Preliminary Analysis of Post-Harvest Losses and Mitigation among ATASP – 1 Smallholder Farmers: Evidence from Selected Crop Value Chains in Nigeria

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Abstract

Post-harvest losses (PHL) remain a significant constraint to Nigeria's food security, farm profitability, and sustainable value chain development. This study examined the extent of PHL and adoption of mitigation technologies among smallholder beneficiaries of the Agricultural Transformation Agenda Support Program Phase 1 (ATASP-1). Funded by AfDB and launched in 2015, ATASP-1 operates in four staple crop processing zones across seven states, covering over 200 rural communities. Its objectives are to target rice, cassava, and sorghum to reduce poverty, create jobs, enhance food and nutrition security and raise incomes through sustainable agricultural growth and diversification. Using a multi-stage sampling technique, data were collected from 600 respondents (480 farmers and 120 processors) and analysed with descriptive statistics. Results revealed that ATASP-1 interventions reduced PHL in cassava (48.44%) and sorghum (29.93%) relative to national averages, while rice showed a moderate reduction (22.86%). Adoption of technologies was high, including metallic silos (85%), mud silos (90%), threshers (68%), drying slabs (84%), root choppers (91%) and safety/quality management systems (82%). Key constraints included high machinery costs (78%), limited accessibility (68%), poor infrastructure (59%), unreliable power supply (66%), high transport costs (81%) and high labour costs (73%). The study concludes that ATASP-1 substantially reduced PHL; sustaining and scaling these outcomes requires robust institutional frameworks, capacity building for farmers, and strategic rural infrastructure investment. Additionally, context-specific, zone-based interventions are essential to address heterogeneous constraints and optimise post-harvest loss reduction strategies across value chains.

Keywords:
ATASP-1, Mitigation technologies, Post-harvest losses, Smallholder farmers, Value chains.

Introduction

Agriculture remains a critical sector in Nigeria, employing over 70% of the rural population, and contributing approximately 24% to the national Gross Domestic Product (GDP) (NBS, 2023). Despite the increase in crop production in recent years, post-harvest losses (PHL) continue to undermine food security, farm incomes, and national food self-sufficiency. According to the Food and Agriculture Organisation (2021), sub-Saharan Africa loses up to 37% of its agricultural produce, post-harvest, with Nigeria alone losing agricultural produce worth over ₦3.5 trillion annually, due to poor post-harvest handling, storage, and processing (FMAFS, 2022).

In Nigeria, staple crops such as rice, cassava, and sorghum form the dietary and income base for millions of smallholder farmers (FAO, 2021). However, the productivity gains from these crops are often negated by substantial losses occurring from harvest to consumption. These losses are primarily attributed to inadequate infrastructure, poor handling practices, pest infestations, limited access to post-harvest technologies, and inefficient value chains (Adewumi et al., 2021; Anyoha et al., 2023). Specifically, losses for cassava can occur within 24 – 48 hours post-harvest due to rapid physiological deterioration (FAO, 2021), while rice and sorghum suffer significant losses of up to 30%

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Agriculture remains a critical sector in Nigeria, employing over 70% of the rural population, and contributing approximately 24% to the national Gross Domestic Product (GDP) (NBS, 2023). Despite the increase in crop production in recent years, post-harvest losses (PHL) continue to undermine food security, farm incomes, and national food self-sufficiency. According to the Food and Agriculture Organisation (2021), sub-Saharan Africa loses up to 37% of its agricultural produce, post-harvest, with Nigeria alone losing agricultural produce worth over ₦3.5 trillion annually, due to poor post-harvest handling, storage, and processing (FMAFS, 2022).

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The Federal Government of Nigeria launched the Agricultural Transformation Agenda Support Program Phase-1 (ATASP-1) in 2015, with funding from the African Development Bank (AfDB) to address these challenges. The program aimed to boost productivity, reduce post-harvest losses, and strengthen rice, cassava, and sorghum commodity value chains across four Staple Crop Processing Zones (SCPZs) (AfDB, 2013). Through its interventions, ATASP-1 promoted the adoption of climate-smart agronomic practices, post-harvest technologies (e.g., silos, threshers, drying slabs), and capacity-building for farmers and processors (IITA, 2023). However, despite these efforts, there is limited empirical evidence on how post-harvest losses (PHL) have been effectively mitigated among ATASP-1 beneficiaries, particularly across the full value chain stages from production and processing to storage and transportation. Understanding these dynamics is crucial for optimising food supply chains, ensuring return on investment in agricultural programs, and advancing progress toward the Sustainable Development Goals, especially SDG 12.3, which seeks to halve per capita global food waste and significantly reduce food losses along production and supply chains by 2030 (John et al., 2023).

Moreover, despite the significant investments in agricultural development programs in Nigeria, including the Agricultural Transformation Agenda Support Program Phase-1 (ATASP-1), post-harvest losses (PHL) remain a critical challenge undermining the productivity, profitability, and food security of smallholder farmers (Osabohien, 2024). Rice, cassava, and sorghum, which are consistently among the top-ranked crops in Nigeria in terms of consumption, production, and economic importance (NBS, 2023), continue to suffer substantial quantitative and qualitative losses along the value chain, especially during harvesting, processing, storage, and transportation stages (Abass et al., 2022; FMAFS, 2022). While ATASP-1 was designed to enhance agricultural productivity and reduce losses by promoting improved technologies and practices, the persistence of high post-harvest losses suggests a gap between policy intentions and field realities.

Compounding the problem are constraints such as the high cost of post-harvest technologies, limited technical know-how, poor rural infrastructure, and inadequate extension support, all of which hinder smallholder farmers' effective adoption of loss-reducing innovations (Adewumi et al., 2021). Despite anecdotal accounts of success in certain ATASP-1 implementation zones, captured in project stakeholder meetings and field communications, rigorous empirical studies evaluating the extent, spatial distribution, and mitigation of post-harvest losses among beneficiaries remain scarce, particularly for the three mandate crops (rice, cassava, and sorghum) across diverse geographic contexts (Nwafor et al., 2019).

This study, therefore, investigates the magnitude, stages, and mitigation of post-harvest losses among smallholder farmers and processors participating in the ATASP-1 program, focusing on the value chains of rice, cassava, and sorghum in Nigeria. The objectives of the study were to: compare the level of post-harvest losses recorded by program beneficiaries at inception and before completion, identify the post-harvest handling technologies/practices adopted by the beneficiaries to mitigate post-harvest losses by crop and actor, and examine the constraints associated with the use of post-harvest technologies adopted by the beneficiaries.

Methodology

The study area

The study was carried out in all four Staple Crop Processing Zones (SCPZs) of ATASP-1, including Adani-Omor, Bida-Badeggi, Kano-Jigawa, and Kebbi-Sokoto, as shown in Figure 1. Each of the zones has distinct agro-ecological features and agronomic practices adopted by the program beneficiaries, who include farmers and farmers' cooperatives, commodity processors, private sector operators, and registered Small and Medium Enterprises (SMEs), input dealers and service providers in the four staple crop processing zones.

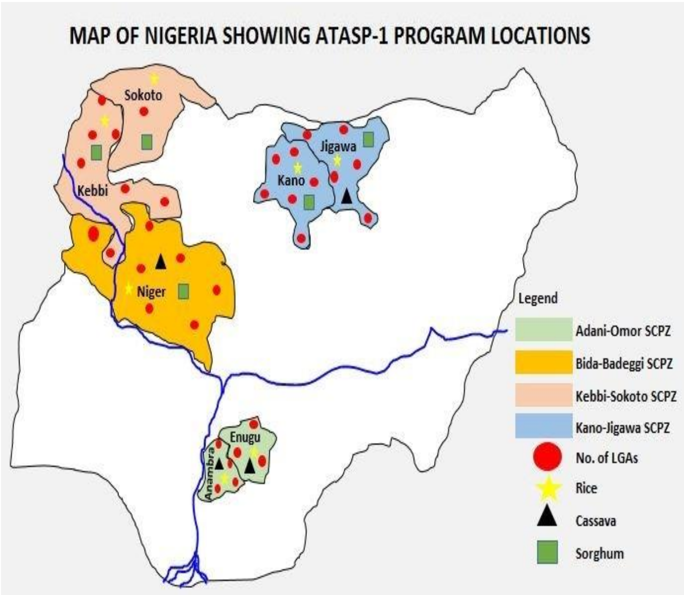

Figure 1: Map of the study area showing SCPZs and mandate crops

Source: Author's Construct

Methods of data collection and analysis

Primary data for this study were collected in 2024 using a structured questionnaire designed to elicit information from sampled producers and processors involved in the Agricultural Transformation Agenda Support Program Phase-1 (ATASP-1) mandate crops, namely rice, cassava, and sorghum, across all participating Staple Crop Processing Zones (SCPZs). Trained enumerators administered the survey instrument to ensure data quality and consistency. Out of the total questionnaires distributed, a response rate of 94% was achieved, indicating strong participant engagement. The questionnaire captured comprehensive data on respondents' socio-economic characteristics, value chain roles, post-harvest handling practices, adoption of mitigation technologies, and training needs. Data were analysed using descriptive statistical techniques aligned with the study objectives, employing STATA (version 15.0) and Microsoft Excel (Office 365) for data processing and presentation. The descriptive statistics include mean, frequency distribution, and percentages, and the level of post-harvest losses was estimated in terms of quantity and percentage losses. All research procedures complied with ethical standards for studies involving human participants. Before data collection, informed consent was obtained from all respondents, participation was voluntary, and confidentiality of information was assured.

Sampling procedures and sample size

A multi-stage random sampling technique was adopted in selecting respondents for this study. The first stage involved the random selection of five (5) LGAs in each of the Zones. The second stage involved randomly selecting three (3) communities/clusters from each sampled LGA. In the third stage, three (3) respondents were selected from each of the sampled communities in Adani-Omor, Bida-Badeggi and Kano-Jigawa. At the same time, for the Kebbi-Sokoto zone, five (5) rice farmers and four (4) sorghum farmers were selected from each of the sampled communities. The sampling procedure for selecting respondents from each community was based on probability proportionate to the size of the respondents in the study areas.

However, given the preponderance of production-based value chain actors (farmers and processors), twenty (20) Local Government Areas were sampled (5 LGAs/Zone) and a maximum of three (3) communities per LGA for both Farmers and Processors. One hundred and twenty (120) smallholder farmers were sampled from each SCPZ, covering the targeted mandate crops (cassava, rice and sorghum), while thirty (30) processors each were sampled from the four zones. Overall, 480 farmers were sampled, while 120 processors were selected across the SCPZs, giving a total of 600 samples for the survey.

Results and Discussions

Socio-economic characteristics of ATASP-1 farmers and processors

Understanding agricultural stakeholders' demographic and farm-level characteristics is crucial for assessing their capacity to adopt post-harvest technologies and participate effectively in value chain activities. Table 1 presents summary statistics of key variables, including age, household size, farm size, and farming experience, collected from ATASP-1 program beneficiaries across the four Staple Crop Processing Zones (SCPZs).

The results reveal that the age of respondents ranged from 41 to 44 years across zones, with a national average of 43 years. This age distribution suggests that the sampled farmers fall within the economically active population, consistent with previous studies indicating that most Nigerian smallholder farmers are within the productive age bracket (Adewumi et al., 2021; NBS, 2023). Age plays a significant role in adopting agricultural innovations, with younger farmers often being more receptive to technology uptake due to higher risk tolerance and adaptability (Anyoha et al., 2023).

The household size shows that the national average was nine members, with values ranging from 6 in Adani–Omor to 10 in Kano–Jigawa and Kebbi–Sokoto. This result corroborates the findings of FAO (2022), which opined that large household sizes are typical in rural Nigeria and often translate to increased family labour availability, which can influence the intensity and scale of agricultural activities (FAO, 2022).

Farm size across the zones exhibited considerable variation. The average farm size was highest in Bida–Badeggi (2.72 hectares) and lowest in Kebbi–Sokoto (1.39 hectares), with a national mean of 2.0 hectares. These figures aligned with existing literature on the small-scale nature of Nigerian agriculture, where most farmers cultivate on plots typically less than 3 hectares (IFPRI, 2021). Smaller landholdings may constrain economies of scale and limit investment in post-harvest infrastructure (Abass et al., 2022).

It was also revealed on average that farmers in Bida–Badeggi had the most experience (15 years), followed by Kebbi–Sokoto (12 years), Adani–Omor (11 years), and Kano–Jigawa (10 years). The national mean was 12 years. Experienced farmers are more likely to recognise the economic impact of post-harvest losses and may be more inclined to adopt mitigation strategies if resources and support systems are accessible (FMAFS, 2022).

Table 1: Socio-economic Characteristics of the Respondents

Variables	Mean	Standard Deviation	Minimum	Maximum
ADANI – OMOR				
Age (Years)	44	14.47	21	71
Household size (Number)	6	2.19	1	12
Farm size (Ha)	2.00	2.13	0.25	11
Farming experience (Years)	11	5.83	3	26
BIDA – BADEGGI				
Age (Years)	42	15.26	21	70
Household size (Number)	9	4.26	1	22
Farm size (Ha)	2.72	2.43	1	12
Farming experience (Years)	15	5.52	3	24
KANO – JIGAWA				
Age (Years)	44	14.30	21	70
Household size (Number)	10	5.75	1	30
Farm size (Ha)	2.01	1.61	0.4	10
Farming experience (Years)	10	5.83	1	26
KEBBI – SOKOTO				
Age (Years)	41	15.33	21	70
Household size (Number)	10	5.63	1	30
Farm size (Ha)	1.39	0.98	0.4	9
Farming experience (Years)	12	6.03	3	26
NATIONAL				
Age (Years)	43	15	21	70
Household size (Number)	9	4	1	24
Farm size (Ha)	2.0	1.8	0.5	10.5
Farming experience (Years)	12.00	5.80	2.50	25.50

Source: Survey Result, (2025).

Post-harvest losses and the effect of ATASP-1 mitigation technologies

Post-harvest losses (PHL) represent a persistent challenge in the Nigerian agricultural sector, contributing to significant food waste and reduced incomes for smallholder farmers (FAO, 2021; FMAFS, 2022). The Agricultural Transformation Agenda Support Program Phase-1 (ATASP-1) was designed, in part, to address these losses by introducing a range of mitigation technologies and practices. Table

2 presents the aggregated post-harvest loss data for rice, cassava, and sorghum across the four participating Staple Crop Processing Zones (SCPZs), comparing baseline values at project inception with those recorded at project completion.

The results indicate that ATASP-1 interventions were associated with reduced post-harvest rice losses across most project zones. In Adani–Omor, the total aggregated loss decreased from 70,936 kg at project inception to 37,325 kg at completion, a 47.38% reduction. This decline appears to coincide with the dissemination of improved threshing, drying, and storage technologies, which have been shown in prior studies to reduce cereal grain losses significantly (Abass et al., 2022; IITA, 2023).

In Kano–Jigawa, and Kebbi–Sokoto, rice PHL declined by 20.78% and 18.52% respectively, further affirming the beneficial role of technology adoption. However, the reduction observed in Bida–Badeggi (4.76%) was relatively marginal, indicating either a lower adoption rate or less effective deployment of interventions in that zone. The disparity aligns with Anyoha et al., (2023) and therefore highlights the need for localised implementation strategies that consider region-specific barriers to technology uptake.

Cassava is particularly prone to post-harvest physiological deterioration within 24 – 48 hours of harvest, making rapid processing critical (FAO, 2021). ATASP-1 introduced food safety technologies to mitigate these losses, such as improved graters, peelers, and processing centres.

The results show considerable variation in cassava loss reduction across zones. Kano–Jigawa and Bida–Badeggi showed reductions of about 66.70% and 67.21%, respectively, reflecting successful intervention efforts. Conversely, Adani–Omor recorded only an 11.40% reduction (from 34,900 kg to 30,923 kg), which may point to logistical or infrastructural limitations affecting project delivery. These findings underscore the importance of access to processing facilities and timeliness in cassava value chains (Adewumi et al., 2021). Nationally, the average cassava PHL declined by 48.44%, demonstrating the project's substantial impact on improving cassava post-harvest management.

Sorghum losses also declined across all project zones, albeit with varying magnitudes. The most substantial reduction was observed in the Bida–Badeggi zone, where PHL dropped from 34,346 to 15,126 kg, representing a 55.96% decrease. This improvement may be associated with the increased use of mechanised threshers and hermetic storage systems provided under ATASP-1 (FMAFS, 2022; IITA, 2023).

Other zones experienced more moderate reductions: 25.39% in Kano–Jigawa, 29.47% in Kebbi–Sokoto, and 8.91% in Adani–Omor. The relatively low reduction in Adani–Omor may reflect limited access to or awareness of post-harvest mitigation technologies among sorghum producers in that region.

Overall, the preliminary analysis suggests that the post-harvest loss mitigation strategies promoted by ATASP-1 had measurable positive outcomes, particularly in cassava and sorghum value chains. Nevertheless, regional disparities in performance, especially the limited reduction in rice losses in Bida–Badeggi, and cassava losses in Adani–Omor, highlight the need for context-specific enhancements in project delivery and farmer support services.

Technologies adopted by beneficiaries to mitigate post-harvest losses

Adopting appropriate post-harvest loss (PHL) reduction technologies is critical for enhancing food security, minimising wastage, and improving farm-level incomes. Under the ATASP-1 initiative, smallholder farmers across the project zones were introduced to various technologies tailored to the specific post-harvest challenges of rice, cassava, and sorghum. Table 3 summarises the frequency and percentage of adoption of multiple technologies among beneficiaries in the four project zones.

The results indicate a widespread adoption of multiple rice PHL reduction technologies, including metallic and mud silos, rice dryers, threshers, decorticators, power milling units, false-bottom storage, and de-stoning machines. Nationally, the most frequently adopted technologies included metallic silos (85%), mud silos (90%), false-bottom technology (88%), and rice drying slabs (84%). Adoption was particularly high in Adani–Omor, Bida–Badeggi, and Kano–Jigawa zones. For instance, 98% of respondents in Adani–Omor reported using metallic silos, while 96% used decorticators and mud silos.

Conversely, adoption rates in Kebbi–Sokoto were comparatively lower, particularly for storage facilities (16%) and threshers (34%). This variation suggests possible infrastructural or financial barriers to technology uptake in the zone. Previous studies have emphasised that disparities in access to storage and processing technologies are often linked to differential infrastructure, market access, and support services (FAO, 2021; Anyoha et al., 2023).

The respondents overwhelmingly affirmed the effectiveness of these technologies in minimising losses, particularly during drying, threshing, and storage stages, traditionally associated with high loss incidence (Abass et al., 2022; FMAFS, 2022).

Cassava post-harvest loss technologies implemented under ATASP-1 included graters, shellers, hand milling machines, root choppers, dehydrators, cassava ratooning, and safety and quality management systems. Adoption was notably high across Adani–Omor, Bida–Badeggi, and Kano–Jigawa, where root chopper usage reached 98% in Adani–Omor, and 93% for shellers in Bida–Badeggi.

The adoption of post-harvest technologies was reported to exert a substantial impact on mitigating cassava deterioration, a prevalent challenge that can result in 25–40% losses within 48 hours of harvest if timely processing is not undertaken (FAO, 2021; Adewumi et al., 2021). Technologies such as mechanical dehydrators and graters were particularly instrumental in reducing tuber moisture content and prolonging shelf life, as affirmed by respondents across the ATASP-1 implementation zones. However, no reported adoption of cassava-specific technologies was observed in the Kebbi–Sokoto zone, a finding plausibly attributed to the region's limited engagement in cassava cultivation. This observation corresponds with agro-ecological variations, wherein cassava production is less viable in northwestern Nigeria's arid and semi-arid climatic conditions (NBS, 2023).

For sorghum, the adoption of technologies such as hermetic storage containers, improved processing technologies, tarpaulin for threshing, community aggregation warehouses, and safety and standard technologies was widespread. Nationally, 78% of respondents used improved storage containers, while 75% adopted improved processing technologies, and 80% reported usage of food safety and standard technologies.

Adani–Omor, Bida–Badeggi, and Kano–Jigawa recorded the highest levels of adoption, while Kebbi–Sokoto demonstrated comparatively strong engagement, particularly in storage container use (78%) and community aggregation warehouse usage (78%). These technologies are particularly effective in reducing microbial contamination and mechanical damage during storage and transport, among the leading causes of sorghum PHL (IITA, 2023).

As Anyoha et al. (2023) supported, community-level storage and aggregation systems offer economies of scale, improve grain handling, and are particularly beneficial for smallholder farmers operating in resource-constrained environments.

The data confirmed that ATASP-1 has made remarkable strides in improving access to and adoption of post-harvest technologies among smallholder farmers. While technology uptake was generally high, regional disparities, particularly in Kebbi–Sokoto, highlight the need for targeted interventions to address zone-specific barriers such as affordability, awareness, and technical support. These findings are consistent with existing literature indicating that successful post-harvest loss reduction hinges on a combination of technology access, farmer training, and institutional support (Adewumi et al., 2021; FMAFS, 2022). Continuous use and scaling of these technologies can significantly improve farm-level income, reduce food waste, and enhance the sustainability of Nigeria's staple crop value chains.

Table 2: Post-Harvest Losses and the Impact of ATASP-1 Mitigation Technologies

SCPZs	Commodity	Losses before ATASP-1 (Kg)	Losses after ATASP-1 (Kg)	Difference	% Reduction
Adani – Omor	Rice	70,936	37,325	-33,611	47.38
	Cassava	34,900	30,923	-3,977	11.40
	Sorghum	9,567	8,714	-853	8.91
Bida – Badeggi	Rice	22,964	21,870	-1,094	4.76
	Cassava	23,384	7,667	-15,717	67.21
	Sorghum	34,346	15,126	-19,220	55.96
Kano – Jigawa	Rice	11,686	9,258	-2,428	20.78
	Cassava	70,254	23,398	-46,856	66.70
	Sorghum	14,937	11,144	-3,793	25.39
Kebbi – Sokoto	Rice	14,434	11,761	-2,673	18.52
	Sorghum	11,871	8,373	-3,498	29.47
National	Rice	30,005	20,054	-9,952	22.86
	Cassava	35,102	17,590	-17,512	48.44
	Sorghum	14,713	8,746	-5,967	29.93

Source: Survey Result, (2025)

Table 3: Technologies Adopted by Beneficiaries to Mitigate Post-Harvest Losses

Technologies Adopted	Adani – Omor		Bida –Badeggi		Kano – Jigawa		Kebbi – Sokoto		National	
Rice	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Use of drier	142	94	131	87	132	88	64	42	117	78
Use of storage facility	125	83	103	68	133	88	24	16	96	64
Power milling	137	91	128	85	122	81	54	36	110	73
Use of threshers	111	74	127	84	120	80	51	34	102	68
Decorticators	145	96	133	88	146	97	71	47	124	82
Metallic silos	147	98	134	89	146	97	82	54	127	85
Mud silos	144	96	141	94	145	96	110	73	135	90
False-bottom technology	134	89	132	88	135	90	125	83	132	88
De-stoning machine	130	86	129	86	141	94	130	86	133	88
Rice drying slab	137	91	123	82	139	92	106	70	126	84
Harvesting and threshing technolo gy	124	82	115	76	117	78	85	56	110	73
Products Certification	133	88	132	88	133	88	120	80	130	86
Cassava										
Hand milling	139	92	139	92	120	80	-	-	133	88
Use of shellers	141	94	140	93	116	77	-	-	132	88
Graters	136	90	129	86	133	88	-	-	133	88
Root choppers	148	98	133	88	133	88	-	-	138	91
Dehydrators	138	92	136	90	125	83	-	-	133	88
Cassava ratooning.	104	69	119	79	120	80	-	-	114	76
Safety and quality management sys	106	70	131	87	134	89	-	-	124	82
Sorghum										
Use of storage containers	143	95	104	69	106	70	118	78	118	78
Improved Processing Technology	144	96	111	74	103	68	91	60	112	75
Safety and standard Technology	143	95	116	77	113	75	110	73	121	80
Community Aggregation warehouse	5	3	112	74	121	80	117	78	89	59
Tarpaulin for threshing	141	94	98	65	90	60	94	62	106	70

Source: Survey Result, (2025). **Note:** Multiple Responses

Constraints to the adoption of post-harvest loss reduction technologies

Adopting post-harvest loss (PHL) mitigation technologies is crucial for improving food quality and quantity, reducing waste, and enhancing agricultural income and food security in Nigeria (FAO, 2021; Abass et al., 2022). However, despite the proven benefits of these innovations, smallholder farmers often face significant constraints that hinder their uptake and sustained usage.

As presented in Table 4, the survey of ATASP-1 beneficiaries across the four project zones identified a broad range of factors constraining the adoption of post-harvest technologies. These constraints fall into economic, technical, institutional, infrastructural, and social categories.

The most commonly reported constraint was the high cost of machines, with 78% of respondents nationwide indicating this as a barrier. This was particularly pronounced in Kebbi–Sokoto (88%) and Bida–Badeggi (86%). The high cost of diesel (67%), labour (73%), and spare parts (61%) was also reported as a significant deterrent. These findings align with prior studies indicating that capital constraints are one of sub-Saharan Africa's foremost barriers to technology adoption (Adewumi et al., 2021; IITA, 2023). Even when technologies are available, many smallholders remain financially out of reach without subsidies or credit support.

Access-related issues were also prominent. Nationally, 68% of respondents identified inaccessibility to machines as a barrier, while 81% cited poor and costly transportation infrastructure. Inadequate road infrastructure and the remoteness of many farming communities significantly hinder the timely transportation of perishable agricultural produce and machinery, particularly during peak harvest periods (FMAFS, 2022). Unreliable power supply (66%) and poor infrastructural facilities (59%) were particularly constraining in Kebbi–Sokoto and Kano–Jigawa zones, limiting the functionality of power-dependent machines like dryers and milling equipment.

Technical complexity and limited technical capacity also emerged as significant challenges. 59% of respondents nationally identified the complexity of machines, while 44% cited inadequate skills and knowledge required for operating or maintaining the equipment. These results reinforced the findings of Anyoha et al. (2023), who argue that farmers' educational levels and exposure to training are critical factors influencing the successful uptake of modern agricultural technologies.

Institutional gaps were also evident. Inadequate government incentives were cited by 77% of respondents, and poor extension services were reported by 25%. The disparity across zones was notable. Adani–Omor reported only 4% citing poor extension services, while Kano–Jigawa recorded 72%. This suggests uneven outreach and support services implementation under ATASP-1, potentially due to staffing, logistics, or funding disparities across SCPZs. Additionally, inadequate commercialisation of new technologies (50%) was identified as a constraint, indicating that while innovations are available, they are often not scaled or made widely accessible through market systems or cooperatives (FAO, 2021; IITA, 2023).

Respondents highlighted unfavourable market situations (57%) and poor market channels (64%) as major barriers to sustaining post-harvest practices. When farmers lack reliable market access or face volatile prices, the incentive to invest in post-harvest technologies diminishes. Furthermore, gender-related challenges were reported by 28% of respondents, highlighting existing social dynamics that may restrict women's access to training, equipment, and extension services, an issue widely acknowledged in agricultural development literature (Adewumi et al., 2021).

Table 4: Constraints to the adoption of post-harvest loss reduction technologies

Constraints	Adani – Omor		Bida – Badeggi		Kano – Jigawa		Kebbi – Sokoto		National	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
High cost of machines	100	66	138	86	107	71	132	88	119	78
Inaccessibility	96	64	95	63	104	69	111	74	102	68
Complexity	82	54	76	50	83	55	117	78	90	59
Unreliable power supply	86	57	98	65	93	62	121	80	100	66
Gender based issue	50	33	18	12	49	32	51	34	42	28
Inadequate skills and knowledge	70	46	34	22	93	62	68	45	66	44
Poor and high cost of transportation	131	87	119	79	136	90	101	67	122	81
Poor market channels	100	66	59	39	140	93	88	58	97	64
Lack of and high cost of spare parts	79	52	113	75	63	42	113	75	92	61
High cost of diesel	98	65	113	75	72	48	119	79	101	67
High cost of labour	126	84	106	70	120	80	89	59	110	73
Labour intensiveness	109	72	89	59	120	80	75	50	98	65
Unfavourable market situation	94	62	55	36	118	78	76	50	86	57
Inadequate government incentives	120	80	109	72	125	83	109	72	116	77
Poor infrastructural facilities	92	61	100	66	90	60	73	48	89	59
Poor extension services	6	4	11	7	108	72	25	16	38	25
Inadequate commercialization of new tech	86	57	74	49	96	64	47	31	96	50

Source: Survey Result, (2025). **Note:** Multiple Response

Conclusion

This study assessed post-harvest losses (PHL) and technology adoption among smallholder producers and processors of rice, cassava, and sorghum under ATASP-1 in Nigeria. Results show that while ATASP-1 interventions reduced PHL through technologies such as silos, threshers, drying slabs, and milling equipment, impacts varied across value chains and zones, being greater in cassava and sorghum (Bida–Badeggi, Kano–Jigawa) and weaker in Adani–Omor and Kebbi–Sokoto. Adoption disparities, especially in Kebbi–Sokoto, reflected barriers such as high costs, poor infrastructure, limited extension, and weak access to power and transport. The findings highlight that technology alone cannot sustain PHL reduction; integrated measures improved infrastructure, financing, training, and institutional support, are essential. ATASP-1 provides a foundation, but addressing systemic constraints is key to equitable and lasting benefits for smallholders.

5. Recommendations

Based on the empirical findings of this study, the following targeted interventions are recommended to enhance the effectiveness and equity of post-harvest loss (PHL) reduction under ATASP-1 and similar initiatives:

1. **Subsidise and support local fabrication:** Provide subsidies and technical support for the local production of post-harvest technologies such as metallic/mud silos, threshers, and root choppers to reduce acquisition costs and ensure availability in rural areas.
2. **Establish community-based machinery service centres:** Create shared equipment hubs at the community level, particularly in low-adoption zones like Kebbi–Sokoto, to enable group access to processing and storage machinery and reduce the burden of individual ownership.
3. **Implement inclusive training programs:** Institutionalise regular training and refresher courses on the use, maintenance, and safety of post-harvest equipment, with gender-sensitive approaches to ensure active participation by women and youth.
4. **Leverage high-performing zones as learning hubs**: Institutionalise knowledge exchange programs using successful zones like Bida–Badeggi and Kano–Jigawa as demonstration and learning centres for scaling best practices to underperforming areas such as Adani–Omor and Kebbi–Sokoto.

Limitations and Suggestions for Future Research

This study is limited by its cross-sectional design, reliance on descriptive statistics, and focus on selected ATASP-1 zones, which restricts causal inference, long-term assessment, and generalizability. The inability to disaggregate adoption patterns between producers and processors and the use of yes/no format for constraint analysis further limit the depth of insights.

Future research should employ longitudinal or panel data, expand to other regions and staple crops, and use mixed methods or quasi-experimental designs (e.g., difference-in-differences, propensity score matching with baseline and endline surveys) to strengthen causal inference. Separating producers and processors, incorporating control groups, and applying Likert-scale instruments with advanced analyses (e.g., importance–performance analysis or Kendall's W) will provide more robust and actionable evidence on post-harvest loss reduction.

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