TECHNICAL REPORT

Investment Plan for Solar-Based Irrigation Systems in Nigeria

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Summary

Northern Nigeria's irrigated farming systems face acute climate and energy pressures that make fuel-based irrigation increasingly uneconomic. This analysis evaluates the transition to Solar-Based Irrigation Systems (SBIS), utilizing a 579-household survey and Discrete Choice Experiments. Standardizing the analysis to a 1-acre production unit, the study confirms that SBIS is a transformative alternative, but only if the "one-size-fits-all" approach is replaced by a targeted investment strategy. Technology Verdict: The fixed USD 428.6[1] SBIS unit is the dominant technology, delivering high operational ROIs and rapid payback periods (1.4–2.1 years). The mobile "With Cart" unit (USD 714.3) carries a premium that destroys value for most crops and should be discontinued for all non-commercial applications.

To resolve the critical question of financing responsibility, the framework strategically maps funding sources to the specific economic realities of each crop tier. Commercial banks are best positioned to fund the Tier 1 commercial track, specifically tomato and pepper, as these high-value vegetables exhibit the exceptional margins and resilience necessary to sustain full commercial loans for fixed SBIS units without external subsidies. For the Tier 2 food security track comprising rice and onion, the Government's role shifts from direct lender to strategic de-risker; this entails deploying 50% credit guarantees via NIRSAL to encourage bank lending and implementing fiscal incentives, such as import duty waivers, to cap the fixed unit price below USD 428.6. Finally, donors must bridge the gap for the Tier 3 inclusion track, covering financially fragile crops like okra, wheat, and maize, by providing Smart Capital Subsidies of 30–40% to write down asset costs and fully funding the essential "software" components of training and extension services to ensure viability for resource-poor farmers.

Scaling pathway and institutional roles: scaling this technology requires a clear division of labor to move from pilot to market saturation:

1. Private sector (supply chain): Solar firms must establish certified installer networks and local spare-parts hubs to minimize technical downtime, shifting from a "sales" model to a "service" model.
2. The Banks, including Bank of Agriculture, should consider farmer-friendly loan products that allows at least two year repayment period, working with NIRSAL to institutionalize risk sharing
3. Cooperatives (aggregation): Agricultural cooperatives must serve as the primary platform for adoption, managing the 2-year, harvest-synced repayment plans and enforcing small-group liability (2–3 members) to secure loans.
4. Regulators (quality assurance): The Standards Organization of Nigeria (SON) must enforce strict quality controls to prevent market spoilage by substandard imports, while insurers bundle products with guaranteed off-taker contracts to protect yields against environmental volatility.

[1] 1 USD = NGN 1400 at the time of this study

1. Introduction

1.1 Background

The agricultural landscape in northern Nigeria, particularly across key production states like Kano and Kaduna, is fundamentally defined by significant climate variability and corresponding water stress, making dependency on irrigation critical for economic viability. Farmers routinely contend with erratic rainfall and prolonged dry spells, necessitating the draw of groundwater to sustain production. This reliance on irrigation, especially for highly profitable dry-season farming of vegetables, spices, and other high-value crops, underpins the region's economic importance, as it serves as a significant food basket for both domestic and regional markets.

The dominant, fuel-based irrigation model currently employed by smallholders is economically unstable and unsustainable. The rising cost of fuel-based irrigation, driven by volatile global energy prices, erodes farmer margins, creating a persistent profitability ceiling that traps households in low-return cycles. Compounding this, the sector suffers from systemic underinvestment in decentralized smallholder irrigation solutions, leaving farmers vulnerable. Moreover, the capacity for farmers to transition to modern, efficient technology is severely hampered by structural barriers arising from fractured credit, unreliable supply chain networks, and complex governance systems, collectively blocking widespread technology adoption.

Solar-Based Irrigation Systems (SBIS) represent a technically and economically superior solution to these systemic constraints. Technical feasibility is exceptionally high, supported by the widespread availability of shallow groundwater accessible via existing tube wells and reinforced by Nigeria's vast solar resource, which averages 5.25-5.44 kWh/m²/day, with northern cities such as Kano and Kaduna receiving higher total radiation and the highest average daily clearness index. This abundant solar energy enables the efficient deployment of photovoltaic technology, making the adoption of solar pumps practical and cost-effective, particularly in rural and off-grid areas. Economically, SBIS unlocks immense economic potential for high-value crops and vegetables by providing predictable, zero-running-fuel cost for water, significantly increasing farm productivity and profitability margins. Finally, SBIS delivers crucial environmental benefits (zero carbon emissions) and substantially enhances farm-level climate resilience, protecting assets and income against energy price shocks and recurrent drought cycles.

1.2 Data Sources and Analytical Framework

1.2.1 Household survey data summary

This investment case analysis is grounded in a robust 579-household survey conducted across Kebbi, Kano, and Kaduna States, with the primary purpose of establishing the empirical foundation for scalable SBIS business models. The survey captured extensive data types necessary for economic modelling, including detailed metrics on current land use and ownership, existing irrigation methods (fuel-based, manual), specific crops grown during dry seasons, and comprehensive records of inputs, costs, and income associated with irrigated agriculture. This rich dataset provides the essential context to understand current profitability constraints and the potential economic uplift provided by the transition to solar technology.

1.2.2 Discrete Choice Experiment (DCE)

To quantify and model farmers' willingness-to-invest and preference structure, a Discrete Choice Experiment (DCE) was integrated into the survey methodology. The experiment's core objective was to quantify farmer preferences for SBIS models under various conditions, moving beyond stated intentions to reveal actual trade-offs. The key attributes tested included the type of ownership (individual vs. communal), the structure of financing (pay-as-you-go vs. upfront credit), the presence of a cart option for mobility, and the total cost of the system. The analysis of the DCE data utilized a Mixed Logit (ML) modelling approach, chosen for its ability to account for unobserved heterogeneity in farmer preferences and its robust performance (as indicated by strong diagnostics, McFadden $R^2 > 0.81$), providing high confidence in the derived policy recommendations.

1.3 Investment Case Analysis Framework

The core of the investment case framework is its ability to model diverse farming realities and rigorously test financial viability. To ensure technical and economic precision, all analyses were standardized to a 1-acre production unit, based on the technical observation that one standard SBIS unit is sufficient to irrigate one acre of farmland. The analysis models different cropping systems, considering traditional monocropping, which is the predominant irrigation cropping system. While diversified mixed cropping patterns are not common, these cropping system considerations are essential for accurately projecting revenue streams. Two primary farm scenarios, cereal production and vegetable farming, are examined at the 1-acre scale to capture the range of value chain opportunities. The required financial analyses are comprehensive, including assessments of profitability with irrigation, a full Cost-Benefit Analysis (CBA), and the calculation of the Payback period. Crucially, the framework models the Net Present Value (NPV) at discount rates of 10% and 15%, specifically under conditions utilizing profit-sharing loans (at 60% benchmarks) to simulate de-risked financial models tailored to the 1-acre production standard.

1.4 Integration of Survey, DCE, and Investment Modelling

The rigor of the investment case is achieved through the systematic integration of survey, DCE, and investment modelling components. Agronomic data from the Household Survey (HHS) defines the input costs and expected yield gains, while financial data establishes baseline profitability and cost structures. Another crucial element, however, is the behavioral data derived from the DCE, which informs the model about farmers' heterogeneous preferences regarding upfront costs and financing mechanisms. This integration allows the framework to move beyond simple technical viability, effectively quantifying the market-specific financial mechanisms that will drive large-scale, sustainable adoption of SBIS.'

2. Socioeconomic and Production Environment

2.1 Household Characteristics

The socioeconomic profiles across the sampled states reveal marked heterogeneity that dictates distinct access pathways for marginalized groups; for instance, while Kaduna's significant female participation (≈31%) in vegetable production (Table 1) allows for individual unit ownership, the male-dominated (≈99%) staple farming in Kebbi and Kano implies that women there face land-tenure barriers and require shared-service models. Similarly, the large household sizes in Kano and Kaduna suggest that capital-constrained youth are best integrated through "service-provider" roles rather than direct asset ownership, while Kano's high illiteracy rate (38%) necessitates visual, demonstration-based training. Despite these challenges, strong cooperative membership across the regions provides a critical "access bridge," enabling smaller farmers and women to leverage group-liability mechanisms and pool resources to bypass the collateral requirements that typically exclude them from individual financing.

2.2 Landholding and Cropping Systems

The foundational production environment is defined by consistent landholding across the states, where average farmland holdings and irrigated areas are comparable (approx. 3.4–4.2 acres and 2.2–2.6 acres, respectively). As shown in Table 1, inheritance is the dominant mode of land acquisition, underscoring deeply rooted customary tenure systems that grant tenure security but may complicate land consolidation for large-scale solar schemes; rental and lease arrangements offer secondary land access mechanisms. The cropping systems are characterized by a strong prevalence of sole cropping, with approximately 92% of farmers cultivating single crops on irrigated plots, especially rice and wheat in Kebbi and Kano. Although this simplifies irrigation management, it limits potential benefits from diversification. This established pattern suggests that SBIS deployment must primarily align with the water demands of existing, specialized, single-crop systems, with opportunities for mixed cropping being a secondary consideration.

Table 1. Summary of key socioeconomic indicators

Metric	Kebbi State	Kano State	Kaduna State	Pooled Average
Gender (Male/Female)	99.5% Male / 0.5% Female	99.5% Male / 0.5% Female	68.8% Male / 31.2% Female	89.3% Male / 10.7% Female
Household Size (Mean)	10.4	17.2	14.9	14.1
Farmland Area (Acre)	3.41	3.51	4.20	3.71
Irrigated Area (Acre)	2.59	2.40	2.20	2.40
Illiteracy (No Schooling)	12.0%	38.0%	13.5%	20.9%
Sole Cropping	~98–100%	~98–100%	~80–85%	~92%
Land Acquisition	Dominantly Inheritance	Dominantly Inheritance	Dominantly Inheritance	Dominantly Inheritance

2.3 SBIS Innovation Description

Investment in irrigation varies widely depending on farm size, crop water requirements, and farmers' financial capacity. For solar-based irrigation systems, costs are closely linked to pump capacity. Among smallholder farmers, typical irrigation investments correspond to 2-inch (≈5.5 hp) and 3-inch (≈6–8 hp) petrol pumps, commonly used in lowland shallow groundwater systems with discharge rates of 400–1,000 L/min. These systems generally serve average farm holdings of about 1 acre or less.

While some farmers irrigate areas larger than 1 acre—up to 1 hectare or more —where land and water access permit (often using multiple tubewells), household survey and field data indicate that most farmers fall within the 1-acre investment bracket for dry-season irrigation. Initial demonstrations and pilots of solar-powered pumps using shallow tubewells and surface water sources have shown strong potential for dry-season crop production. Accordingly, the primary objective of SBIS is to replace petrol pumps among smallholder farmers, without altering existing irrigation practices or crop choices, particularly for vegetables and cereals, which dominate local production systems.

The Pump

A 3 hp (minimum 900 W) solar pump, equipped with three 400 W solar panels, has been demonstrated to effectively irrigate a 1-acre field when used in irrigation blocks, a common practice among smallholder farmers (Figure 1). Larger irrigated areas require higher pump capacities and correspondingly greater investment. The cost of solar irrigation pumps also varies by brand and quality. Accordingly, the SBIS investment plan is based on widely available, market-standard brands that are familiar to and preferred by farmers.

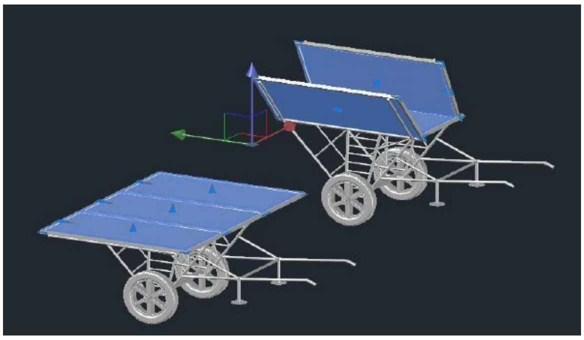
Pump specifications:

- Pump diameter: 3” x 3”
- Max flow: 27m^3/hr (480l/min)
- Power rating: 1.2 – 1.5Hp
- Max Head: 14m
- Suction Head: 6m
- Speed: 3000 – 3600rpm
- Power: solar
- Motor: DC Brushless

Figure 1. The Solar Irrigation Pump, preferred among farmers

The Cart

To facilitate easy conveyance of the pump and solar panels, a cart has been developed. The cart is an optional accessory required where pilfering and insecurity are a challenge. It adds about 30-40% to the cost of the SBIS.



2.4 Crop Yields and Market Analysis for High-Value Crop Opportunities

The analysis of pooled yield data across Kebbi, Kano, and Kaduna states highlights the high production potential of certain key staples and vegetables, while also confirming that overall yields are generally modest compared to national benchmarks. Among the staple cereals, as shown in Table 2, rice shows a strong pooled average yield of 2.68 t/acre, confirming its role as a dominant crop, while maize averages 1.77 t/acre, and wheat’s yield is relatively lower at 1.41 t/acre. High-value vegetables demonstrate varying pooled performances: onion and okra are strong with average yields of 3.64 t/acre and 2.62 t/acre, respectively. Conversely, the pooled averages for pepper (2.36 t/acre) and tomatoes (1.69 t/acre) are less striking, suggesting that regional production strengths (like Kaduna’s low tomato yields) are diluted by lower observations from the other states.

Table 2. Pooled average yields of key crops (tonnes/acre)

Crop Type	Crop	Pooled Average Yield (t/acre)
Cereals	Rice	2.68
	Maize	1.77
	Wheat	1.41
High-Value Vegetables	Onion	3.64
	Okra	2.62
	Pepper	2.36
	Tomatoes	1.69

Meanwhile, the agricultural value chain in the sampled state is characterized by a high degree of commercialization, confirming that farmers are deeply integrated into the cash economy and rely heavily on market income. Approximately 69% of harvested output is sold, far exceeding the 21% consumed, which makes reliable production paramount for financial stability and underscores why investments like SBIS are essential for climate resilience. This commercial focus is spatially differentiated by location advantage: Kaduna State is the most commercialized (70% sold), benefiting from its superior proximity and access to large consumer markets, particularly the Federal Capital Territory (Abuja). The high sales rate suggests a robust value chain driven by various intermediaries (traders and aggregators). Meanwhile, Kano State displays a unique tactical focus, with the highest rate of saved output (7%), signalling a deliberate strategy by farmers to engage in post-harvest handling and storage aimed at improving their price bargaining power later in the season. Ultimately, the high dependence on stable market prices reinforces the critical role that stable production, facilitated by SBIS, plays in enabling successful and profitable market engagement.

2.5 Discrete Choice Experiment

2.5.1 Financial constraints and preference for risk mitigation

The preference analysis reveals that the primary drivers for Solar-Based Irrigation System (SBIS) adoption are centered on financial risk mitigation and cost distribution. Islamic financing emerged as the single most influential positive determinant, particularly dominating preferences in Kebbi and Kano, highlighting a clear and urgent demand for Sharia-compliant financial products. To address the high initial capital cost, which is the dominant barrier, farmers exhibit a strong positive preference for shared ownership structures (2-member and 3-member groups), allowing them to pool resources. Furthermore, affordability dictates the required repayment structure: the longer BOA 2-year financing option is highly preferred, while the 1-year option is highly aversive, underscoring that long repayment tenures are critical for integrating the investment into the farm's annual cash flow.

2.5.2 Strategic implications for SBIS commercialization

The analysis of preference heterogeneity confirms the need for highly flexible and targeted product offerings. While the strong positive preference for Islamic financing is near-universal, its highly significant positive standard deviation suggests the intensity of this preference varies greatly across farmers, requiring tailored outreach and trust-building. Conversely, the high aversion to short-term, conventional loans is consistently reinforced across the farmer population. Crucially, the analysis confirms that farmers prioritize cost savings over flexibility, evidenced by the consistent negative coefficient for the "With cart" mobile option. Therefore, any successful commercialization strategy for SBIS must fundamentally integrate cost-effective, fixed SBIS configurations with flexible, long-term, Sharia-compliant financing and small-group ownership (2-3 members) to overcome affordability barriers and align with dominant cultural and economic preferences. This approach, supported by the Willingness to Invest (WTI) analysis showing the highest appeal for these same group-based, long-term options, is the most viable pathway for large-scale SBIS adoption.

2.6 Building the Investment Analysis

The investment analysis employs a comprehensive approach to model the financial viability of SBIS across diverse farming contexts. The approach defines seven investment scenarios, covering both specialized monocropping (cereal and vegetable). The cost structure incorporates the full SBIS unit cost and installation. Revenue projections rely on actual farmer-reported crop yields from the survey data, complemented by sensitivity analysis around price variability and value chain margins of 10 and 15 percent shocks. Financial viability is rigorously confirmed through core discounting and financing assumptions, including calculating the Payback Period and modelling the Net Present Value (NPV) using both 10% and 15% discount rates (for two years), with a strategic assumption of a 60% profit-sharing loan structure to reflect flexible, de-risked financing requirements.

2.7 Results of the Investment Analysis

2.7.1 Comparative synthesis

The investment analysis across seven crop enterprises reveals a clear hierarchy of financial viability for SBIS. High-value horticulture crops (tomato, pepper, onion) demonstrate the strongest capacity to support SBIS investment, eliminating recurring fuel costs and delivering robust returns. Staple crops (rice, maize, wheat) offer operational benefits but face tighter margins, making them highly sensitive to capital costs. Okra is currently financially fragile and non-viable without a subsidy. Critically, the analysis establishes a strict preference for the fixed SBIS unit USD 428.6 over the mobile unit (USD 714.3). The fixed unit is viable for 6 out of 7 crops, whereas the mobile unit is largely financially essentially non-viable, with negative IRR for most enterprises (see Annex A for detail analyses of each enterprise).

Table 3. Consolidated investment and sensitivity analysis across crop enterprises

Crop Enterprise	Fuel Savings (USD/acre)	Fixed Unit (USD 428) Performance	Mobile Unit (USD 714) Performance	Sensitivity & Risk Profile
Tomato	43.2	Highly Viable NPV: USD 420.8 IRR: Robust (>35%) Payback: ~2.2 Years	Viable NPV: USD 135.1 IRR: Positive	High Resilience: Fixed unit maintains strong profitability even with a 15% revenue drop. The only crop where Mobile unit is defensible.
Pepper	43.2	Highly Viable NPV: USD 232.6 IRR: 42.20% Payback: 2.1 Years	Marginal IRR: 5.73% Low/Neg NPV	Resilient: Fixed unit withstands 15% shock. Mobile unit fails (negative IRR) under stress.
Onion	28.9	Viable IRR: 41.68% Payback: 2.15 Years	Non-Viable IRR: -1.47% NPV: Negative	Moderate: Fixed unit remains profitable under shock. Mobile unit collapses catastrophically (-2.53% IRR).
Rice	71.4	Viable NPV: USD 33.2 IRR: 40.18%	Non-Viable IRR: -0.43% NPV: Negative	Moderate: Fixed unit IRR drops to 29% under 10% shock. Mobile unit is

		Payback: 2.11 Years		financially strained from the start.
Maize	43.3	Marginal/Viable IRR: 29.99% NPV: Negative (at 10%)	Non-Viable IRR: -9.14% NPV: Deeply Negative	Vulnerable: Fixed unit IRR drops to 10.66% with a 10% shock. Requires risk mitigation to be safe.
Wheat	43.2	Constrained IRR: 11.04% NPV: Negative	Non-Viable IRR: -18.78% NPV: Deeply Negative	Highly Vulnerable: Fixed unit IRR falls to 5.38% with a 10% shock. Requires subsidies or insurance.
Okra	43.2	Non-Viable IRR: -4.73% NPV: Negative	Non-Viable IRR: -32.37% NPV: Deeply Negative	Fragile: Lacks resilience to any market shock. Not suitable for commercial SBIS without support.

3. Conclusion and Recommendations

The investment analysis clearly demonstrates that SBIS is a transformative and financially viable alternative to fuel-powered irrigation across the major irrigated crop enterprises in northern Nigeria, but only when deployed under specific conditions. Standardizing the analysis to a 1-acre production unit, the evidence confirms that SBIS is technically feasible and economically compelling. While crops such as tomato, pepper, onion, and rice exhibit strong profitability, rapid payback periods, and highly positive Net Present Values (NPVs)—especially with the low-cost fixed SBIS configuration (USD 428.6)—the analysis also reveals substantial variability. The higher-cost mobile "With Cart" SBIS option (USD 714.3) consistently results in reduced returns, lower IRRs, and frequent investment failure under even moderate revenue shocks, making it unsuitable for most smallholder applications. Meanwhile, enterprises like Wheat, Maize, and Okra remain financially fragile, requiring robust risk protection mechanisms to remain viable.

The recommended SBIS commercialization strategy is to adopt the fixed USD 428.6 SBIS unit as the standard product, given its consistently strong IRR, positive NPV, and overall resilience across crop types. Farmers should be further segmented into a "Tiered Priority Framework" according to crop profitability and investment risk:

- Tomato and Pepper (Tier 1): High Viability. These enterprises can sustain full commercial financing. In the case of Tomato, the margins are high enough to potentially sustain the mobile unit, though the fixed unit remains the superior financial choice.

- Onion and Rice (Tier 2): Moderate/Strong Viability. These should be offered only the fixed system, as the mobile unit is not financially viable and leads to negative NPVs or excessive payback periods for these crops.

- Okra, Wheat, and Maize (Tier 3): Fragile Viability. These crops require concessional financing, performance-based subsidies, or bundled risk-mitigation, as their margins are insufficient to reliably cover the capital costs of SBIS under standard commercial terms and quickly fail under revenue shocks.

- Technology Rationalization: The mobile SBIS unit should be discontinued for marginal crops, as its additional USD 285.7 cost leads to investment failure and negative IRRs across most categories.

- Risk Mitigation: All SBIS investments should incorporate a robust "protection bundle" including guaranteed off-taker contracts, crop insurance, and mandatory agronomic and extension support to stabilize yields against environmental and market volatility.
- Financing Design: Financing packages must align with validated farmer preferences for long repayment periods (tenors), low upfront costs, and small-group liability (2–3 members). Cooperatives should serve as the primary platform for deployment, ensuring collective responsibility for repayment and system maintenance.

Annex A.

Table A.1. Investment analysis for the rice enterprise[2]

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour cost*/acre	69.6	69.6	69.6
Other costs/acre (Organic manure, storage, sacking)	11.0	11.0	11.0
Fertilizer cost/acre	112.6	112.6	112.6
Pesticide cost/acre	8.1	8.1	8.1
Traditional seed cost/acre	8.8	8.8	8.8
Improved seed cost/acre	0.4	0.4	0.4
Herbicide cost/acre	7.2	7.2	7.2
Fuel cost	0.0	0.0	71.4
Production cost/acre	217.8	217.8	289.3
Revenue/acre	653.8	653.8	653.8
Gross margin/acre	436.0	436.0	364.5
Profit margin %	0.048	0.048	0.040
ROI (operational) %	200.1433	200.1433	
ROI (SBIS inclusive/upfront payment) %	1.723187	-38.96609	
ROI (combined) %	67.44444	46.77104	
BCR	3.001433	3.001433	
Payback period (60%)	2.111079	2.56635	
NPV @10%	46,423.08	-353,576.9	
NPV @15%	5,516.116	-394,483.9	
IRR	0.401776	-0.00432639	
Investment cost	428.6	714.3	

Table A.2. Sensitivity analysis for rice enterprise

Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	588.4	555.7	588.4	555.7
GM (USD/ha)	370.6	337.9	370.6	337.9
ROI SPIS (%)	17.299663	9.610624	95.499439	82.684374
NPV @10%	-446,565.32	-492,752.75	-46,565.32	-92,752.75
NPV @15%	-481,587.79	-524,852.38	-81,587.79	-124,852.38
IRR	-0.08663551	-0.11691420	0.29635075	0.22971949
Payback (years)	2.664468	2.710378	2.235993	2.297626

Table A.3. Investment analysis for the wheat enterprise

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour/acre	84.3	84.3	84.3
Other costs/acre (Organic manure, storage, sacking)	14.2	14.2	14.2
Fertilizer cost/acre	155.5	155.5	155.5
Pesticide cost/acre	11.2	11.2	11.2
Traditional seed cost/acre	36.4	36.4	36.4
Improved seed cost/acre	0.3	0.3	0.3
Herbicide cost/acre	8.6	8.6	8.6
Fuel cost	0.0	0.0	43.4
Production cost/acre	310.5	310.5	353.9
Revenue/acre	498.6	498.6	498.6
Gross margin/acre	188.1	188.1	144.7

[2] *All costs are in USD at the rate of 1USD = N1400)*

Profit margin %	37.7286	37.7286	
ROI (operational) %	60.58736	60.58736	
ROI (SBIS inclusive/upfront payment) %	-56.10584	-73.6635	
ROI (combined) %	25.4536	18.35697	
BCR	1.605874	1.605874	
Payback period (60%)	2.404202	2.744622	
NPV @10%	-259,196.50	-659,196.50	
NPV @15%	-280,763.20	-680,763.20	
IRR	0.1104187	-0.1878128	
Investment cost	428.6	714.3	

Table A.4. Sensitivity analysis for wheat enterprise

Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	448.75	423.82	448.75	423.82
GM (USD/ha)	138.26	113.33	138.26	113.33
ROI SPIS (%)	-66.21679	-68.91200	-43.69465	-48.18667
NPV @10%	-720,316.7	-749,708.9	-320,316.7	-349,708.9
NPV @15%	-738,015.7	-765,547.8	-338,015.7	-365,547.8
IRR	-0.20584983	-0.22351069	0.05384088	0.02171233
Payback (years)	2.796025	2.812225	2.512435	2.557455

Table A.5. Investment analysis for the maize enterprise

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour/acre	78.0	78.0	78.0
Other costs/acre (Organic manure, storage, sacking)	30.1	30.1	30.1
Fertilizer cost/acre	147.6	147.6	147.6
Pesticide cost/acre	16.4	16.4	16.4
Traditional seed cost/acre	26.3	26.3	26.3
Improved seed cost/acre	0.0	0.0	0.0
Herbicide cost/acre	27.9	27.9	27.9
Fuel cost	0.0	0.0	43.4
Production cost/acre	326.2	326.2	369.6
Revenue/acre	662.0	662.0	662.0
Gross margin/acre	335.7	335.7	292.4
Profit margin %	50.7206	50.7206	
ROI (operational) %	102.9246	102.9246	
ROI (SBIS inclusive/upfront payment) %	-21.65848	-52.99509	
ROI (combined) %	44.48304	32.26824	
BCR	2.029246	2.029246	
Payback period (60%)	2.355662	2.72954	
NPV @10%	-110,527.40	-510,527.40	
NPV @15%	-141,502.20	-541,502.20	
IRR	0.2999	-0.0914	
Investment cost	428.6	714.3	

Table A.6. Sensitivity analysis for maize enterprise

Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	595.76	562.66	595.76	562.66
GM (USD/ha)	269.55	236.46	269.55	236.46
ROI SPIS (%)	-77.78	-81.35	-62.96	-68.91
NPV @10%	-607,031.1	-655,282.9	-207,031.1	-255,282.9
NPV @15%	-631,898.9	-677,097.3	-231,898.9	-277,097.3
IRR	-0.2202	-0.2887	0.1066	0.0051
Payback (years)	2.8166	2.8500	2.5440	2.6361

Table A.7. Investment analysis for the pepper enterprise

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour/acre	143.6	143.6	143.6
Other costs/acre (Organic manure, storage, sacking)	25.7	25.7	25.7
Fertilizer cost/acre	375.4	375.4	375.4
Pesticide cost/acre	33.1	33.1	33.1
Traditional seed cost/acre	17.1	17.1	17.1
Improved seed cost/acre	3.8	3.8	3.8
Herbicide cost/acre	23.7	23.7	23.7
Fuel cost	0.0	0.0	43.2
Production cost/acre	622.4	622.4	665.6
Revenue/acre	1035.0	1035.0	1035.0
Gross margin/acre	412.6	412.6	369.4
Profit margin %	39.86344	39.86344	35.68915
ROI (operational) %	66.28821	66.28821	
ROI (SBIS inclusive/upfront payment) %	-3.729747	-42.23785	
ROI (combined) %	39.25715	30.86609	
BCR	1.662882	1.662882	
Payback period (60%)	2.102085	2.439093	
NPV @10%	325,669.30	-74,330.68	
NPV @15%	267,091.10	-132,908.90	
IRR	0.4220018	0.05732141	
Investment cost	428.6	714.3	

Table A.8. Sensitivity analysis for pepper enterprise

Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	931.50	879.75	931.50	879.75
GM (USD/ha)	309.09	257.34	309.09	257.34
ROI SPIS (%)	-88.01157	-88.92940	-80.01929	-81.54900
NPV @10%	-217,147.4	-288,020.5	182,852.6	111,979.5
NPV @15%	-266,687.93	-333,076.03	133,312.07	66,923.97
IRR	-0.05375837	-0.14309212	0.36008157	0.22409644
Payback (years)	2.500284	2.564702	2.171402	2.245037

Table A.9. Investment analysis for the tomato enterprise

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour/acre	67.0	67.0	67.0
Other costs/acre (Organic manure, storage, sacking)	35.6	35.6	35.6
Fertilizer cost/acre	163.3	163.3	163.3
Pesticide cost/acre	25.3	25.3	25.3
Traditional seed cost/acre	10.0	10.0	10.0
Improved seed cost/acre	7.6	7.6	7.6
Herbicide cost/acre	16.6	16.6	16.6
Fuel cost	0.0	0.0	43.2
Production cost/acre	325.4	325.4	368.6
Revenue/acre	1094.4	1094.4	1094.4
Gross margin/acre	769.0	769.0	725.8

Profit margin %	70.26597	70.26597	66.3181492
ROI (operational) %	236.315	236.315	
ROI (SBIS inclusive/upfront payment) %	79.42763	7.656579	
ROI (combined) %	101.9896	73.96211	
BCR	3.36315	3.36315	
Payback period (60%)	2.217588	2.477134	
NPV @10%	589,160.30	189,160.30	
NPV @15%	513,907.80	113,907.80	
IRR	0.2167152	0.03449091	
Investment cost	428.6	714.3	

Table A.10. Sensitivity analysis for tomato enterprise

Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	984.94	930.22	984.94	930.22
GM (USD/ha)	659.54	604.82	659.54	604.82
ROI SPIS (%)	-66.00000	-70.00000	-43.33333	-50.00000
NPV @10%	37,225.81	-38,384.13	437,225.81	361,615.87
NPV @15%	-28,411.94	-99,237.12	371,588.06	300,762.88
IRR	0.00000577	-0.06886942	0.38552888	0.35081032
Payback (years)	2.480871	2.516143	2.254865	2.323100

Table A.11. Investment analysis for the onion enterprise

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour/acre	48.8	48.8	48.8
Other costs/acre (Organic manure, storage, sacking)	12.3	12.3	12.3
Fertilizer cost/acre	79.9	79.9	79.9
Pesticide cost/acre	7.1	7.1	7.1
Traditional seed cost/acre	17.5	17.5	17.5
Improved seed cost/acre	2.6	2.6	2.6
Herbicide cost/acre	12.9	12.9	12.9
Fuel cost	0.0	0.0	28.9
Production cost/acre	181.1	181.1	210.1
Revenue/acre	561.7	561.7	561.7
Gross margin/acre	380.5	380.5	351.6
Profit margin %	67.74943	67.74943	
ROI (operational) %	210.0721	210.0721	
ROI (SBIS inclusive/upfront payment) %	-11.20619	-46.72371	
ROI (combined) %	62.41295	42.49831	
BCR	3.100721	3.100721	
Payback period (60%)	2.154738	2.548602	
NPV @10%	-45,222.13	-445,222.10	
NPV @15%	-80,329.60	-480,329.60	
IRR	0.4168	-0.0147	
Investment cost	428.6	714.3	

Table A.12. Sensitivity analysis for onion enterprise

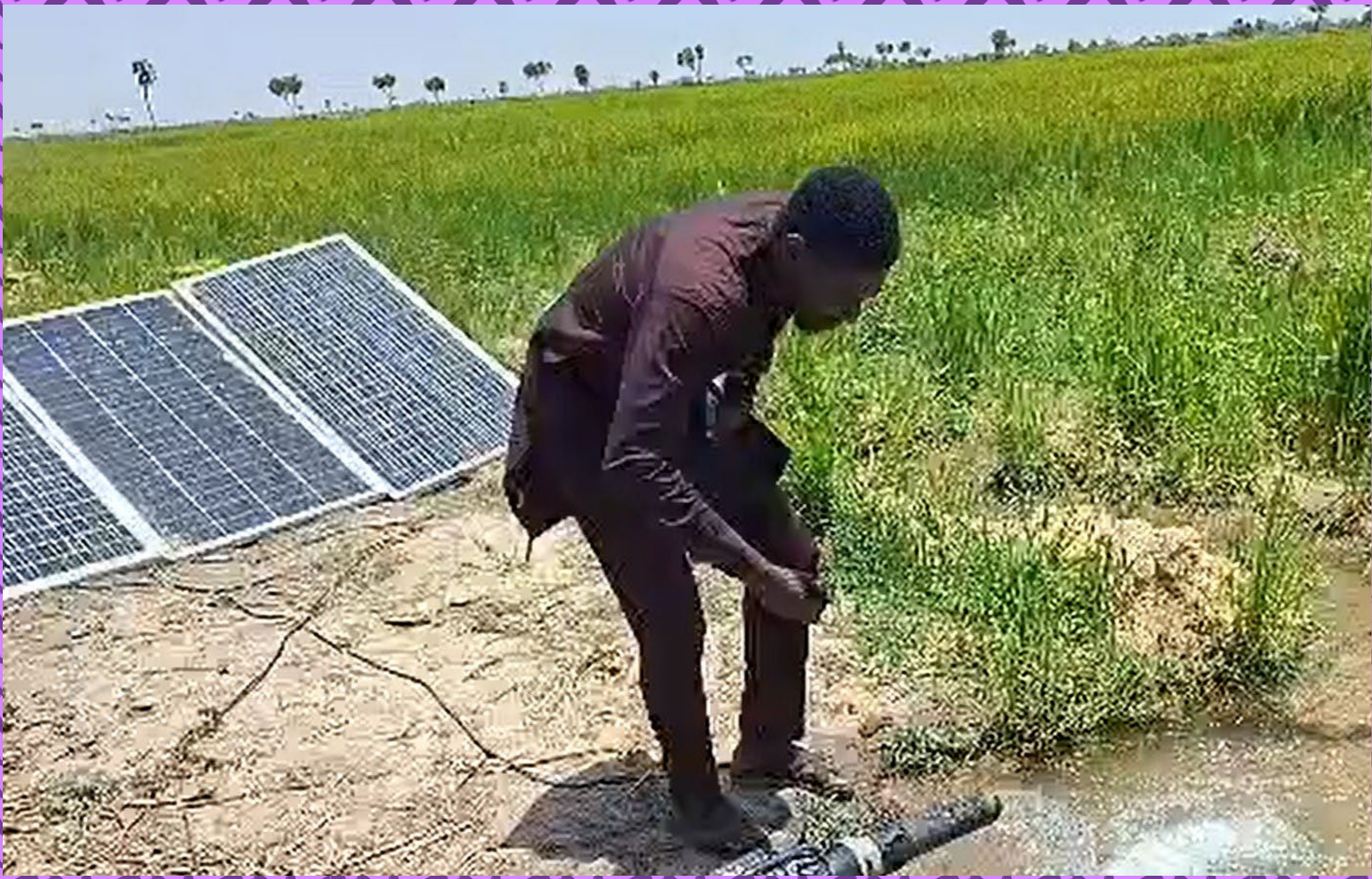
Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	505.53	477.44	505.53	477.44
GM (USD/ha)	324.38	296.29	324.38	296.29
ROI SPIS (%)	22.52	14.33	104.20	90.55
NPV @10%	-527,108.8	-566,953.0	-127,108.8	-166,953.0
NPV @15%	-557,034.4	-594,357.1	-157,034.4	-194,357.1
IRR	-0.0253	-0.0842	0.3951	0.3066
Payback (years)	2.6903	2.6985	2.2808	2.2519

Table A.13. Investment analysis for the okra enterprise

Variable	Without Cart	With Cart	Fuel Irrigation
Total labour/acre	65.7	65.7	65.7
Other costs/acre (Organic manure, storage, sacking)	18.6	18.6	18.6
Fertilizer cost/acre	68.4	68.4	68.4
Pesticide cost/acre	10.9	10.9	10.9
Traditional seed cost/acre	12.4	12.4	12.4
Improved seed cost/acre	1.5	1.5	1.5
Herbicide cost/acre	10.9	10.9	10.9
Fuel cost	0.0	0.0	28.9
Production cost/acre	188.5	188.5	217.4
Revenue/acre	408.8	408.8	408.8
Gross margin/acre	220.3	220.3	191.4
Profit margin %	53.89366	53.89366	
ROI (operational) %	116.8899	116.8899	
ROI (SBIS inclusive/upfront payment) %	-48.59333	-69.156	
ROI (combined) %	35.70435	24.40437	
BCR	2.168899	2.168899	
Payback period (60%)	2.617087	2.817517	
NPV @10%	-278,814.50	-678,814.50	
NPV @15%	-299,139.80	-699,139.80	
IRR	-0.04728	-0.32368	
Investment cost	428.6	714.3	

Table A.14. Sensitivity analysis for okra enterprise

Scenarios	With Cart	With Cart	Without Cart	Without Cart
Revenue Change (%)	-10	-15	-10	-15
Revenue (USD/acre)	367.92	347.48	367.92	347.48
GM (USD/ha)	179.43	159.00	179.43	159.00
ROI SPIS (%)	-15.95	-21.75	40.08	30.42
NPV @10%	-738,193.0	-766,675.2	-338,193.0	-366,675.2
NPV @15%	-754,760.6	-781,440.4	-354,760.6	-381,440.4
IRR	-0.3659	-0.4154	-0.1110	-0.1830
Payback (years)	2.857981	2.894350	2.673296	2.696610



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