International Journal of Innovative Human Ecology & Nature Studies 14(1):87-97, Jan-Mar., 2026

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doi:10.5281/zenodo.19241578

Impact Of Improved Technologies Of Water Harvesting Techniques And High Quality Seeds On Farm Budget Model Analysis

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ABSTRACT

This study was conducted in Sheikan, Um Rawaba and El Rahad localities, North Kordofan State, Sudan during the period of 2022 - 2024. The main objective of the study was to assess the impact of water harvesting techniques and high-quality seeds in farmer's economic situation. Primary data were collected using household questionnaire. A multi-stage cluster random sampling technique was applied to select targeted sample where, 434 households were selected from4340 households dwelling twelve villages in the study area. A sampling frame was developed from existing records at the Ministry of Production and Economic Resources, North Kordofan State and International Fund of Agricultural Development projects. Comparisons of means, analysis of variance and descriptive statistics were used in data analysis. Both EXCEL and SPSS analytical tools were used. Farm budget analysis was applied to detect the impact of technologies used. The study identified some group of farmers due to their adoption of improved technologies that include water harvesting techniques, high quality seeds and improved varieties. Group (I) represented farmers used all three technologies. Group (II) were farmers' practiced water harvesting techniques and improved varieties without using high quality seeds. Group (III) farmers' practiced improved varieties and high quality seeds without water harvesting techniques. Group (IV) represented farmers' who practiced water harvesting techniques without using improved varieties and high quality seeds. Group (V) farmers used improved varieties without water harvesting techniques and high quality seeds. Group (VI) is the control group, without any of the aforementioned improved technologies. The study results found that when farmer practiced improved technologies in crops production, Benefit/Cost (B/C) Ratio became high and more than one in each crop which indicated positive gross margin. Sorghum recorded the highest B/C Ratio (3.3), groundnut recoded relatively high (2.7) while sesame recorded the lowest one (2.0) in contrast to the control group where B/C Ratio (0.6) below one which indicated that the crop revenue was less than cost of production leading to negative gross margin. Sorghum B/C ratio was the highest in *Sheikan* locality (3.5) followed by *El Rahad* locality (2.7) while *Um Rawaba* recorded the lowest (2.1). When farmer practiced improved technologies, B/C ratio became high and more than one in each crop indicating positive gross margin. Highest revenue as SDG497,568, 286,432 and 610,760 for Sorghum, Sesame and Groundnut; respectively that obtained when farmer used the three technologies (group I). Groundnut recorded the highest revenue and sesame recorded the lowest. Revenue reported relatively high when farmer practiced water harvesting techniques and improved varieties without using high quality seed (Group II) but less than group I. Revenue reported low when farmer used water harvesting techniques without improved varieties and high quality seeds (group IV), while the control group reported the lowest revenue (SDG67, 525, 66,447 and 75,177 for Sorghum, Sesame and Groundnut; respectively. The study provided some recommendations, but the most important is that improved technologies and services should be made readily available and accessible to producers in time and at affordable price. Improved technologies regarding sesame crop need more attention, which characterized by the lowest B/C ratio. The adoption of improved agricultural technologies led to higher household income, and potentially improved food entitlements and farmers' health as well as nutritional status.

Keywords: Improved technology, Water harvesting technique, Gross margin, North Kordofan

1. INTRODUCTION

Agricultural sector is the most important economic sector in Sudan; it contributes about 43% of the country Gross Domestic Product (GDP). The sector provides employment for more than 70% of the population and provides inputs to many major manufacturing industries. Agriculture is the key sector for poverty reduction and food security, for fueling growth and replacing oil as the key engine of the economy. The Agriculture Revival Program (ARP) was aimed to increase agricultural exports and decrease reliance on oil exports through increased productivity, improved food security and agricultural incomes, reduced rural poverty and redressed regional imbalances.(ARP, 2017).

The rain-fed farming system is an important agricultural subsector, typically divided into semi-mechanized farming, traditional crop production and livestock systems. Depending on rainfall, rain-fed subsectors contributed three-quarters of foreign exchange earnings from agricultural exports (Seirab, 2005). Traditional rain-fed farming is practiced by family households with farms ranging from 2 to 50 hectares in size, farming for income and subsistence (FAO, 2021). Traditional rain-fed farming covers about 4.7 million ha, growing about 95% of the country's millet, 38% of sorghum, 67% of groundnut and 38% of sesame. The subsector also grows gum Arabic, Roselle and water melon seeds for export. Semi-mechanized rain-fed farming is practiced by large-scale farmers and companies with low rent leases granted by the federal government producing 40% of the country's sorghum, 62% of sesame and 90% of sunflower and cotton grown in the country (IFAD, IAMDP, 2017).

In Sudan, poverty remains a rural phenomenon and closely associated with livelihood systems of rain-fed subsistence agriculture. The Interim Poverty Reduction Strategy study revealed that 46.5% of Sudan population is situated below the poverty line, with 26.5% of the urban and 66.5% of the rural (IPRSP, 2004). The last country poverty assessment revealed that 39% of the population are confined below the poverty line and it's around 37% on North Kordofan(Central Bureau of Statistics 2015).

During the last decades North Kordofan State has experienced huge variations in environmental conditions- drought, desertification and instability of rainfall - are the major environmental troubles, these changes have a major influence on economic activities, crop production, poverty and food security. North Kordofan State faces a number of problems which are the result of combination constraints such as environmental, economic, resources, marketing, inputs and political factors.

Due to the fact that, Sorghum and Millet In North Kordofan State are an important staple food crops while Sesame and Groundnut representing main cash crops. Since these crops have a substantial influence on farm economy it is important to increase and maintain high yields. The study objective is to assess the impact of improved technologies of water harvesting technique, high quality seeds and improved varieties on the analysis of farm budget model

2. STUDY AREA AND RESEARCM METHODOLOGY

2.1 Study Area

The study area covered North Kordofan State, which including *Sheikan, Um Rawaba* and *El-Rahad* localities. The area in general, is subjected to further degradation due to harsh environmental conditions, climatic instability, desert encroachment to the South, recurrent drought episodes, cutting down of trees for various uses, over cultivation and over grazing. The state generally situated between desert, semi-desert, arid and semi-arid agro-ecological zones. The rainfalls are less than 50 mm/year in the North and more than 400 mm in the South of the State, while there are a lot of surface and underground water (ARS, Elobied, 2018). Agricultural crops productivity depends largely on both distribution and amount of rainfall. The average temperature ranges between 6 ºC in winter and more than 45 ºC during summer seasons. The degree of temperature decreases towards the North Kordofan state by nights while it increases towards the South between latitudes 10 and 20 N. The winds differ according to the season. During autumn the humidity of the temperature wind direction and rainfall have very important role of plant growth. According to 2025 national population census, the population is about 3.03 million people, 79% (about 407,173 households) of them depend on agricultural production for livelihood. About 37% of households are below poverty line (Central Bureau of Statistics report in 2015) which estimated as

190,697 household and 90% of them are economically active which reached 173,534 households (Natural Resource Base Document 2024)

The soil is classified into six types as sandy, clay, loamy, sandy-loamy, clay-loamy and *gardud* soil (ElObeid research station,).

2.2. Research Methodology

2.2.1Data sources

Primary data was collected through designed questionnaire which consisted of three sections, the first section was to gain data regarding household income and expenditure, the second was for individual questionnaire to collect data regarding farm budget model, the third one was to collect data regarding improved technology adoption. Secondary data depended on published & unpublished books, reports and articles from IFAD, FAO and other related institutions and websites. The study relied on database that collected by Seed Development Project (SDP) and Integrated Agricultural and Marketing Development Project (IAMDP) funded by IFAD.

2.2.2 Sampling and Sample Frame

A sample frame was developed from existing records and database at the Seed Development Project (SDP) and Integrated Agricultural and Marketing Development Project(IAMDP) that project co-financed by IFAD and Sudan government and used to accomplish random selection.

Multi-stage cluster random sampling system was used to identify the sites and respondents from the three determined localities of North Kordofan State. In the first stage three localities out of eight were selected (37.5%). Second stage 45% of targeted communities was selected randomly 12 communities out of 27 whereas; 10% of the targeted beneficiaries were randomly selected as the third stage.

2.2.3 Sample size

A total of 434 households were selected randomly from 4340 households representing 10% from total population that served by (IAMDP) that funded by IFAD and government of Sudan and State Ministry of Production and Economic Resources in North Kordofan State as leader agency. IAMDP targeted 27 communities from three targeted localities and12 of them were selected from a total (45%), giving a total of 434 selected household for the study area and selected 8-12 households from each community, this due to homogeneity of household potentiality in the selected community.

Table (1) Distribution of population and sample size in the study area

Locality	Population		Sample	
	Communities	Households	Communities	Households
Sheikan	9	1387	4	145
El Rahad	9	1230	4	114
Um Rawaba	9	1723	4	175
Total	27	4340	12	434

2.2.4 Analytical Framework

Comparisons of means, analysis of variance and descriptive statistics were used to describe study area to covering the first objective of "reviewing the socio-economic characteristics indicators of the farmers in the study area". EXCEL and SPSS analytical tools were used in data analysis. Formulas were used to calculate total yearly household income and expenditure. To calculate total household income (THHI) it is necessary to calculate farm income (FI) and non-farm income (NFI). The FI included income from crop (ICP), income from livestock selling (ILS),income from animal production (IAP) and income from forestry (IF).The non-farm income (NFI) source includes: local trading (ILD), employment (IE), gifts(IG), local labor (LL) and property renting (Formulas 1-3).

Formula (1) THI = FI + NFI
Formula (2) FI=IFC + ILS +IAP + IF
Formula (3) NFI=ILD + IE + LL + others

In order to calculate the yearly total household income, the mean yearly total household income should be calculated by adding all observed values and divided by number of observations (formula 4).
Formula (4) Mean HHI

$$\bar{X} = \frac{\sum X_i}{n}$$

The main components of the total household expenditure (THHE) are basic expenses (BE) that include food items and watering and secondary expenses (SE) that include health, education and other expenses such as social events, shelters, clothes and others (Formula 5).
Formula (5) THHE= BE + SE
Different enterprises were calculated in money values, and with data on yields, prices, costs of labor and inputs were used to build up enterprises budget models. These enterprises budget models were used to compare between different enterprises to be consolidated into farm budget models for the different localities, thus provides basis for farm gross margin analysis (farm budget models), through calculations of gross output, gross margin and net farm income using different formulas (Formula 6).
Formula (6) R= Y X P
Where (R) stand for revenue in SDG, (Y) for yield in kg/feddan and (P) for prices in SDG.
In order to investigate the effects of use of high-quality seeds, improved varieties and water harvesting techniques contribute to the income generation and economic situation for smallholder farmers in the study area, cost of production is separated into variable and fixed costs. For a given enterprise, the gross margin is the difference between gross output and variable cost (Formula 7).
Formula (7) GM= GR – GV
Where GM= Gross margin, GR= Gross Revenue and GV= Gross variable costs.
The total sum of all enterprises gross margins gives the total farm gross margin.
Formula (7) Net farm income = total gross margin – fixed costs.
To conduct crop budget analysis for the farming system prevailed using different improved technologies as compared with local practices will be covered through detailed analysis of farm budget model with household income and expenditure
To detect the distribution of the collected data the standard deviation (STD) was calculated according to formula 8.

Formula (8)

$$STD = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}}$$

3. RESULTS AND DISCUSSIONS

3.1 Farm budget analysis (FBA)

A farm budget analysis is a financial tool used to assess the economic viability and profitability of farm for overall financial performance. This analysis can be done for an entire farm operation crop production. This farm analysis is a partial for three seasonal farm crops and off farm income. Costs are divided into two-parts: fixed and variable costs where fixed cost is the overhead cost which represents the expenses that do not vary with production (e.g., land, depreciation of machinery, hand tools, insurance). The variable costs are expenses that change based on production levels (seeds, fertilizers, labor and transportation).

3.1.1 Crop revenue

Table (1) showed that groundnut recorded highest revenue (SDG 454,064), followed by sorghum (SDG 371,362), while sesame recorded the lowest (SDG 220,953). This due to high yield of groundnut followed by sorghum and sesame is the lowest one. In fact, farm crop residues contribute significantly in revenue as sold as livestock feeds therefore, groundnut recorded the highest while sesame recorded lowest and sorghum farm residues recorded more than sesame and less than groundnut. Revenue obtained from groundnut crop residues contributed by 15% of total crop revenue, whereas; sorghum and sesame crop plants residues contributed by about 10% and 6%; respectively.

3.1.2 Crop variable cost

Groundnut recorded highest variable cost (SDG 185,148), followed by sesame (SDG 130,185), while sorghum recorded the lowest (SDG 129,942). This due to high yield of groundnut followed by sorghum and sesame is lowest one. Average farm revenue reached more than one million SDG while the average cost of production less than half million SDG. This implied that family farm revenue represent doubling of average cost of production which revealed profitability of crop production practices. These results assured that the use of improved technologies contributed positively to the income generation and economic situation for smallholder farmers in the study area.

3.1.3 Benefit Cost Ratio (B/C ratio)

B/C Ratio is the financial tool to measure crop performance, as calculated by dividing crop revenue to variable cost of production (total revenue/total variable cost. IFAD co-finance projects adopted B/C ratio in order to measure crop performance during the annual crop assessment. If the B/C ratio below one that means the crop revenue less than cost of production. In this study, Sorghum B/C ratio was 2.9 while sesame and groundnut reported 1.7 and 2.5 respectively (Table1). These results displayed that sorghum was the highest profitable crop than groundnut while sesame is the lowest one, these situation can be attributed to high production cost of groundnut rather than sorghum, while sesame need more attention towards improved technologies. In other words, sorghum and groundnut highly responded to improved technologies of water harvesting techniques, high quality seeds and improved variety used, while sesame characterized by low response to these technologies. To elaborate, I Table (3), sorghum B/C ratio was the highest in *Sheikan* locality (3.5) followed by *El Rahad* locality (2.7) while *Um Rawaba* recorded the lowest (2.1). This result was probably due to that *Sheikan* locality is dominant by using sorghum improved varieties rather than the other two localities, and water harvest practices and availability of certified seeds. Highest sesame B/C ratio (2.0) was obtained at *El Rahad* locality in contrast to *Sheikan* and *Um Rawaba* Localities (1.7) as presented in Table(3). This result was due to high potentiality that suitable for sesame production in *El Rahad*. Sesame represents the main cash crop cultivated in *El Rahad* Locality while *Um Ruwaba* reported highest groundnut B/C ratio (2.6) and *El Rahad* locality reported the lowest (2.2). *Sheikan* locality reported the highest revenue for all crops; *El Rahad* locality reported the lowest revenue from sorghum and groundnut while *Um Ruwaba* manifested the lowest revenue from sesame crop. These results revealed that all three crops attained positive economically effect in traditional rain-fed farming system, particularly when practicing improved technologies. *Sheikan* locality recorded the highest effects and *El Rahad* is the lowest. It was plausible, this ranking was attributed to the level of adoption of improved technologies in question.

Table (1): Crops cost benefit analysis in the study area

Crop type	Variable	Revenue – cost (SDG)
Sorghum		
	Total revenue	371,362
	Total cost	129,942
	Gross margin	241,420
	Benefit Cost Ratio (B/C ratio)	2.9
	Revenue per feddan	86,363
	Cost per feddan	30,219
	Gross margin	56,144
	Benefit Cost Ratio (B/C ratio)	2.9
Sesame		
	Total revenue	220,953
	Total cost	130,185
	Gross margin	90,768
	Benefit Cost Ratio (B/C ratio)	1.7
	Revenue per feddan	55,238
	Cost per feddan	32,546
	Gross margin	22,692
	Benefit Cost Ratio (B/C ratio)	1.7
Groundnut		
	Total revenue	454,064
	Total cost	185,148
	Gross margin	268,712
	Benefit Cost Ratio (B/C ratio)	2.5
	Revenue per feddan	174,639
	Cost per feddan	71,211
	Gross margin	103,428
	Benefit Cost Ratio (B/C ratio)	2.5

Sources: Survey data, 2023

Table (2): Farm revenue for the three crops in the study area

Product	Crop			Revenue SDG	SE±
	Sorghum	Sesame	Groundnut		
Crop revenue	335,023	207,509	386,759	929,291	17,096.5**
Crop Residues	36,339	13,444	67,267	117,050	1,762.31**
Total revenue	371,362	220,953	454,026	1,046,341	18,009.4**

Sources: Survey data, 2023

Table (3) Crop Benefic cost ratio (B/C ratio) by Localities

Crop	Descriptive	Sheikan	El Rahad	Um Rawaba
Sorghum				
	Total revenue	695,506	189,942	218,845
	Total cost	201,055	68,705	104,882
	Gross margin	494,451.	121,237	113,963
	Benefit cost ratio (B/C) RATIO)	3.5	2.7	2.1
Sesame				
	Total revenue	304,748	194,465	167,908
	Total cost	184,774	98,618	99,686
	Gross margin	119,974	95,847	68,222
	Benefit cost ratio (B/C) RATIO)	1.7	2.0	1.7
Groundnut				
	Total revenue	788,634	262,232	299,565
	Total cost	320,738	120,887	113,370
	Gross margin	467,896.	141,345	186,195
	Benefit cost ratio (B/C))RATIO)	2.5	2.2	2.6

Sources: Survey data, 2023

3.2 Impact of adoption improved technologies on the Benefit Cost Ratio (B/C ratio)

Empirical data found that there was no farmer reported practicing improved varieties coupled with high quality seeds without water harvest techniques, and also no farmer was reported using improved varieties without practicing water harvesting techniques and high quality seeds, so groups III and V are not measured due to unavailability of data within the selected sample group.

3.2.1 Revenue and variable cost of farmers group

Table (4) showed the highest revenue as SDG497,568, 286,432 and 610,760 for Sorghum, Sesame and Groundnut; respectively that obtained when farmer used the three technologies (group I). Groundnut recorded the highest revenue and sesame recorded the lowest. Revenue reported relatively high when farmer practiced water harvesting techniques and improved varieties without using high quality seed (Group II) but less than group I. Revenue reported low when farmer used water harvesting techniques without improved varieties and high quality seeds (group IV), while the control group reported the lowest revenue (SDG67,525, 66,447 and 75,177 for Sorghum, Sesame and Groundnut; respectively.

On the other hand, crop revenue for group II decreased by only 1- 2% comparing with group I, while group V decreased by more 80-83% and control group decreased by 87- 90% when compared with group I. These results illustrated that the difference between group I and group II (without using high quality seed) revenue is smallest indicating the performance of using high quality seeds is low in crop revenue in contrast to water harvesting and improve varieties practices. The revenue in group IV (only used water harvesting) comparing with group I revenue recoded wide difference that decreased by 83% implying low impact of water harvesting techniques without improved varieties and high quality seeds. With regard to comparing revenues in group I and control group, that recorded decrease by 83%, which confirmed the high impact of the use of improved technologies as one package.

3.2.2 Benefit Cost Analysis by groups

Table (5) displayed that benefit cost ratio (B/C ratio) on control group recorded below one which indicate the crop revenue less than cost of production so the gross margin became negative. The study found that sorghum and groundnut B/C ratio recorded relatively high although it below one (losses impact), while sesame B/C ratio recorded the lowest (only 0.6), by the other words sesame cultivated in control group lost more than 40%.When farmer practiced improved technologies (group I), B/C ratio became high and more than one in each crop which indicated positive gross margin. Sorghum recorded the highest B/C ratio (3.3), groundnut B/C RATIO recoded relatively high (2.7) while sesame B/C ratio recorded the lowest one (2.0), these results confirmed that sorghum crop recorded the highest performance of improved technologies rather than groundnut while sesame crop recorded the lowest.

Table (4) Revenue, variable cost of farmers group in the study area

	Group	Revenue/ Cost (SDG)		
		Sorghum	Sesame	Groundnut
Revenue				
	Group I (all technologies)	497,568	286,432	610,760
	Group II (WH + IV) without CS	487,237	284,146	600,506
	Group III (IV+ CS) without WH	0	0	0
	Group IV (WH) without IV & CS	83,103	72,000	99,658
	Group V (IV) without WH & CS	0	0	0
	Croup six Control (non)	65,687	36,947	58,562
V. cost				
	Group I (all technologies)	151,712	143,436	226,049
	Group II (WH + IV) without CS	149,770	143,385	222,312
	Group III (IV+ CS) without WH			
	Group IV (WH) without IV & CS	69,375	77,418	83,396
	Group V (IV) without WH & CS			
	Croup six Control (non)	67,525	66,447	75,177

Sources: Survey data, 2023

Table (5) Benefit Cost Analysis by groups

Crop	Descriptive	Control	Group 1	Group II	Group IV
Sorghum					
	Total revenue	65,687	497,568	487,237	83,103
	Total cost	67,525	151,712	149,770	69,375
	Gross margin	- 1,838	345,856	337,467	13,728
	(B/C ratio)	0.9	3.3	3.2	1.2
Sesame					
	Total revenue	36,947	286,432	284,146	72,000
	Total cost	66,447	143,436	143,385	77,418
	Gross margin	- 29,500	142,996	140,761	- 5,418
	(B/C ratio)	0.6	2.0	1.9	0.9
Groundnut					
	Total revenue	58,562	610,760	600,506	99,658
	Total cost	75,177	226,049	222,312	83,396
	Gross margin	- 16,615	384,711	370,194	16,262
	(B/C ratio)	0.8	2.7	2.7	1.2

Sources: Survey data, 2023

CONCLUSION AND RECOMMENDATIONS

The study concluded that Benefit cost ratio (B/C ratio) on control group recorded below one which indicated that the crop revenue was less than cost of production so the gross margin became negative. The study found that sorghum and groundnut B/C ratio recorded was relatively high although it was below one (losses impact), while the sesame B/C ratio recorded the lowest,

When farmer practice improved technologies, B/C ratio became high and more than one in each crops which indicated positive gross margin. Sorghum recorded the highest B/C ratio; groundnut B/C ration recoded relatively high, while sesame B/C ratio recorded the lowest one, these results confirmed that sorghum crop recorded the highest performance of improved technologies rather than groundnut while sesame crop recorded the lowest.

The study recommended the following

- Improved technologies and services should be made readily available and accessible to producers in time and at affordable price.
- Means of production should be avail and accessible to producers in order to make use of improved technologies such as suitable hand tools, intermediate technology tools and mechanization equipments
- Improved technologies regarding sesame crop need more attention in the themes of verity and cultural practices, which characterized by the lowest B/C ratio in different situations.
- Private public producers' partnership approach should be strengthened and deployed to ensure accessibility and availability of improved technologies at producers level.
- Agricultural policies need to be directed toward supporting production system and governed institutional set up (institutional relationship between research centers and extension authority)

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