oversight by the coordinators in the schemes due to level of their percentage has also shifted the preventive maintenance to total breakdown maintenance (corrective maintenance) and in the long run resulted to high cumulative costs of repairs and maintenance.

Result of Percentage of farm machinery, degree of mechanisation and utilisation index of farm machinery in the irrigation schemes

Table 5 gives the detail analysis of total percentage of farm machinery and equipment available in each irrigation scheme for this study as extracted from the internal requisition logbook. The total farm machinery at Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan irrigation schemes were 206, 48, 169, 197 and 139 respectively. Farm machinery composition data showed that annual procurement favored heavy tillage implements (disc ploughs, harrows) and irrigation pumps at Patigi, Tada-Shonga and Oke-Oyi with corresponding values of 31.3, 18.9 and 15.3% while weeding implement, fertiliser applicators and boom-sprayer were neglected. This imbalance limited full-cycle mechanisation, keeping overall asset utilisation and degree of mechanisation low.

Table 6 illustrates the degree of farm mechanisation for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan schemes with the corresponding values of 40.50%, 24.50%, 20.00%, 46.70% and 6.30%, respectively. The results show that Ejiba irrigation scheme has the degree of mechanisation while Giriyan irrigation scheme has the lowest degree of mechanisation. This result supported the findings of Oduma *et al.* (2019) that degree of mechanisation below 50% is low and such sectors possessing this value is under-utilised which failed to address agricultural mechanization sustainability in public irrigation schemes.

Table 7 illustrates the annual appropriation budgetary allocation from 2012-2024 in the irrigation schemes. The data reveals a consistent and significant disparity between the capital allocation and operation and maintenance across all schemes (Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan) and operation and maintenance budget was pegged at exactly 2.50% of the capital allocation. This stagnant percentage of 2.50% was responsible for the setback in maintenance activities across the schemes and forced idleness of farm machinery to achieve standard 1000 h per annum. This corroborates the findings established by Oduma *et al.* (2019) that less than 10% of capital allocation of operation and maintenance will lead to serious setback in maintenance and increase failure rates. However, in the year 2012 – 2024 there were steady growth in capital allocation across the irrigation schemes and the effect on farm machinery reveal that there were high potential for new machinery acquisition. Then in the year 2017 – 2018 there were significant fluctuations and the capital dropped from ₦15 million to ₦5 million at Oke-Oyi. The rapid reduction in the capital allocation did not allow expansion of fixed asset. Therefore, in the

year 2020 – 2024 there were gradual recovery and peak funding at Tada-Shonga schemes reaching ₦30 million which favour farm machinery expansion but there were persistent 2.50% of operation and maintenance allocation that suggests high risk of premature machinery failure and low utilisation of farm machinery in the schemes.

Table 5: Total percentage of farm machinery and equipment in each irrigation scheme

Farm Machinery	Tada-Shonga	Patigi	Oke-Oyi	Ejiba	Giriyán
Tractor	18.90	10.40	15.90	25.90	6.50
Boom sprayer	5.80	4.20	3.60	7.60	3.60
Fertilizer spreader	0.97	0.00	0.60	1.00	7.20
Trailer	5.33	6.30	6.50	5.60	25.20
Disc plough	16.00	14.50	19.50	19.80	25.20
Ridger	13.60	12.50	14.20	14.20	3.60
Disc harrow	15.50	14.50	18.90	16.20	10.10
Planter	1.94	2.08	2.40	5.10	1.40
Thresher	2.42	4.20	3.00	5.10	2.90
Irrigation pump	18.90	31.30	15.30	1.50	10.10
Rice-mill	0.49	0	0	0	0.80

Table 6: Degree of farm mechanisation in the five selected irrigation schemes

Scheme	Total Area (ha)	Total Commanding Area (ha)	Major Available Power (kW)	Mechanization Degree (%)
Tada-Shonga	4200	1700	55.95	40.50
Patigi	500	100	55.95	20.00
Oke-Oyi	500	120	55.95	24.00
Ejiba	4500	2100	55.95	46.70
Giriyán	3200	200	55.95	6.30

Tada-Shonga irrigation scheme displays the most consistent growth of annual capital allocation that suggests long-term machinery scheduling and higher field capacity and Oke-Oyi scheme experienced rapid dropping in 2016 and spiking in 2020 which really affect the optimum utilisation due to poor funding of operation and maintenance. Specifically, the irrigation schemes recorded poor funding for operation and maintenance in the year 2016 - 2018 ranging from ₦125,000:00K - ₦190,000:00K which failed to support standard utilisation hours and lead to low utilisation of farm machinery across all the selected irrigation schemes.

Table 7: Annual appropriation budgetary allocation from 2012 -2024 in the selected irrigation schemes

SCHEME	TADA- SHONGA		PATIGI		OKE-OYI		EJIBA		GIRIYAN	
YEAR	CAPITAL ALLOCATION ₦ : K	OPERATION & MAINTENANCE ₦ : K	CAPITAL ALLOCATION ₦ : K	OPERATION & MAINTENANCE ₦ : K	CAPITAL ALLOCATION ₦ : K	OPERATION & MAINTENANCE ₦ : K	CAPITAL ALLOCATION ₦ : K	OPERATION & MAINTENANCE ₦ : K	CAPITAL ALLOCATION ₦ : K	OPERATION & MAINTENANCE ₦ : K
2012	21,100,150:00	527,503:75	15,7789,000:00	394,725:00	15,700,011:67	392,500:29	23,646,837:00	591,170:93	15,700,011:67	392,500:29
2013	23,222,207:00	580,555:18	19,781,797:00	494,544:93	15,131,749:00	378,293:73	24,229,512:00	605,737:80	15,585,738:00	389,643:45
2014	22,368,710:00	559,217:75	21,400,000:00	535,000:00	16,136,734:50	403,418:36	25,446,813:00	636,170:33	17,554,606:00	438,865:15
2015	22,543,154:88	563,578:87	16,700,000:00	417,500:00	15,000,000:00	375,000:00	14,000,000:00	350,000:00	15,000,000:00	375,000:00
2016	25,500,000:00	637,500:00	22,760,000:00	569,000:00	5,000,000:00	125,000:00	20,000,000:00	500,000:00	10,000,000:00	250,000:00
2017	26,000,000:00	650,000:00	7,613,966:80	190,349:17	8,000,000:00	200,000:00	32,000,000:00	800,000:00	20,000,000:00	500,000:00
2018	26,465,500:00	661,637:50	14,578,900:00	364,472:50	5,000,000:00	125,000:00	15,000,000:00	375,000:00	5,000,000:00	125,000:00
2019	27,700,000:00	692,500:00	14,400,000:00	360,000:00	6,100,000:00	152,500:00	22,500,000:00	562,500:00	24,615,776:00	615,394:40
2020	28,950,450:85	723,761:27	19,865,900:00	496,647:50	30,000,000:00	750,000:00	25,450,500:00	636,262:50	25,000,052:00	625,001:30
2021	28,750,350:00	718,758:75	22,500,600:00	562,515:00	31,500,400:00	787,510:00	35,075,000:00	876,875:00	25,650,300:00	641,257:50
2022	26,560,500:00	664,012:50	21,980,350:00	549,508:75	32,567,800:00	814.195:00	27,400,300:00	685,007:50	30,050,600:00	751,265:00
2023	32,450,750:00	811,268:75	19,950,300:00	498,757:50	15,200,00:00	380,000:00	31,250,000:00	781,250:00	19,600,000:00	490,000:00
2024	30,650,780:00	766,269:50	19,870,450:00	496,761:25	22,500,000:00	562,500:00	32,570,600:00	814,265:00	25,780,450:00	644,511:25

Table 8a presents the type of maintenance activities in the irrigation schemes. These are classified into Reliability Centered Maintenance (RCM), Total Productive Maintenance (TPM) and Mixed Measure Maintenance (MMM). The RCM shared 57.8%, 63.2%, 65.9%, 68.2% and 55.6% for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan irrigation schemes, respectively. Total Productive Maintenance (TPM) possess 15.50%, 10.90%, 16.40%, 18.40% and 9.80% for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan irrigation schemes while Mixed Measure Maintenance (MMM) also possess 26.70%, 25.90%, 17.70%, 13.30% and 34.60% for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan irrigation schemes, respectively.

The low value of TPM was due to inadequate provision of annual budgetary allocation for maintenance activities on yearly basis and failed to strengthen standard utilisation of 1000 hours. Moreover, it impedes the successful economic sustainability in the schemes. Table 8a also presents the percentage of failure rate for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan schemes with corresponding values of 71.90%, 69.10%, 52.70%, 74.30% and 53.20%, respectively. Ejiba irrigation scheme recorded highest percentage of failure rate (74.30%) which hindered adequate support for utilisation hour and good turnover in the scheme.

Table 8b illustrates the maximum, average and minimum utilisation hours of farm machinery in the irrigation schemes for the period of 2012 – 2024. Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan had maximum utilisation hours of 762.50, 586.70, 684.20, 768.80 and 637.50 hours, respectively. The average utilisation hours obtained for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan were 556.30, 399.20, 498.40, 556.10 and 429.20 hours while the minimum utilisation hours were 350, 211.70, 312.30, 343.30 and 220.80 hours, respectively. The results support the findings of Emmanuel (2015) and Oduma *et al.* (2019) that any utilisation hour which is below the global standard of 1000 hours of utilisation is low.

Result of total asset turnover pattern for the selected irrigation scheme

Figures 2a-e present the total asset turnover patterns for Tada-Shonga, Patigi, Oke-Oyi, Ejiba and Giriyan irrigation scheme respectively for the year 2012 - 2024. Figure 2a illustrates the value of 0.58 at Tada-Shonga as the highest turnover from 2012 - 2018 indicates the farm machinery utilisation generated highest output turnover to its total asset. In 2019, there were sharp falls of the turnover of 0.43 which suggests significant operational challenges of farm machinery utilisation. Moreover, in the year 2020, there were clear and steady downward trend untill 2024 which reveals declines in asset utilisation efficiency.

Table 8a: Failure rate, utilization period, repair time and maintenance strategies between 2012 – 2024.

Selected irrigation	No. of failures	Utilization period	Failure rate	% of maintenance strategies/year		
Schemes	(FN)	(UP)	(FR) (%)			
	(n)	(n)		Reliability centered maintenance (RCM)	Total productive maintenance (TPM)	Mixed measure maintenance (MMM)
Tada-Shonga	256	3562	71.90	57.80	15.50	26.70
Patigi	156	2258	69.10	63.20	10.90	25.90
Oke-Oyi	135	2562	52.70	65.90	16.40	17.70
Ejiba	242	3256	74.30	68.20	18.50	13.30
Giriyani	143	2687	53.20	55.60	9.80	34.60

Table 8b: Annual utilisation hours and seasonal pattern of utilisation from 2012 – 2024

Selected irrigation Schemes	Total max. hrs	Total max. hrs/yr	Total avrg hrs	Total avrg hrs/yr	Total min hrs	Total min hrs/yr	Seasonal pattern of utilization		
							April – Aug	Aug – Oct	Oct –Dec
Tada-Shonga	9,150	762.50	6,675	556.30	4,200	350	Tillage operation	Tillage operation	Farm transportation
Patigi	7,040	586.70	4,790	399.20	2,540	211.70	Tillage operation	Tillage operation	Farm transportation
Oke-Oyi	8,210	684.20	5,981	498.40	3,751	312.60	Tillage operation	Tillage operation	Farm transportation
Ejiba	9,225	768.80	6,673	556.10	4,120	343.30	Tillage operation	Tillage operation	Farm transportation
Giriyani	7,650	637.50	5,150	429.20	2,650	220.80	Tillage operation	Tillage operation	Farm transportation

The declining trend in year 2021 – 2024 also suggests that while the assets utilisation remains steady, there was increasingly under utilisation of farm machinery that correlates with the expansion of fixed asset (i.e farm machinery). Still output does not corroborate the utilisation process to have optimum utilisation hour and good turnover pattern. The consistent average values of turnover obtained between the range of 0.5 – 0.6 imply that for every amount of ₦1 invested in assets in Tada-Shonga scheme, only ₦0.55 in output value is generated which indicate systemic inefficiencies in machinery scheduling. This finding corroborated the assertion established by Langemeier and Ibendahi (2020) that TAT ratio below 0.65 has negative effects on operational efficiency and economic sustainability of the investment.

Figure 2b describes the TAT for Patigi irrigation scheme from 2012 – 2024. The result revealed a pattern of structural decline. In the year 2012 – 2014, the scheme maintains a value of 0.55 as the highest turnover ratio within this period and there was relatively high productivity in maximising total asset in the scheme. Starting from 2015, Patigi irrigation scheme shows a consistent year- to -year erosion of asset efficiency up to 2018, while in the year 2019, the turnover scaled up to 0.43 and there were serious terminal declines from 2021 – 2024. In 2021 – 2024, the turnover value fell to 0.45 indicating that the vast majority of the total assets were effectively grounded and the farm machinery were poorly utilised, which suggests more severe decayed of farm machinery, as established by Ibrahim and Yakubu (2025).

Figure 2c also illustrates the total asset turnover for Oke-Oyi irrigation scheme ranging from 2012 – 2024. The analysis reveals that the TAT showed general decline from 2014 and 2021, and a much more severe decline occurred in 2021. The TAT at Oke-Oyi maintained a consistently high level performance in the early years of 2012 – 2016, with corresponding value of 0.62 indicating a period of high managerial efficiency in farm machinery utilisation relative to total asset turnover. In the year 2021, the value of TAT is 0.48. This is a significant outlier compared to the previous years, and there were severe under utilisation of farm machinery. There were recovery attempts to improve utilisation of farm machinery in the year 2022, with a value of 0.56, but it failed to reach normal value of TAT 0.60 in the pre-year of 2020 period. In the years 2022 – 2024, there were

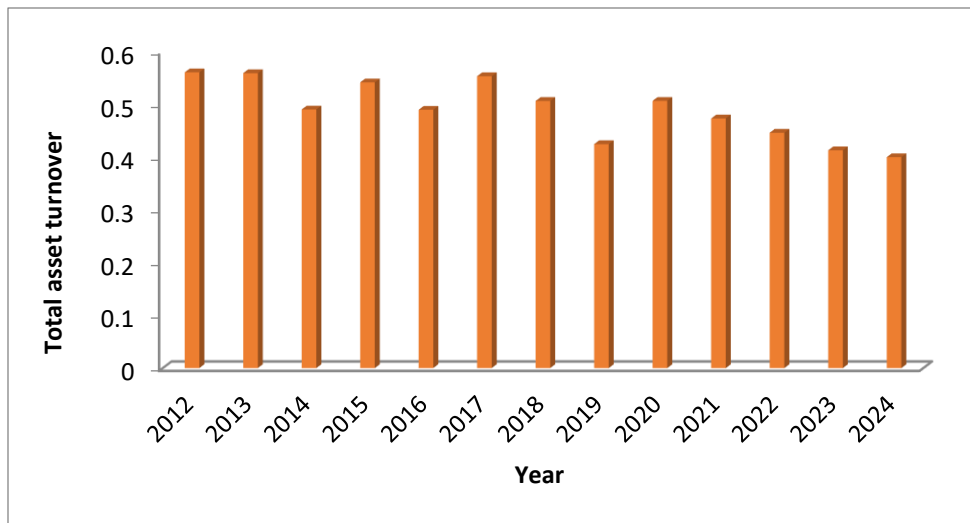


Figure 2a. Annual turnover ratio trend for Tada-Shonga irrigation scheme (2012-2024)

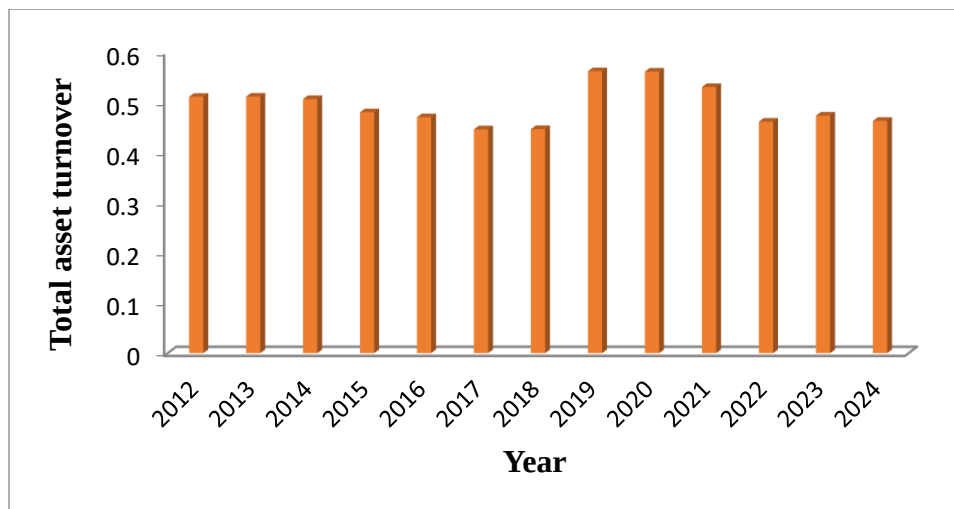


Figure 2b. Annual turnover ratio trend for Patigi irrigation scheme (2012-2024)

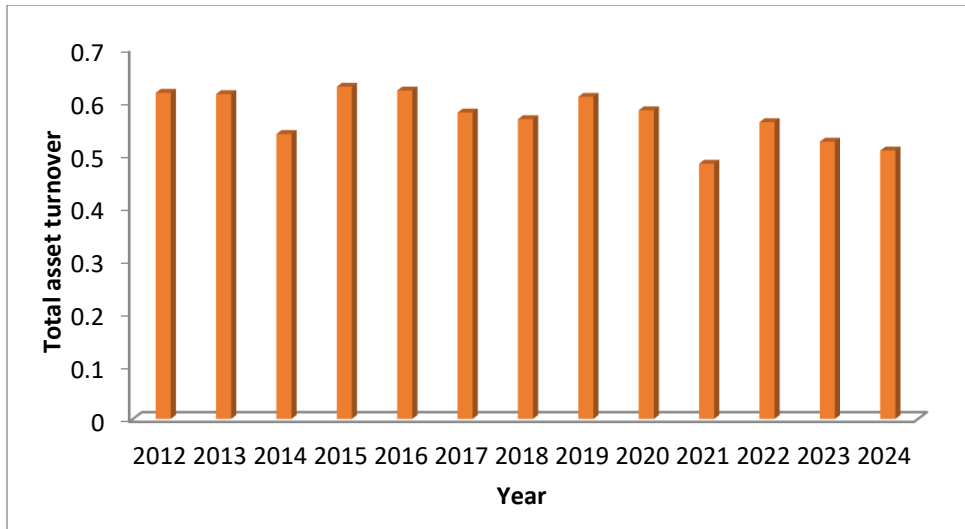


Figure 2c. Annual turnover ratio trend for Oke-Oyi irrigation scheme (2012-2024)

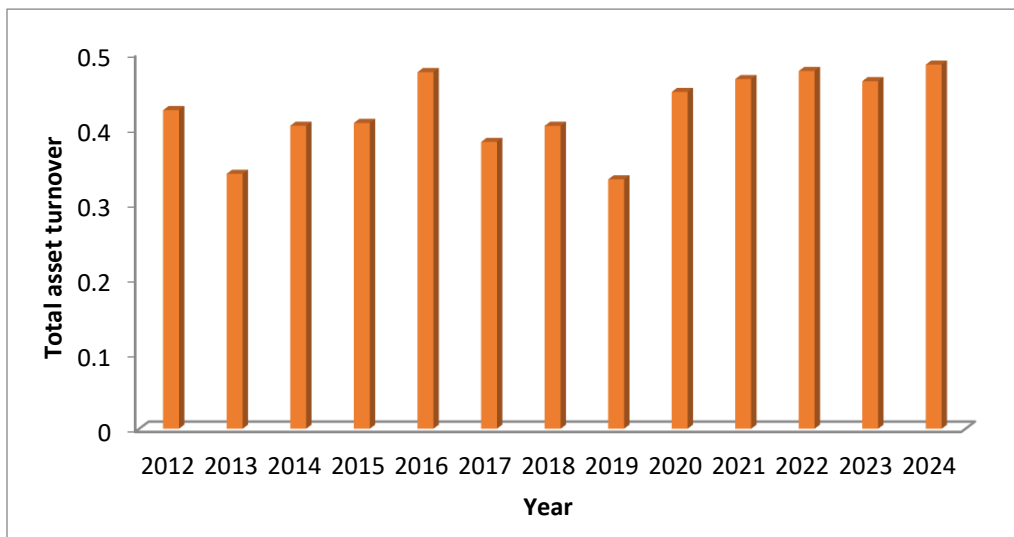


Figure 2d. Annual turnover ratio trend for Ejiba irrigation scheme (2012-2024)

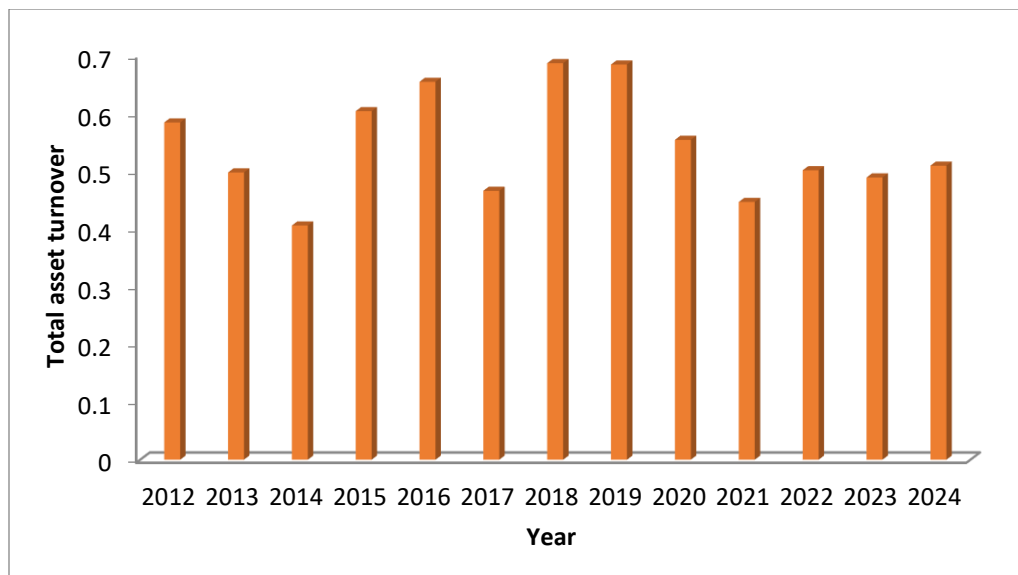


Figure 2e. Annual turnover ratio trend for Giriyan irrigation scheme (2012-2024)

systemic issues of exhaustion of downward TAT, approaching 0.52 indicating low operation of farm machinery in the scheme.

Figure 2d highlighted the total asset turnover for Ejiba irrigation scheme from 2012 – 2024. There was adequate resurgence pattern, making it a distinct outlier compared to Tada-Shonga, Patigi and Oke-Oyi irrigation schemes. There were two major crashes in efficiency at Ejiba scheme. The first occurred in 2013 when the TAT value dropped to 0.35 and the second occurred in 2019 with the TAT value of 0.33. In the 2014 - 2018 period, the performance was inconsistent but reach peak value of 0.47 in 2016 before entering a three-year decline suggesting aging of farm machinery in the Ejiba scheme. In 2024, the TAT value was 0.48 which also indicates unprecedented period of growth in farm machinery utilisation efficiency.

Figure 2e revealed the TAT for the Giriyan scheme from 2012 – 2024. The result revealed the similar trend of turnover pattern across all the irrigation schemes. In the year 2014 and 2017, the TAT experienced sharp decline and the TAT value were approximately 0.42 but increased suddenly to 0.68 by 2016.

A similar crashed in TAT occurred in 2017, with an approximate value of 0.50 followed by another crashed in 2019. The TAT in 2018 – 2019 recorded highest value of 0.68. It was the highest value of TAT recorded across all the selected irrigation schemes (Tada-Shonga, Patigi,

Oke-Oyi, Ejiba and Giriyan) which indicates optimal performance of farm machinery as established by Langemier (2016) and Simeon-Illogho (2025), crossing a benchmarks of 0.65 TAT values. The year 2021 was also a year of aggressive decline in Giriyan scheme, with a TAT of 0.44 while from 2022 – 2023, the TAT in the scheme entered a phase of low stagnation and suddenly increased to 0.50 in 2024 but failed to reach high efficiency experienced between 2018 – 2019.

The persistently low turnover ratios across all schemes indicate systemic inefficiencies in machinery scheduling, weak managerial coordination, maintenance planning and asset management. For instance, Ejiba’s relatively higher mechanisation degree did not translate into higher turnover, suggesting that mechanisation alone is insufficient without corresponding improvements in maintenance funding, operator competence and good managerial skills. The growth rate of investment sustainability of farm machinery in the selected irrigation schemes has been set back due to low turnover pattern. These findings corroborated the statement of Takeshima *et al.*, 2015; Ibrahim and Yakubu 2025 and Simeon-Illogho (2025) that most of public agricultural sector in Nigeria faced the challenges of low turnover for investment sustainability and failed to promote SDGs (2 and 8) in Nigeria.

Linear Regression Analysis Output

Table 9 presents the overall diagnostic and goodness-fit statistics for the developed Ordinary Least Squares (OLS) regression model and Table 10 outline the individual regression coefficients, standard errors and significance levels (t-statistics and ρ -values) for the intercept and the independent predictor variables.

Table 9: Summary of Model Fit

Parameters	Value
R	0.871
R-squared (R^2)	0.792
Adjusted R-squared (Adj R^2)	0.778
Standard error of estimate	0.0384
F-statistic ($\partial f = 4.0$)	57.14***

Note: *** Significant at $\rho < 0.001$

Table 10: OLS Parameter Estimation

Predictor variable	Parameter	coefficient (B)	Standard error	t-statistic	p-value
Intercept	B_0	0.2043	0.0491	4.161	< 0.001***
Machinery utilisation hours (U_{hr})	B_1	0.0009	0.0002	4.500	< 0.001***
O&M budget ($OM_{i,t}$)	B_2	3.9852	1.0210	3.903	< 0.001***
Failure rate ($FR_{i,t}$)	B_3	-0.0031	0.0008	-3.875	< 0.001***
Technical literacy ($Lit_{i,t}$)	B_4	0.1524	0.0451	3.379	< 0.001***

The model statistics show strong predictive power and demonstrate that the regression model illustrates a substantial proportion of the variance of economic sustainability with an adjusted R^2 : 0.792. This indicates that 79.2% of the variability in TAT across the schemes over the 13 year period is directly accounted for by changes in operational machinery utilisation, maintenance fund allocations, technical failure rates and technical skill level of operators. The positive and highly significant coefficient for annual machinery utilisation runtime (U_{hr}) $B_1 = 0.0009$, $\rho < 0.001$). The overall model F-statistic (57.14, $\rho < 0.001$) predict within the fitted model as established in the foundational principles of agricultural mechanisation economics (Bukhari *et al.* 2011).

The partial regression coefficient for annual utilisation hours had a positive coefficient and highly significant ($B_1 = 0.0009$, $\rho < 0.001$). This establishes that holding all other variables constant, for every additional 100 hour of field operations per tractor adds 0.09 units directly to the scheme's TAT index. This is statistically related to tractor fleets within public schemes and cannot achieve commercial self-sustainability unless field operations are scaled up past the current 600-700 hour bottleneck to approach the 1000 hour global benchmark. The questionnaires completed by technical personnel indicated that maximum utilisation hours ranged between 586.70 hours (Patigi) and 768.80 hours (Ejiba). When cross validated against the

internal logbooks, these low hours described why the overall asset is associated with low turnover patterns, averaging between 0.46 and 0.62. Because the actual runtime (utilisation hours) falls significantly short of the 1000 hour standard for effective productivity, fixed capital sits idle, preventing the schemes from reaching the stable 0.65 (65%) turnover benchmark required for sustainable reinvestment (Langemeier and Ibendahi, 2020).

Specifically, the regression model uncovered a critical structure flaw and operational maintenance funding ratio ($OM_{i,t}$) emerged as a positive driver of economic viability ($B_2 = 3.9852$, $\rho < 0.001$). This high positive coefficient reveals that a 1% increase in the allocation of O&M funds relative to initial capital budgets yields an absolute expansion of 3.98 units in TAT efficiency. This ascertain that irrigation schemes receiving consistent, timely budget releases for maintenance as recorded in their financial year booklets are able to keep assets operational, sustaining asset turnover ratios. The regression coefficient is associated with rigid institutional funding structure acts as an artificial ceiling on performance even when the capital allocations increased overtime such as Tada-Shonga reaching ₦32.45 million in 2023 the cross validated financial records show that the corresponding O&M budget (₦811.268) was mathematically too small to carry out operational spare parts, fuel and upkeep needed to run the expanded asset. This result is in agreement with the assertions of Takeshima *et al.* (2015) that economic failure of public farm machinery hiring units in West Africa is rarely due to a lack of demand but rather a structural lack of capital allocation for maintenance activities.

Moreover, the technical machinery failure rate ($FR_{i,t}$) exhibited a strong statistically significant negative relationship with economic output ($B_3 = -0.0031$, $\rho < 0.001$), high breakdown frequency inducing severe economic losses that was responsible for the setback to TAT. It indicates that every 10% increase in machinery failure rates reduces the TAT by 0.0031 units. The statistical trend demonstrated in the Ejiba scheme, which recorded a severe historical failure rate of 74.3% among its primary tillage machinery. The technical surveys completed by Ejiba's staff revealed that this high failure rate is compounded by an elevated Meantime to Repair (MTTR) of 0.39 hours per work, reflecting long delays in procuring replacement components. When cross validated with the scheme's financial year booklets, these failure rates associated with sharp drops in annual revenue generation is statistically related to unexpected machinery downtime short circuits the scheme's earning capacity.

This finding predicts within the fitted model of regional mechanisation studies (Olaoye and Rotimi, 2010; Al-Mansoori, 2023), which highlight that high downtime resulting from poor preventive maintenance system severely undermines the return on public agricultural investments. Cross validating this field data with the Ejiba financial year booklets shows a direct correlation: the years with high mechanical breakdown frequencies match severe downward drops in Annual Revenue Generated (ARG), with the TAT index dropping to 0.35 in 2013 and 0.33 in 2019.

The technical literacy variable captured via survey questionnaires indicated had a positive coefficient on asset turnover. The demographic surveys revealed that 52.8% of participants have no formal education, indicating that over half of the active workforce operates with limited technical literacy. The effect of operator literacy ($Lit_{i,t}$) ($B_4 = 0.1524$, $\rho < 0.001$) on the TAT was statistically significant within the ($t = 3.379$, $\rho < 0.001$). A 10% improvement in the proportion of technically literate operators within a scheme leads to a 0.015 absolute increase in the TAT index. The regression output predicts within the fitted model that literacy gap severely limits asset efficiency. The technical operators who cannot read or interpret technical instruction on the attached operator's manual frequently cause accidental operator abuse, violate standard engine maintenance schedules and eventually miss early warning signs of mechanical wear and tear. This shifts the irrigation schemes maintenance mix away from Total Productive Maintenance (TPM) and forces a reliance on expensive corrective breakdowns lowering overall asset turnover.

Specifically, a highly skilled operator can overcome the economic losses associated with acute starvation of operation and maintenance ($OM_{i,t}$) and high machinery failure rates ($FR_{i,t}$). Consequently, technical literacy remains a good condition for economic sustainability within these irrigation schemes.

CONCLUSION AND RECOMMENDATIONS

Conclusions

The study reveals that utilisation hour, educational status of operators, degree of mechanisation and annual allocation for operation and maintenance were low and regression model predicts within the fitted model the factors limiting public farm mechanisation.

The statistical analysis demonstrates that the low asset turnover patterns (ranging from 0.45 to 0.61) is statistically related to institutional 2.5% of O & M budgeting cap, high machine failure rates and low technical literacy of operator.

The least squares regression model predicts within the fitted model that machinery operational hour had a positive coefficient on financial turnover $R^2 = (0.784, \rho < 0.001)$. The primary drivers of this low efficiency include strict limits on operations and maintenance budgets pegged at 2.5% of capital allocations,

Recommendations

1. The Management should intensify efforts on capacity building for technical operators and implement operator certification programs to reduce misuse and extend machinery lifespan for economic sustainability.
2. The Management should introduce a ring fenced maintenance budget of at least 10% of capital allocation to prevent premature machinery failure.
3. The Management should introduce a Public Partnership Programme (PPP) to enhance handlings of government investment in public agricultural sector.
4. The management should adopt sensor based tracking system to capture utilisation hours of farm machinery to reflect the TAT for appropriate investment sustainability.
5. The management should establish performance-based incentives for schemes coordinators tied to utilisation and turnover targets.
6. Create a centralized machinery-sharing framework across schemes to reduce idle time and improve asset turnover.

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