Temporal price analysis of sorghum (*Sorghum bicolor*) in selected markets, Sudan

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Abstract

This study conducts temporal price analysis of sorghum crop prices of Khartoum, Madani, Gadaref, Dongola and Alfashir markets in order to identify seasonal price patterns and their expected changes over time as compared to their storage costs. The analytical approach upon which this study was based is so called "classical model". The study based preliminary on secondary data collected from Agricultural Statistics Department, Ministry of Agriculture and Forests during period 2007-2015. The study found that the seasonal prices spread increased about 16% from the index low to the high on average for Khartoum market, about 19% for Madani, 17% for Gadaref, 21% for Alfashir and 11% for Dongola, while the annual interest rate of the year 2015 was 10%. Thus monthly price variations indicate an opportunity to capture above normal returns to storage. Causes of these prices differences are inadequate transportation, marketing infrastructure and government policy.

Keywords: Centered moving average; Classical Model; Market Information; Storage.

Introduction

Sorghum is the most important staple food produced and consumed in Sudan for human and livestock. Sorghum plays a central role in Sudanese diets and is an important source of foreign exchange from exports to regional markets and the Gulf States. Nearly 45 percent of sorghum is produced in the semi-mechanized, rain fed sector, 25 percent in the irrigated sector and 30 percent in the traditional rain fed sector (MASTAT, 2015).

Agriculture markets in the Sudan can be categorized according to the structure, periodicity, location and types of crops sold. For most crops, the present marketing arrangements for agricultural commodities consist of tertiary markets (at village level), wholesale assembling markets and primary or terminal markets usually located in cities and urban centers. Regarding periodicity most markets at the village level are held on weekly basis whereas some of them are held on daily basis. In areas with easy access to transport markets can be held twice a week, whereas difficulty in access to markets can extend their periodicity to even once every fortnight (Pakwan, 2008). The role in the Sudanese sorghum marketing system starts at the producer level. Sorghum producers vary from small-scale producers in the traditional rain fed production systems to large-scale producers in the country's high-productivity irrigated and semi-mechanized rain fed areas. Large-scale producers are also engaged in marketing through storage and trading activities (buying from smaller neighboring producers) particularly in the country's most productive areas (Babiker et al, 2008). Prices are standard and are an important component of market and food security analysis because they serve as an indicator for both food availability and food access. Prices of food grains tend to rise during the lean seasons and reach a peak prior the next harvest as demand exceeds supply, and they tend to fall as supply increases during years of bumper harvest. Prices observed through time are as a result of a complex mixture of changes associated with seasonal, cyclical, trend and irregularity factors. The most common regularity observed in agricultural prices is the seasonal pattern of change. Understanding price seasonal variation and trend is of crucial importance for all stakeholders, the producers, the consumers and the policy and decision makers. Producers confer their products at lower prices at harvest and consumers need the same amount of food all seasons given their limited income. For instance, prices directly affect the household purchasing power; as prices rise and household incomes remain constant the same

amount of money buys fewer food grains (Abdalla, 2016). This research aims to reduce price differences between seasons by product storage. Storage is encouraged when price differences are greater than storage costs. This could be done through studying the pattern of price variations, price trends, monthly seasonal indices and their deviations and determining efficiency of the marketing system. The specific objective was to conduct temporal price analysis of sorghum in Khartoum, Madani, Gadaref, Alfashir and Dongola markets to identify seasonal price patterns and their expected changes overtime.

Meterial and Methods

Data sources and data collection

Data of Khartoum, Madani, Gadaref, Dongola and Alfashir sorghum markets (2007-2015) was collected to realize the above objectives. Khartoum, Alfashir and Dongola were selected to represent the consumption areas while Madani and Gadaref were represented the production areas, moreover the Madani market represented a permanent irrigation production system while the Gadaref market is based around a mechanized rain fed production system. Khartoum is the largest consumption center in Sudan while Gadaref produces a surplus sorghum which is sold elsewhere.

Methods of data Analysis

The analytical approach in this study was based on the so-called "classical model". According to Wayne and James (1989) the classical approach to time series analysis begins with the premise that a typical time-series has the following four components i) long-term trend: is the general behavior of a given variable over a long period of time, ii) seasonal variation: referring to a variation of periodic nature, iii) cyclical variation: refers to those up-and-down fluctuations that are observable over extended periods of time and iv) erratic variation: variation which can’t be accounted for by trend, cycle, or seasonal factors (irregular component). John and Arthur (1991)

stated that the most widely used model for time series decomposition is the multiplicative model. The equation below was used to formulate the multiplicative model:

$Y = T \times C \times S \times I$ (1)

where

Y = Actual value of the variable of interest (price in this case), T = trend component, C = cyclical component, S =seasonal component and I = irregular component.

Trend was calculated using the constant and the trend coefficient resulting from the regression equation:

$Ti = a + bti$ (2)

where Ti = trend value during period i, a = the constant estimated by the regression, and b = the trend coefficient, and ti = the value of the variable during period i. The seasonal price movements on the other hand, which usually result from fluctuations in supply, demand or both were estimated by a seasonal price index by calculating a centered moving average (CMA^{12}) using the formula:

$CMAt = \_ Pi/n$ (3)

$i = t-(n/2)-1/2$

For CMA^{12} i.e. CMA over 12 months the specific formula is

$CMAt^{12} = [Pi + \_ Pi]/24$ (4)

A moving average is an artificially constructed time series in which the value for a given time period is replaced by the mean of that value and the values for some number of preceding and succeeding time periods. Consequently, the CMAn eliminates random variations and systematic movements of a duration equal to n. The CMA^{12} thus eliminates seasonality and randomness (Wayne and James, 1989). In terms of equation (1)

$CMA^{12} = TCi$ (5)

The CMA^{12} thus represents the trend and cyclical components of the original series, and eliminates seasonality and randomness. The formula for the seasonal index can then be written as:

$SIi = (TCSEi/TCI) = SEi=(Pi / CMAi^{12})*100$ (6)

The SI is already deflated since it is a result of dividing a nominal series (the original price) by another nominal series (CMA^{12}). The cyclical index (CI) of a time-series can be calculated as follows:

$CIi=TCi/Ti = Ci= CMAi/Ti$ (7)

The grand seasonal index (GSI) is useful to summarize the typical seasonal behavior of a time series. It is calculated by obtaining the average seasonal index for each month of a given year then adjusting this 12-figure series in such a way that it adds up to 1200. Specifically:

$GSIi = SIi * 1200/\_ Sli$ (8)

Where, SIi = the average seasonal index for month I It is an average of the seasonal indices that removes all random movements of the time series. Consequently, the GSI represents the pure seasonal average of the series during the period under analysis.

Results and Discussion

Table 1 summarizes the preliminary analysis of monthly nominal prices of sorghum during 2007-2015 for five markets namely; Khartoum, Madani, Gadaref, Alfashir and Dongola. The results showed that the year 2008 recorded higher percentage fluctuations in Khartoum, Madani and Dongola markets but in Alfashir the highest percentage of sorghum price fluctuation was recorded in 2012. While in Gadaref the year 2011 was the highest price fluctuations in all studied markets. In Khartoum market the year 2015 was the lowest fluctuation percentage with 19.84%. 24.46% was lowest price fluctuation of the crop in Madani market which was observed in the year 2013. For Gadaref, Alfashir and Dongola markets the lowest price fluctuations were in 2015, 2014 and

2015 with percentage of 23.32%, 22.48% and 8.58% respectively. Generally at the beginning of the year specifically January, February and March the crop prices reach their minimum level then increase rapidly after that till to the end of the year in which the prices reach the maximum peak. Yearly price variability results from changes in supply, demand and poor market infrastructure and information. Bashir (2003) stated that sorghum production depended mainly on rainfall, which in low rainfall seasons was expected to negatively affect agricultural production and trade of the crop. The variation in the production is attributed mainly to the variation in yields and cropped areas (Satti, 1994). The supply available in any year is based mainly upon the current production and carryover of the crops from the previous year. It is obvious that prices of sorghum fluctuate monthly and year after year, and, in general, follow a common seasonal pattern. Theoretically, prices decrease to low levels immediately after harvest and rise thereafter until the next harvest, as farmers and merchants store some supplies to meet the continuous demand. The trend for all crop markets were an increase over time but with the different levels depending on demand, supply of the crop, the responsiveness of the crop to market prices and also the distance of the market from production crop areas in addition to difficulties and cost of transportation.

Table 1. Preliminary analysis of monthly sorghum nominal prices (SDG/100 Kg) of Khartoum, Madani, Gadaref, Alfashir and Dongola markets

	Khartoum market			Madani market		
Year	lowest prices	highest prices	Fluctuation %	lowest prices	highest prices	Fluctuation %
2007	May	September	58.06	January	December	63.33
2008	Mar and Apr	September	168.33	Jan and Feb	September	129.31
2009	January	December	29.67	March	December	32.14
2010	August	February	58.06	December	May	67.11
2011	March	December	64.77	January	December	80.77
2012	January	December	34.67	January	October	34.00
2013	March	December	34.76	February	December	24.46
2014	January	September	63.22	January	September	72.29
2015	July	December	19.84	January	November	33.85
	Gadaref market			Alfashir market		

Year	lowest prices	highest prices	Fluctuation %	lowest prices	highest prices	Fluctuation %
2007	Apr and May	December	35.48	September	February	55.26
2008	February	September	120.83	February	December	71.05
2009	January	December	43.37	February	October	83.61
2010	October	July	69.44	June	August	112.79
2011	May	December	212.33	June	November	37.5
2012	March	May	34.27	September	April	148.57
2013	May	December	44.81	February	September	60.00
2014	January	September	105.00	January	June	22.48
2015	June	Oct and Dec	23.32	January	November	28.89

	Dongola market		
Year	lowest prices	highest prices	Fluctuation %
2008	January	September	135.38
2009	March	December	61.86
2010	October	Jun and Jul	19.43
2011	January	December	23.08
2012	October	July	96.97
2013	May	December	10.98
2014	January	September	70.73
2015	December	Sep and Oct	8.58

The Darfur States were once self-sufficient in grain production. Many years of conflict and civil unrest have significantly disrupted production and marketing systems in Darfur, and the populations that remain there rely heavily on imports from elsewhere in the country and on relief commodities (FEW Net, 2011). The prices of Alfashir market tended to increase by higher rate compared to the other crops (3.97) followed by Dongola market (3.65). For the other three markets the increased trends of the crop were almost the same which equal to 2.66, 2.65 and 2.50 for Khartoum, Madani and Gadaref markets respectively.

Table 2 shows temporal price analysis for sorghum in Khartoum as an example to the markets investigated in this study for the period 2007– 2015. It should be noted that there are no values of the CMA[12] and seasonal index for the first and last six months of the period under analysis. This is due to the formulae used to compute these series. The trend and cyclical indices for all crops are

positive. The cyclic indices for Alfashir market was lowest compared to the other markets although it had the highest price trend rate.

Table 2. Temporal analysis for sorghum prices in Khartoum during 2007-2015

	Prices*	CMA	SI	T	C		Prices*	CMA	SI	T	C
2007 Jan	43			2.7		Jul	108	110.6	.98	146.0	.76
Feb	43			5.3		Aug	109	116.1	.94	148.7	.78
Mar	37			8.0		Sep	113	122.1	.93	151.3	.81
Apr	37			10.6		Oct	141	129.6	1.09	154.0	.84
May	31			13.3		Nov	131	138.3	.95	156.6	.88
Jun	48			15.9		Dec	145	146.8	.99	159.3	.92
Jul	42	42.7	.98	18.6	2.30	2012 Jan	150	154.6	.97	162.0	.95
Aug	42	44.3	.95	21.2	2.09	Feb	159	162.3	.98	164.6	.99
Sep	49	46.0	1.07	23.9	1.92	Mar	163	169.1	.96	167.3	1.01
Oct	44	48.8	.90	26.6	1.84	Apr	196	174.0	1.13	169.9	1.02
Nov	47	52.4	.90	29.2	1.79	May	197	178.8	1.10	172.6	1.04
Dec	39	55.8	.70	31.9	1.75	Jun	200	183.9	1.09	175.2	1.05
2008 Jan	64	60.8	1.05	34.5	1.76	Jul	194	188.2	1.03	177.9	1.06
Feb	60	67.5	.89	37.2	1.81	Aug	207	191.7	1.08	180.5	1.06
Mar	60	75.6	.79	39.8	1.90	Sep	180	194.2	.93	183.2	1.06
Apr	82	81.9	1.00	42.5	1.93	Oct	191	195.5	.98	185.9	1.05
May	73	85.5	.85	45.2	1.89	Nov	196	195.9	1.00	188.5	1.04
Jun	88	89.6	.98	47.8	1.87	Dec	202	195.9	1.03	191.2	1.02
Jul	120	92.9	1.29	50.4	1.84	2013 Jan	197	196.3	1.00	193.8	1.01
Aug	125	95.4	1.31	53.1	1.80	Feb	195	197.6	.99	196.5	1.01
Sep	161	98.1	1.64	55.8	1.76	Mar	187	200.0	.93	199.1	1.00
Oct	83	100.5	.83	58.4	1.72	Apr	203	203.5	1.00	201.8	1.01
Nov	94	102.9	.91	61.1	1.69	May	200	206.5	.97	204.4	1.01
Dec	91	104.9	.87	63.7	1.65	Jun	197	209.8	.94	207.1	1.01
2009 Jan	91	104.7	.87	66.4	1.58	Jul	207	213.7	.97	209.7	1.02
Feb	93	102.7	.91	69.0	1.49	Aug	225	217.6	1.03	212.4	1.02
Mar	92	99.3	.93	71.7	1.39	Sep	221	222.9	.99	215.1	1.04
Apr	108	98.0	1.10	74.3	1.32	Oct	233	230.4	1.01	217.7	1.06
May	105	99.9	1.05	77.0	1.30	Nov	225	239.1	.94	220.4	1.08
Jun	104	102.0	1.02	79.7	1.28	Dec	252	249.1	1.01	223.0	1.12
Jul	98	104.1	.94	82.3	1.27	2014 Jan	242	260.9	.93	225.7	1.16
Aug	100	107.0	.93	85.0	1.26	Feb	243	273.9	.89	228.3	1.20

Sep	105	110.0	.95	87.6	1.26	Mar	267	287.8	.93	231.0	1.25
Oct	106	111.9	.95	90.3	1.24	Apr	302	297.9	1.01	233.6	1.28
Nov	117	113.5	1.03	92.9	1.22	May	310	303.9	1.02	236.3	1.29
Dec	118	115.3	1.02	95.6	1.21	Jun	328	306.4	1.07	239.0	1.28
2010 Jan	116	117.5	.99	98.2	1.20	Jul	358	307.3	1.16	241.6	1.27
Feb	137	118.3	1.16	101.0	1.17	Aug	386	310.6	1.24	244.3	1.27
Mar	121	117.2	1.03	103.5	1.13	Sep	395	312.8	1.26	246.9	1.27
Apr	124	117.6	1.05	106.2	1.11	Oct	301	312.6	.96	249.6	1.25
May	128	119.3	1.07	108.9	1.10	Nov	301	311.3	.97	252.2	1.23
Jun	123	120.5	1.02	111.5	1.08	Dec	236	309.3	.76	254.9	1.21
Jul	131	119.9	1.09	114.2	1.05	2015 Jan	280	303.6	.92	257.5	1.18
Aug	88	116.8	.75	116.8	1.00	Feb	283	295.3	.96	260.2	1.13
Sep	89	113.4	.79	119.5	.95	Mar	280	286.9	.98	262.8	1.09
Oct	132	110.6	1.19	122.1	.91	Apr	284	282.3	1.01	265.5	1.06
Nov	132	107.8	1.22	124.8	.86	May	298	281.8	1.06	268.2	1.05
Dec	131	105.4	1.24	127.4	.83	Jun	292	284.7	1.03	270.8	1.05
2011 Jan	89	103.5	.86	130.1	.80	Jul	257			273.5	
Feb	89	103.4	.86	132.8	.78	Aug	287			276.1	
Mar	88	105.3	.84	135.4	.78	Sep	293			278.8	
Apr	91	106.6	.85	138.1	.77	Oct	293			281.4	
May	93	107.0	.87	140.7	.76	Nov	297			284.1	
Jun	100	107.5	.93	143.4	.75	Dec	308			286.7	

*Price=SDG/100Kg SDG=25 USD

Table 3 reveals the analysis of seasonal indices for sorghum in Khartoum market as an example. Seasonal price analysis tests the effectiveness of market arbitrage over time. Standard deviations on monthly indices reveal the stability of the seasonal price pattern and measure their variability i.e. indicate the usual level of uncertainty for a given month (Bashir, 2003). For all crop markets, in general, the standard deviations were lowest when the market uncertainty was at its minimum level-i.e. just after harvest. And when the information of the market's conditions is unavailable, the standard deviations were at their peak just before harvest, which showed great uncertainty compared to other months

Figure 1 illustrates the average of the seasonal indices (GSI) for sorghum in Khartoum, Madani, Gadaref, Alfashir and Dongola markets. The lines over and under GSI indicate that fluctuations

were erratic and unpredictable. The seasonal price indices for Khartoum market were above average in April, June, July, August and September and exactly equal average in May, October and November and below average from December to March. The seasonal price index of Khartoum market increased from a low of 0.93 in March to a high of 1.09 in September before the next harvest.

Table 3: Analysis of seasonal indices for sorghum in Khartoum market (2007-2015)

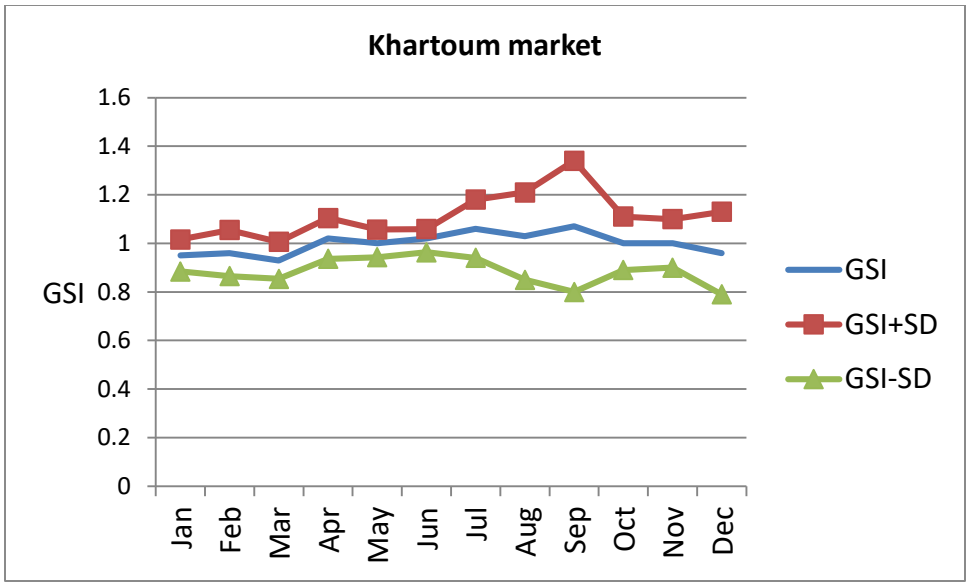
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007							.98	.95	1.07	.90	.90	.70
2008	1.05	.89	.79	1.00	.85	.98	1.29	1.31	1.64	.83	.91	.87
2009	.87	.91	.93	1.10	1.05	1.02	.94	.93	.95	.95	1.03	1.02
2010	.99	1.16	1.03	1.05	1.07	1.02	1.09	.75	.79	1.19	1.22	1.24
2011	.86	.86	.84	.85	.87	.93	.98	.94	.93	1.09	.95	.99
2012	.97	.98	.96	1.13	1.10	1.09	1.03	1.08	.93	.98	1.00	1.03
2013	1.00	.99	.93	1.00	.97	.94	.97	1.03	.99	1.01	.94	1.01
2014	.93	.89	.93	1.01	1.02	1.07	1.16	1.24	1.26	.96	.97	.76
2015	.92	.96	.98	1.01	1.06	1.03						
Mini	.86	.86	.79	.85	.85	.93	.94	.75	.79	.83	.90	.70
Maxi	1.05	1.16	1.03	1.13	1.10	1.09	1.29	1.31	1.64	1.19	1.22	1.24
Mean	.95	.96	.93	1.02	1.00	1.02	1.06	1.03	1.07	1.00	1.00	.96
St. D	.07	.10	.07	.08	.06	.06	.12	.18	.27	.11	.10	.17

For Madani market the seasonal indices were above average from almost April to October and below average in the rest of the year because of crop planting in mid-June to mid-July whilst some farmers delay sowing till August. On the other hand the majority of the crop is harvesting in November and December. The seasonal price index of Madani market increased from a low of 0.90 in November to a high of 1.09 in July the date of planting. For Gadaref market seasonal indices were above average from July to December and below average in the rest of the year. The seasonal price index of Gadaref market increased from a low of 0.93 in February and March to a high of 1.10 in August. The seasonal indices for Alfashir were above average in January and from March to August and low average in the rest of the year. Seasonal indices of Alfashir market increased from a low of 0.89 in November to a high of 1.12 in August. In Dongola market the

seasonal indices were above average in February and from April to September and under average for the remaining months. The seasonal indices ranged between 0.95 low in December and January to 1.06 high in July (11% gap). small seasonal price gap in Dongola may be due to the fact that in the Northern State wheat is traditionally the main food grain followed by sorghum. This result is confirmed by (Abdalla, 2016).

Conclusion

Osman and Idris (2002) stated that in a competitive market, the increase in seasonal prices will equal the cost of storage (interest charges on capital invested in the stored commodity, costs of the storage facility, physical losses and normal profits). Seasonal prices spread increased about 16% from the index low to the high on average for Khartoum market, about 19% for Madani, 17% for Gadaref, 21% for Alfashir and 11% for Dongola while the annual interest rate of the year 2015 was 10%. Thus farmers or traders who usually perform storage activity during harvest to post harvest period will gain profits (especially in Alfashir market) if they buy on the seasonal low and sell on the seasonal high and if they could secure storage loans. Seasonal fluctuations in sorghum crops prices are likely to be harmful for both producers and consumers. Hence a basic objective of a policy maker is reasonable price stability. In addition, there is a need to invest in collecting and disseminating market information. Lack of market information adds to marketing costs and inefficiency.


Khartoum market
GSI
1.6
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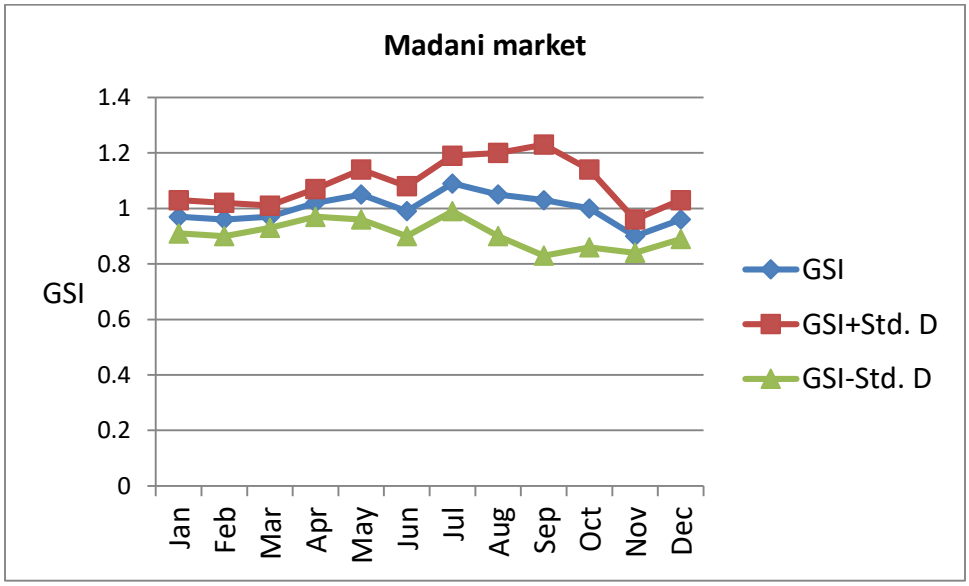
GSI+SD
GSI-SD


Madani market
GSI
1.4
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GSI+Std. D
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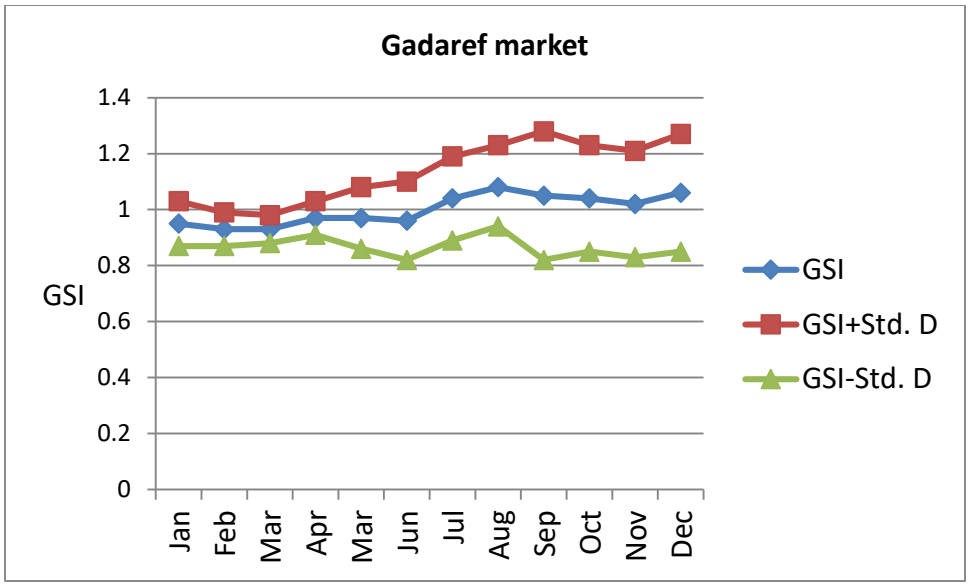
Gadaref market
GSI
1.4
1.2
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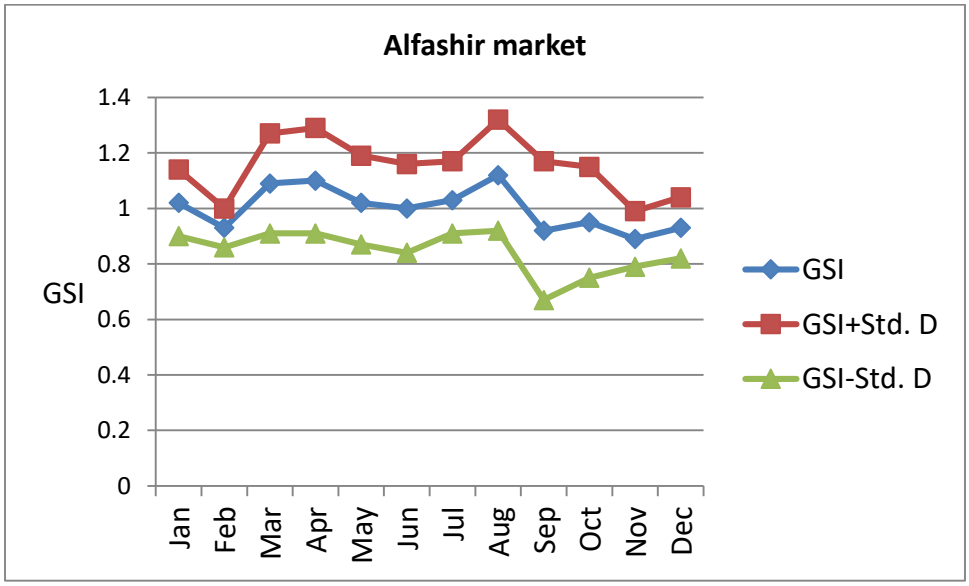
Alfashir market
GSI
1.4
1.2
1
0.8
0.6
0.4
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GSI
GSI+Std. D
GSI-Std. D

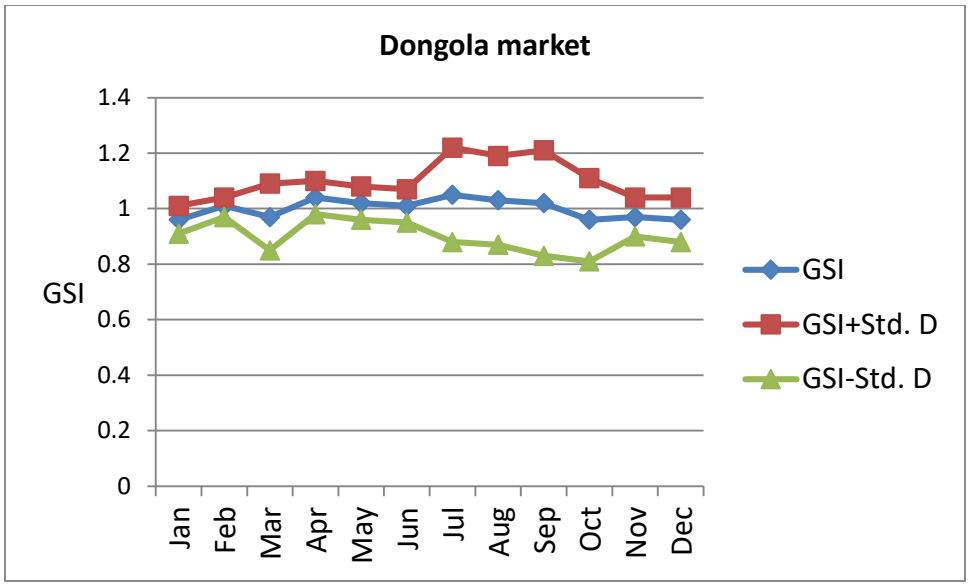

Figure 1. Grand seasonal indexes (GSI) for Khartoum, Madani, Gadaref, Alfashir and Dongola sorghum markets

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