The Impact of Rainfall and Strategies for Agricultural Accommodativeness on Sesame Crop Productivity Under Mechanized Rain-Fed Sub Sector in Al-Jabalain at The White Nile State, Sudan

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Abstract:

The study was conducted in Al-Jabalain at the White Nile State, Sudan during the period (1970-2019)to analyze the effect of rainfall and agricultural adaptation strategies on sesame yield in the mechanized rainfed subsector, primary data and Secondary data were collected to study the yield variability , rainfall rates and agricultural adaptation strategies from the annual reports of the Ministry of Agriculture, the Sudan Meteorological Authority, observations, personal interviews, design and distribution 160 questionnaire forms were answered by farmers in the targeted area. Primary and secondary data were analyzed using coefficient of dispersion, correlation, simple regression and percentages. The study found that the fluctuation of rainfall during the study period led to decrease in the yield of sesame, which represent the cash crop of the farmers in the area. As a result of the fluctuation of rainfall and the continuous decline in the yield of sesame, farmers developed a number of agricultural strategies as alternative solutions to maintain the production, including early cultivation, sowing of good quality seeds, implication of the proper crop rotation and storage system. The study recommended the development of the meteorological station in Al-Jabalain, using water harvesting technology, development of agricultural adaptation strategies invented by farmers in order to ensure high crop productivity

Key words: Rainfall, Agricultural adaptation strategies, Sesame, Productivity, Mechanized rain-fed subsector.

Introduction:

The *Sesamumindicum* ranks third in terms of area in the world and Sudan, and it is considered as one of the important oil seed crop because its seeds contain high Oil content (48-60%), protein, some Minerals and vitamins, in addition to their use in some Food and feed industries, medicines and cosmetics. Exports and products of sesame play an important role in the national economy, as it ranks second after cotton in terms of total export return(Alkhader, 2010; Ministry of Trade and Industry,2013;Shaima, 2017; Masrahi, 2018). Areas of sesame crop cultivated in Sudan Is estimated by (1891.18) thousand hectares and the

average yield Is about 238 kg/ hectare. Its total areas in the White Nile State are estimated by (624.37) thousand hectares, and the average yield is (288) kg/ hectare .In the mechanized rain–fed sub sector is about (205.88) thousand hectares, 33% of its total area, and the average yield is (314) kg / hectare, and in the of Al-Jabalain it is about (966.38) thousand hectares, and the average yield is about (119) kg / hectare.. The cultivation of sesame crop at the White Nile State depends mainly on rainfall as a source of irrigation in both the mechanized rain-fed and the traditional rain-fed sectors. The mechanical seeding in Al-Jabalain area at the beginning of June and harvested in late September and in early October.(Ministry of Agriculture and Animal Resources,2011; reefnet.gov.sy2019;marefa.org 2019 ; Gad Allah,2019).

The efforts made by farmers who suffer from erratic rainfall in order to obtain a return from the cultivation of the crop may have a negative impact on the environment and on the use of natural resources, which causes an additional deterioration in the livelihood of these families in the livelihoods for future generations (Mohammed,1992).

The climate changes in general and the fluctuation of rainfall in particular have cast a shadow over the economic, social and political aspects of Sudan, which are represented by the decline in the standard of living, the migration of farmers from the countryside to big cities and the widening of the gap between production and consumption. Despite the fluctuation of rainfall, the agricultural profession was the only way out of the risk of food gaps in some years thanks to the agricultural adaptation strategies that farmers invented to increase and preserve production. (Al-Shaigi, 1990; Abdullah, 2012) .

The study problem:

The impact of the fluctuation of rainfall and the decrease in its rates in the study area range between (300 mm to 700 mm) during the study period it has an impact on the yield of sesame as a main crop in the investigated area, and this may lead to a decrease in the productivity and the final production of the crop in Al-Gabalinl area. Therefore, the study problem can be formulated in the following points:

1.What the features of fluctuating rainfall that hit the targeted area and its effect on the yield of sesame crop?

2.What were the agricultural adaptation strategies that farmers have devised to increase and maintain production?

Study objectives:

The study aims to find out the following:

1.Evaluating the effect of Rainfall flactuations rates on the productivity of sesame crop in Al-Gabalin- White Nile State.

2.Assessment the most applicable adaptation strategies Which can be developed by farmers to maintain the production capacity of sesame crop by farmers to ensure the success of sesame cultivation.

Study hypothesis:

1.The presence of fluctuation in rainfall rates since the seventies led to a fluctuation in the production of sesame crop in the studied area.

2.The agricultural adaptation strategies created by farmers will have a significant impact on ensuring the success of the agricultural season for sesame crop.

The previous studies:

Faiqa (2003) studied the effect of the rainfed sector in its contributing to achieve food security in Sudan. The researcher used the descriptive bee approach in the study and concluded that the scarcity and fluctuation of rainfall had a direct effect on the yield and production of crops grown in the mechanized rain-fed and traditional rain-fed subsectors, including *Sesamumindicum* (Faiqa,2003).

The Arab Organization for Agricultural Development(2004,2011) concluded that sesame crop faces many natural hazards that negatively affect on its production, including diseases and insects and fluctuations in rainfall rates. (Arab Organization for Agricultural Development, 2004 and 2011).

Abdullah (2008) concluded study of crop cultivation adaptation strategies in North Darfur, El Fasher locality, that the farmer devised a set of adaptation strategies in crop cultivation that helped mitigating the decline of crop production. (Abdullah,2008).

Al-Hussein *et al* (2016)studied the analysis of the environmental effects of yield in the *Sorghum bicolor* and *Sesamumindicum* crops in the Gedaref region. The researchers used the descriptive analysis method and concluded that the yield of sesame crop was affected by the fluctuation of rainfall rates. (Al-Hussein *et al*., 2016).

The econometric model, and data methodology:

The study area: Al-Jabalain region which is located in the Southern part of the White Nile State and East of the White Nile River, between latitudes 13: 3-12 u. Its longitudes are 32.48-33.15 BC, and it is bordered on the North by Rabak, on the east by Sennar locality, on the west by Alsalam locality, and on the south bordering the Upper Nile State of the Southern Sudan Republic. The area of the Targeted environment is about (6000) square kilometers, equivalent to about (1,428,571) feddans, and it is considered as agricultural and pastoral region. The local population is about (177,414).(whitenilestate.gov.sd/jabalinloc.aspx,2021)

Sources of data collection: Three types of data from primary sources were used in this study including observations, personal interviews and designing a questionnaire that included three axes: rainfall fluctuation, the effect of rainfall fluctuation on sesame yield and agricultural adaptation strategies. A random sample was chosen consisted of (160) farmers representing (5%) of the studied population.

Table (1) Number of farmers and questionnaires distributed in the studied area:

The project	Number of farmers	Number of questionnaires	The percentage of the total number (%)
Tacksaboon	700	35	**22**
Alsharak	600	30	**19**
Abueraif	500	25	**16**
Lorry	500	25	**16**
Wajwaj	400	20	**12**
Abueldakhera	250	13	**8**
Wadielnaiem	150	7	**4**
Ellbra	100	5	**3**
Total	3200	160	**100**

Source:authorcomputation,Fromdataoftherain-fedagriculturedepartmentinAl-Jabalain2020.

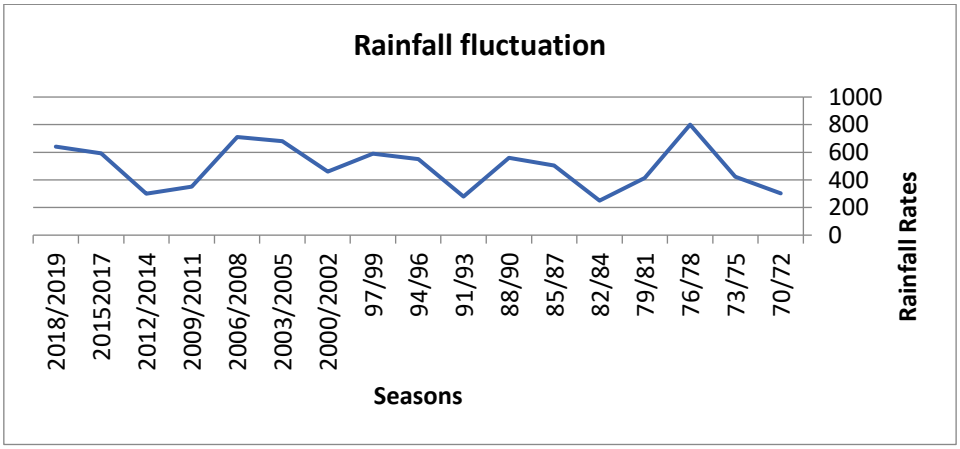
Two types of data from secondary sources were used in this study. The average of annual rainfall (mm),during autumn season was obtained from the Sudan Meteorological Authority (SMA,1970/2019). Production data, which included time series data of sesame yield (kg),

area (feddan) was obtained from Ministry of Agriculture and Forestry, Statistics division, Khartoum, Sudan (1970/2019) and White Nile Ministry State of Agriculture, Information Centre,Sudan (1970/2019).

Data analysis: Primary data was analyzed statistically for percentage. Secondary data was analyzed statistically forThe mean, $M=\sum_k \frac{x}{n}$ .Where: M=mean,x=data,n= number of data.The coefficient of variation (CV) is the ratio of the standard deviation to the mean. If the value of (CV) is higher than means greater is the level of dispersion around the mean. CV = σ/m *100Where: CV = coefficient of variation; σ = standard deviation; m= mean.The value of correlation coefficient (r) range from -1 to + 1. The value of (r) near zero indicated a correlation between variables, while a value near +1 and -1 indicates a high positive or negative level of correlation.Thesimple linear regression analysis, which is a model for measuring the relationship between one dependent variable (Y) and one independent variable(X) and is calculated by the followings formula: $Y_1=B_0+B_1X$, $Y_2=B_0+B_1X$,$Y_3=B_0+B_1X$.Where: Y_1=Cultivated area, Y_2= Harvested area, Y_3=Yield, X=Rain fall rates,B_0,B_1 = coefficients ofregression . Regression constant (B_0) has a positive value, the sign of the regression coefficient is positive and its value is less than the integer one, therefore, this model is suitableformeasuringtherelationshipbetweenvariables,Y_1,Y_2,Y_3andX.(Suleiman,2008;wikipedia.org/wiki,oug, 2019).

Results and discussion:

Rainfall fluctuation: Climatic data indicate the extent of the large fluctuation in rain rates during the period between 1970-2019, with the dispersion rate reaching (59.8%). Where the region witnessed a recurrence of drought periods represented in the periods1982-1984,1991-1993,2009-2001,2012-2014 (Figure1). 96% of the farmers confirmed that the continual back down of sesame crop yield was caused by the fluctuation of rainfall.



Figure(1): The fluctuation of rainfall in Al-Jabalain due to (1970-2019).
Source:authorcomputation,From data of (SMA)(1970-2019).

Average cultivated and harvested areas, yield and rainfall of sesame crop in Al-Gabalin during the period (1970-2019):

The great fluctuation in rainfall rates during the studied period (1970-2019) led to the fluctuation in areas, production and yield of sesame crop, as a main cash crop of the farmers of the study area. During the period of fluctuating rainfall in the 1982-1984 seasons, the average rainfall rate decreased to its lowest level of 250 mm, reaching 158 mm in the 1984

season, compared to the general average of 179.5 mm. The cultivated area was about (17.2) thousand feddans, and the average yield decreased to (10.2) kg / feddan.During 1985-1987 seasons and 1988-1990 seasons, the average rainfall rates increased to 504 mm and 560 mm, respectively, which had a positive impact on the average cultivated, harvested and productive areas. (174.5) thousand feddans, average harvested areas to (146.9) thousand feddans, and average productivity declined to (98.3) kg/feddan,in the seasons from 1994-1996 to the 2006-2008 seasons, there was an increase in the average rainfall, which positively affected the averages of cultivated and harvested areas and productivity, except for the 2000-2002 seasons, which experienced a decrease in average precipitation (459 mm), which led to a decrease in the averages of cultivated and harvested areas and crop yield during those seasons.In seasons 2009-2011, the rainfall rates decreased to 350 mm, which led to a decrease in the average cultivated areas to (104.2) thousand feddans, and the average harvested areas to (85.6) thousand feddans, and the average yield decreased to (70.3) kg / feddan.Also in the 2012 -2014 seasonsthe average rainfall rate decreased to 300 mm, which negatively affected the cultivated areas, as its average decreased to (99.1) thousand feddans, and the harvested areas decreased to (76.4) thousand feddans, and the average yield decreased to (46.3) kg / feddan.As for the 2015-2017 and 2018-2019 seasons, the average rainfall increased, which had a positive impact on the averages of cultivated and harvested areas and productivity (Appendix 1).

The evaluation of the impact of rainfall on the sesame yield by coefficient of variation in Al-Jabalain region during the studied 1970/2019):

Table (2) explains the fluctuation of rainfall rates, which affected the yield of the sesame crop by (58.4%). It was also noticed that the cultivated and harvested areas were affected by 67% and 68% respectively, due to the fact that yield is affected by other factors such as the cultivated seeds, the level of quality of agricultural operations, the lack of fertilizer use, the pattern of cultivation, lack of pests and diseases control and others. (FAO,2016),which will have a negative impact on the final production of feddan .

Table(2):Coefficient of variation ofcultivated area, harvested area, yield and rainfallof sesame in Al-Jabalain site during the period (1970-2019).

Variables	Value of variation (%)
Cultivated Area	67
Harvested Area	68
Crop yield	58.4
Rainfall	59.8

Source:author computation, From data of The State Ministry of Agriculture and (SMA) (1970-2019)

The evaluation of the impact of rainfall on sesame yield by coefficient of correlation in Al-Jabalain during the period(1970/2019):

From Table (3) it was clearing noticed that a very strong correlation between the fluctuation of rainfall rates and yield estimated at period 1970/2019 (80.7%), and it was also noted from the results that there is correlation between the fluctuation of rainfall rates and the cultivated and harvested areas percentage(64.4%)(53.3%) respectively, in order to adopt the determination of the size of cultivated areas and the beginning of cultivation with the first rainfall.

Table(3) Coefficient of correlation of cultivated area, harvested area and yield of sesame crop in Al-Jabalain during the period (1970-2019)

Variables	Value of (%)
Cultivated Area	**64.4**
Harvested Area	**53.3**
Crop yield	**80.7**

Source: author computation, From data of The State Ministry of Agriculture and (SMA) (1970-2019)

The evaluation of the impact of rainfall on sesame yield by coefficient of regression in Al-Jabalain Locality during the period(1970/2019) :

Table (4) shows that rainfall rates affected yield and cultivated area percentage (72.4%),(71.6%)respectively, but harvested area was negatively affected by 47.3%only,due to the fact that harvested area is affected by other factors such as the level of quality of agricultural operations, resistance to pests and diseases and pattern of cultivation

Table(4): Coefficient of regression of cultivated area, harvested area and yield of sesame crop in Al-Jabalain during the period (1970-2019).

Variables	F-statistic	Sig.
Cultivated area	0.001	**71.6**
Harvested area	0.000	**47.3**
Crop yield	0.000	**72.4**

Source: author computation, From data of The State Ministry of Agriculture and (SMA) (1970-2019)

The problem of fluctuation rainfall is one of the most important problems facing the agricultural sector in general, and sesame crop farmers in the studied area in particular, because the irrigation of the crop depends mainly on rainfall.(96%) of the farmers in the study area confirmed that the lack of rainfall and its poor distribution are main reasons for the decline in the areas and yield of the crop. This is consistent with the results of studies of Faeqa (2003), Arab Organization for Agricultural Development (2004 and 2011) and Al-Hussein *et al* (2016).

Agricultural adaptation strategies with the fluctuation of rainfall: As a result of the drought conditions and the frequent failure of cultivation, farmers invented agricultural strategies as alternative solutions to ensure good yield in order to reach greater profits because sesame crop represents the cash crop for most of the farmers of the studied area, which is considered as a major source of income for most of the farmers in the targeted region.. The most important adopted strategies are:

1.Early cultivation: The results of the study indicated that (60%) of farmers are interested in early cultivation (figure, 2). The farmer's knowledge the environment made him resort to early cultivation before the beginning of autumn, This helped the farmers to know about the rainy and non- rainy seasons.The importance of this thing lies in that it determines the appropriate time to prepare the land by plowing and removing parasitic weeds, usually before autumn in early time (April-May), then sowing the seeds in order to benefit from the soil moisture. This strategy contributed to avoid the threat of pests,which led ultimately, to a significant increase in the crop yield.

2.Selection of seeds:One of the strategies invented by farmers is to select seed samples that can stand with fluctuation rainfall,have high yield and compete in global markets. The study proved that (20%) of farmers in the study area switched from cultivating the municipal red sesame, the Hirahri , Kenana2 and Wad alkhadir varieties, to cultivating the white sesame varietyPromo,its maturity period is eliminated (70-90) dayswhich is certified by the

Agricultural Research Authority(1998) andAbu-sundog islocal variety,both varieties Are capable of enduring thefluctuation of rainfall (300-700 mm),high yielding and universally desirable (figure, 2).

3.Diversity of agricultural crops: Diversity in cultivation of agricultural crops is one of the strategies that the farmers of the study area have known after the drought periods since the early seventies. Cultivation of more than one crop had escaped the risk of natural disasters, especially those related to rain They have to be mentioned as they are the only guarantee for the success of the agricultural season. The field study confirmed that (10%) of farmers who were keen to cultivate more than one crop, where *Pennisetum americanum*, *Sorghum bicolor*, *Helianthus annuus*, *Cajanus cajan* and *Cyamopsis tetragonoloba*(figure,2).

4.Storage system: The study indicated that (10%) of farmers are interested in the process of storing the crop after harvest in warehouses designed from well-ventilated, fixed materials to ensure the safety of the crop grain from pests and weather conditions for use in the oil industry and animal feed inputs, then selling the surplus in times of high prices to fill the costs of their living necessities and saving the surplus money or transferring it to other sectors such as trade.

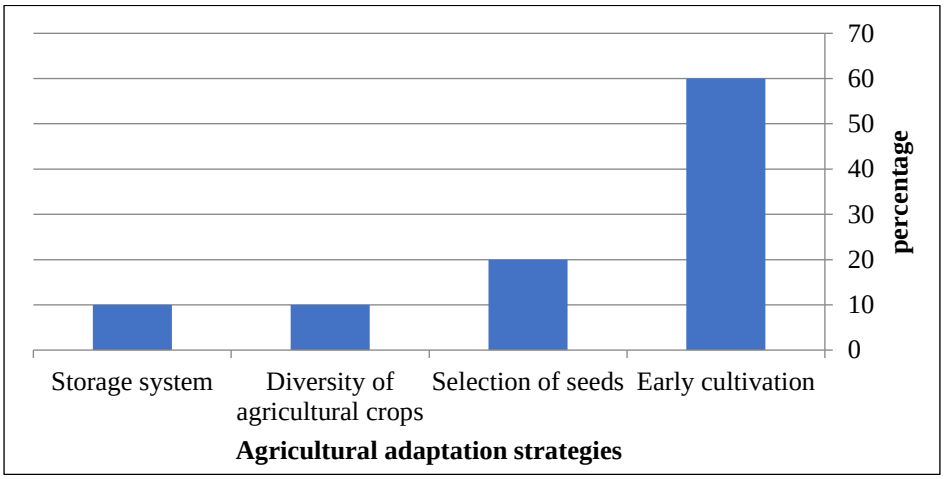


Figure (2) The agricultural strategies invented by farmers adapt to the fluctuation of rainfall
Source:authorcomputation,FromPrimary data2020

The farmers of the studied area had devised several strategies in the agricultural field, including early cultivation, seed selection, crop diversification and storage system in order to stabilize and increase production and ensure the success of the growing season.This is consistent with the study of Abdullah (2008).

Throughthe observations,rural women had a major role in agricultural adaptation strategies with the aim of increasing production through their participation in cooking food for workers**.** Also, through thepersonal interviews, sesame farmers in the study area knew that most of them depend on the Agricultural Bank to finance production inputs and agricultural operations, but they complain about the low level of funding and sometimes delay in the appropriate date for planting the crop.Others, who are large farmers, depend on their own resources to finance the requirements of the agricultural season for the crop.

Conclusions:

1.The rainfall factor is considered as a fundamental factor for the success or failure of the growing season. 96% of the farmers confirmed that the decrease in the rainfall rate is a direct cause of low yield of sesame crop in the studied area.

2.The farmers of the studied area had devised several methods and strategies in the agricultural field to avoid the risk of rain fluctuation on sesame crop, including early cultivation, seed selection, diversity of agricultural crops and storage system.

Recommendations:

1.Developing the Meteorological Station in Al-Jabalain to record data on climatic elements for the purpose of analysis and to be used in early warning programs.

2.Using water harvesting techniques during rainy periods to take advantage of it in dry periods.

3.Elaboration of improved, drought-resistant, fast-ripening, high-yielding and affordable seeds to reduce repeated yield failures due to shorter rainfall period.

4.Development of agricultural adaptation strategies invented by farmers with the aim of increase agricultural production.

5.Directing the Agricultural Bank branch in Al-Jabalain region to commit to increasing the volume of financing and providing it in a timely manner to avoid delaying cultivation of crop, which will have a negative impact on the cultivated crop yield.

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(Appendix1) Average of cultivated and harvested areas,yield and rainfall formechanized rain- fed sesame crop in Al-Jabalain during the period(1970- 2019)

Seasons	Cultivated (area(1000 fed)	Harvestedarea (1000 fed)	Yield (kg/fed)	Rainfall (mm/year)
1970/1972	56.4	41.1	21	302
1973/1975	75.6	68.6	44.6	424
1976/1978	189.5	168.5	99.3	800
1979/1981	77.7	65.1	42.5	414
1982/1984	17.2	15.5	10.2	250
1985/1987	89.2	77.2	12	504
1988/1990	174.5	143.9	98.3	560
1991/1993	93.3	78.2	47.7	280
1994/1996	279.4	228.7	95	551
1997/1999	293.5	251.4	83	589
2000/2002	191.2	161.5	81.7	459
2003/2005	252.5	215	119.7	681
2006/2008	259.5	244.6	157.3	710
2009/2011	104.2	85.6	70.3	350
2012/2014	99.1	76.4	46.3	300
2015/2017	270.6	234.7	110.7	593
2018/2019	425.7	353	165	640

Source :Prepared by author, From, The State Ministry of Agriculture and (SMA) (1970-2019)

تأثير الهطول المطري واستراتيجيات التكيف الزراعي في إنتاجية محصول السمسم في القطاع المطري الآلي بمحلية الجبلين في ولاية النيل الأبيض، السودان

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الملخص

نفذت الدراسة في محلية الجبلين بولاية النيل الأبيض في السودان خلال الفترة (1970-2019) لدراسة تأثير معدلات الهطول المطري واستراتيجيات التكيف الزراعي في إنتاجية محصول السمسم ،تم جمع البيانات الأولية والثانوية لمتغيرات الدراسة وهي الإنتاجية ،معدل هطول الأمطار واستراتيجيات التكيف الزراعي من التقارير السنوية لوزارة الزراعة ،الهيئة العامة للأرصاد الجويه ، الملاحظات، المقابلات الشخصية، تصميم وتوزيع (160) استمارة استبيان أجاب عليها المزارعين في منطقة الدراسة. تم تحليل البيانات الأولية والثانوية باستخدام معامل التشتت،الارتباط، الانحدار الخطي البسيط والنسب المئوية. توصلت الدراسة الى ان تذبذب هطول الامطار خلال فترة الدراسه ادى الى تدني انتاجية محصول السمسم الذي يمثل المحصول النقدي لمزارعي منطقة الدراسة. نتيجة لتذبذب الامطار والتراجع المستمر لانتاجية السمسم ابتدع المزارعون عدداً من الاستراتيجيات الزراعيه كحلول بديله لضمان الانتاج منها التبكير في الزراعة – انتخاب البذار – تنوع المحاصيل الزراعية ونظام التخزين.أوصت الدراسه بتطوير محطة الأرصاد الجوي ،استخدام تقنية حصاد المياه ،تطوير استراتيجيات التكيف الزراعي التي ابتكرها المزارعون بغرض استقرار وزيادة الإنتاج.

الكلمات المفتاحية: الهطول المطري، استراتيجيات التكيف الزراعي،محصول السمسم،الانتاجية،القطاع المطري الآلي.