International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 1 | ISSN : 2456-3307

Sudanese River Nile State Water Resources Management

Jehan Mohmed Sharief*[1], Abbas Abd Alla Ibrahim[2], El Sadig El Hadi El Hassan[3]
*[1]Faculty of Civil engineering, Sudan University of science & Technology, Khartoum , Khartoum North, Sudan
[2]Faculty of Water & Environmental Engineering, Sudan University of science & Technology, Khartoum, Khartoum North, Sudan
[31]Faculty of Civil engineering, Sudan University of science & Technology, Khartoum, Khartoum South, Sudan

ABSTRACT

Using the concept of Water Resources Management (WRM) it was found possible simple and straight forward approach to study the integrated water resources management (IWRM) in the River Nile State of Northern Sudan taken as a pilot area. The approach required the determination of River Nile State domestic, industrial, and the agricultural water use. The approach required application of sophisticated software and advanced statistical models beside the simple statistical models. These required determination of averages, standard deviations, beside the more sophisticated statistical parameters such as coefficient of variation, skewness and their corrections. The software applications paved the road towards the solution of the problems and fulfilling the objectives to create an integrated water resources management body in the River Nile State pilot area, to travel parallel with the expected present and future population growth.

Keywords: integrated water resources means, standard deviations, coefficient of variation, skewness.

I. INTRODUCTION

In the International Conference of Mar Del of 1977 recommended that industrial arrangement should ensure development and management of water resources. That was because water is basic for life and economic development. Furthermore, in 2000 Global Water Partnership (GWP) defined IWRM as a process of developed management of water to maximize economic and welfare. Dublin guiding principles presented four principles. These were use of fresh water as a finite resource, water management is based on a participatory approach, women have important role, and water management is an economic good. Integrated Water Resources (IWR) was practiced long time ago, while Integrated Water Resources Management IWRM is a recent technique. However it is well known that water demand and supply are unbalanced. Water supply management without social, ecosystem economics, impacts are insufficient.

According to the different international intellectual organizations and genuine stake holder and their different intellectual organizations and genuine stake holder wide spectrum of the integrated water resources management was broadly divided into two parts. The first part used the **Integrated Water Resources (IWR**), which was concerned with the integration of rain water, surface water, and ground water qualitatively and quantitatively which was the objective of the former research. This later research conception ally dealt with the Water **Resources Management (WRM).** mainly focusing on the main three different types of water namely domestic use, industrial use and agricultural use.

II. METHODS AND MATERIAL

A. Study Area

The study area is the River Nile State. Figure (1), shows the map of the Sudan including River Nile State. The River Nile State is connected with high way roads with Khartoum and Port Sudan. River Nile State is suffering from drought due to the desert forming most of its area. Water sources in the River Nile State are mainly from the River Nile. In the River Nile State rainfall is erratic variable and not reliable The River Nile State is located between longitudes 15 and 30 east and latitudes 22 and 16 north. The total area of fertile land or arable land in the River Nile State is estimated as 3.289 million feddans. River Nile State cultivates many crops, such as palms, citrus, wheat and broad beans.

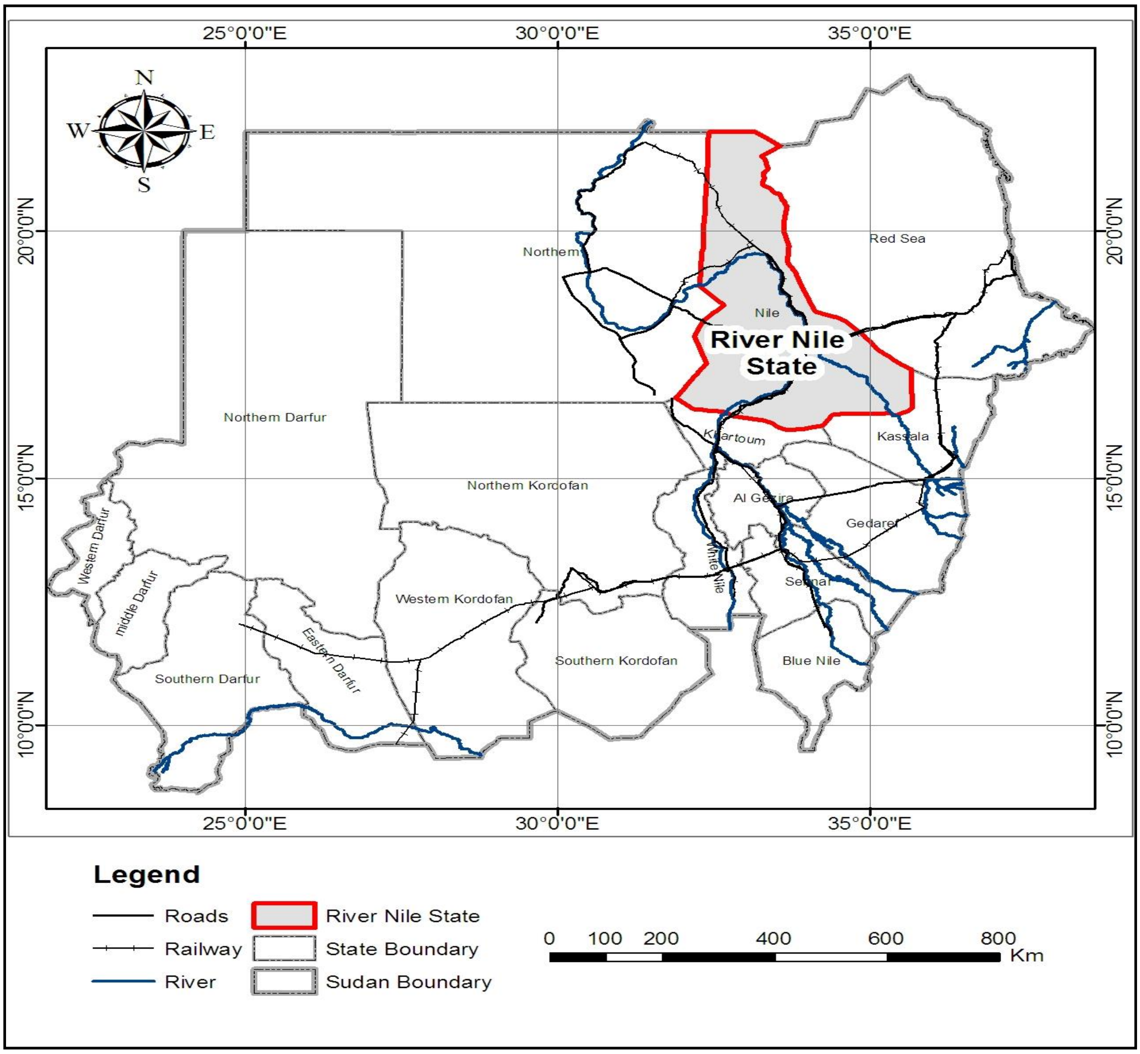

Figure 1. Map of Sudan With River Nile State

B. Methodology

The pilot area of the River Nile State, its rural and urban areas is in the vicinity of River Nile State. It included metrological stations, population, geology and demography of the River Nile State. It covered the geographic information system in the River Nile State. The data considered, population, the distribution of which in the River Nile State is concentrated on the River Nile and Atbara River banks. From 2008 to 2013 population of the River Nile State increased continuously, that required revision of water management. FAO water report 2005 indicated that there was a problem in water in the River Nile State. The River Nile State depends on the Nile River as a source of water; with its cities and villages spread along its banks. The River Nile State has great potentials of water that is not exploited. It is the State that has the greatest area of desertification in the Sudan. The remaining required data to be collected in IWM consisted domestic, industrial and agricultural water supply. The population data is essential forming the main beneficiaries of the study objective. It is fortunate that the quality of the three types of water rain surface and ground water in the River Nile State was tested according to the Sudan by laws and WHO and was perfectly suitable for use.

C.Data Collection and Analysis

The data obtained from local and federal management water Authority and the Ministry of Irrigation, was analyzed by suitable programs to obtain the results. Modeling the data was very essential which led to the achievements of the research specific objectives. The achievements included qualitative determination of domestic and industrial water together with agricultural water in the pilot area. It could also be used to reveal capacity building needed to technical staff to develop the area of the River Nile State. However, care was focused on water estimation only, forming the part of the objectives. This study involved using Statistical Package of Social Sciences (SPSS). (SPSS) is software that can analyze most types of data. It can take two mutually exclusive values of a variable in two aspects. It could also be original scaled data, usually programmed as questionnaires, interval or, ratio data. The data used in this study are interval and ratio data. (SPSS) is suitable software, because it is easy and accurate (Andrew Garth-2008).Some advantages of (SPSS) are that it can find both means and medians. It can also graph data on a box plot, showing both level and spread indicating any outliers. Furthermore it also reveals the differences or correlation between elements of the available data.

III. RESULTS AND DISCUSSIONS

Table 1 shows the population growth and future forecast of the River Nile State. There was a noticed population decrease after 1983 due to the population movements to other jobs such as gold mining and attractive salaries of the then new cement factories.

Table 1. Population in River Nile State

Year	Total Population	Population Growth
1956	874000	-
1973	1198000	1.07
1983	1378000	1.41
1993	1551000	1.19
2008	1808700	1.03
2010	1856250	1.50
2013	1903800	1.50
2017	2020600	1.80
2050	3640000	

To improve and develop the River Nile State it was found vitally necessary to use the available cultivable land properly. The people leaving their homes due to drought and low agricultural income must be encouraged by the local and central federal governments to stay with the challenge that they must enjoy better chances of living using the (**IWRM**) as an effective tool. That must be supplemented by balanced development in urban and rural religions in the state. Use of software such as **Hec-HMS** or simple and advanced statistical models should be applied. These ambitious suggestions must be strengthened with adoption of a policy directed against desertification through stakeholders, including **NGOs** and association with awareness spread, being the well known tools that help in (**IWRM**) in the state. These last ambitious changes which are adopted in this research are considered the keys leading to solution of the problems and fulfilling the objectives to create an integrated water management body in the River Nile State pilot area, to travel parallel with the expected present and future population growth. Using the collected data and analysis, applying simple correlation regressions analyzing the results of the analysis and its effects on the River Nile State problems, further in depth discussion was found necessary. More advanced analysis was conducted, and discussed in relation with (**IWRM**). The advanced discussion included some simple and advanced statistical model analysis. These included beside the means, standard deviations, the more sophisticated statistical parameters such as coefficient of variation, skewness and their corrections. They involved use of the famous statistical tables of Foster Hazin and Fuller equations. The use of these model equations together with the known statistical coefficient and parameters has paved the road of fulfilling the study objective together with their inherently knitted problems.(Murray R.Spiegel,1972,New York,Schaums Series).Table Hazin ,together with Foster table (I) and Foster table (III),are given in appendix (I).are available in many hydrological text books.

The average value of any statistical relevant parameter given as for example the discharge (Q), by the equation:-

$$Average\ \text{Discharge}\ (Q) = \frac{\text{Sum of the Q s}}{n} = \bar{Q} \ ---(1)$$

Or

$$Average\ \text{Rainfall}\ (P) = \frac{\text{Sum of the P s}}{n} = \bar{P} \ ---(1)$$

Where:-

$\bar{Q}$ = The average discharge per year $m^3 / year$ oraverage rainfall in m m./year.

$n =$ The number of years of records.

$$S\tan dard\ \text{Deviation}\ \sigma = \sqrt{s} = \sqrt{\frac{\sum_{i=1}^{20}(Q_i - \bar{Q})^2}{20-1}} ---(2)$$

for rains Q is substituted by P

(Murray R.Spiegel, 1972,New York,Schaums Series)

$$Coefficient\ \text{of variation} = C_v = \frac{\sigma}{\bar{Q}} ---(3)$$

$$Skewness\ \text{coefficient}\ C_s = \frac{\sum_{i=1}^{20}\left[\frac{Q_i}{\bar{Q}} - 1\right]^3}{(20-1)C_v^3} ---(4)$$

Correction factor to skewness coefficient =

In Foster Table (I) $F = 1 + \frac{6}{n} ---(5a)$

In Hazin Table and Foster Table (III)

$$F = 1 + \frac{8.5}{n} ---(5b)$$

Corrected skewness factor $C_s' = F \times C_s ---(6)$

(Murray R.Spiegel,1972,New York,Schaums Series)

The discharge for recurrent return periods is obtained by the equation:-

$$Q = \bar{Q}(P_m C_v + 1) ---(7)$$

As in the table

Best solution in the table

P	%age Probability	20	5	1	0.1
I	$C_s' =$				
II	$I \times C_v$				
III	$II + 1$				
IV	$III \times \bar{Q}$				
V	$Trecurrence - period$	5	20	100	1000

$$T\ \text{- Recurrence} - period = \frac{100}{P_m} \rightarrow e.g.\frac{100}{20} = 5 \text{ years} ---(8)$$

$$and\ \text{P \% age Probability} = \frac{100}{T} \rightarrow \text{e.g.}\frac{100}{5} = 20\ \% ---(9)$$

The above is the application of Foster table (1); the same is applied on Foster (III) and Hazin table.

Fuller equation is expressed as :- (Murray R.Spiegel, 1972, New York, Schaums Series)

$$Q_T = \bar{Q}[1 + 0.80\log\ T] ---(10)$$

$Q_T = Expected$ discharge after (T) years.

$\bar{Q} = Average$ discharge during (t), *years* of records.

Application of the Concept Relation Among the Three Water Supply Types and WRM:-

According to the data collection in the River Nile State the three types of water domestic water, agricultural water, and industrial water are available. The statistical analyses were applied on the three of them.

Domestic Water: - The three sources of the three types of water data of River Nile State are studied using the concept relation among the three water resources and WRM. The River Nile State swings between repeated droughts. This is translated into harmful effects on agriculture. It has also deep and profound effects on industrial and domestic water in River Nile River Atbara and Hafiers, together with painful low groundwater recharge resulting from short rainfall periods. The application is conducted in the three types of water:

Domestic Water:

year	2005	2006	2007	2008	2009	2010	2011
Total	4.72	12.32	6.04	10.70	2.73	6.69	5.78
year	2012	2013	2014	2015	2016	2017	
Total	5.46	10.92	12.23	15.94	17.03	17.57	

Table 2. Statistical Analysis Total Domestic water River Nile State

Expected Population	P %age Probability	Years	Foster I	Foster III	Hazin	Fuller	Average
2209122	20	5	13.95	13.93	14.08	15.37	14.33
2886931	5	20	18.63	18.60	19.15	20.12	19.12
12029844	1	100	23.00	23.09	22.91	25.63	23.66
113046820	0.1	1000	28.35	28.47	26.35	33.51	29.17

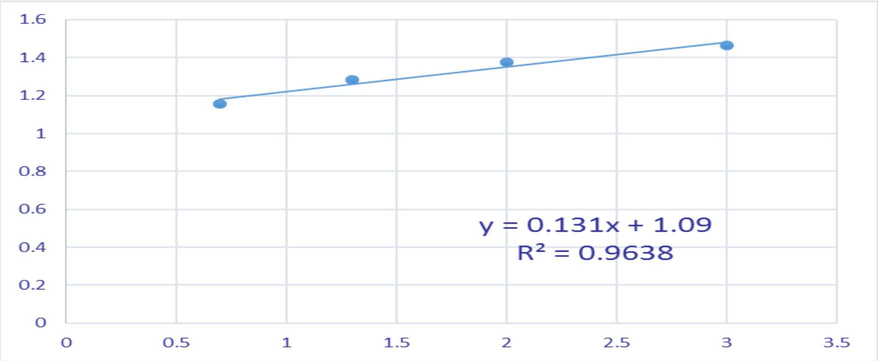

Figure 2. Log Log Total Domestic water River Nile State Average

Agricultural Water :

Year	2005	2006	2007	2008	2009	2010
	0.86	1.76	1.01	1.56	0.63	1.10
	2011	2012	2013	2014	2015	
	0.84	0.58	0.78	1.89	1.92	

Table 3. Statistical Analysis Total Agricultural water River Nile State

Expected Population	P %age Probability	Years	Foster I	Foster III	Hazin	Fuller	Average
2209122	20	5	1.58	1.57	1.60	1.83	1.65
2886931	5	20	2.12	2.12	2.15	2.40	2.20
12029844	1	100	2.66	2.67	2.60	3.06	2.75
113046820	0.1	1000	3.39	3.38	3.02	4.00	3.45

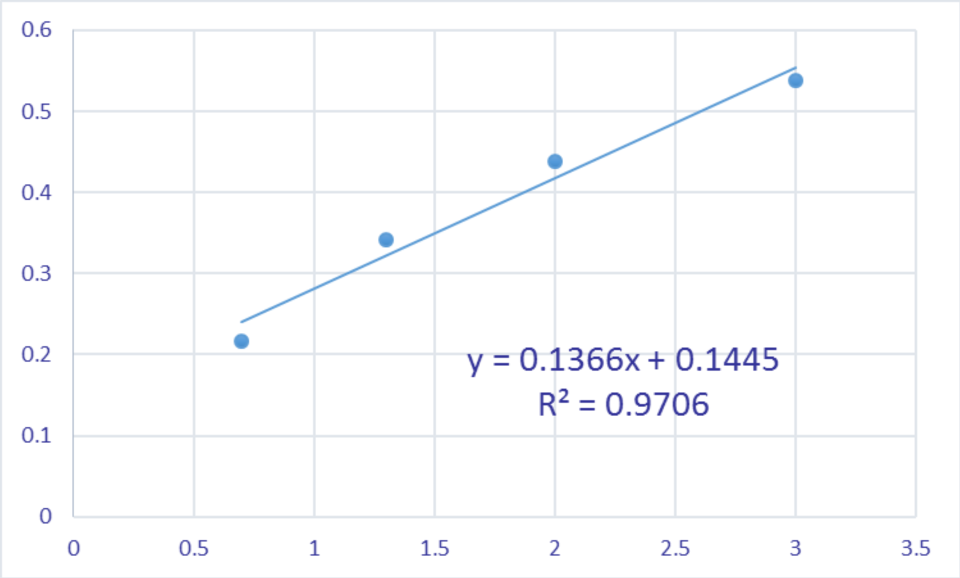

Figure 3. Log Log Total Total Agricultural water River Nile State Average

Industrial Water:-

Industrial Water

	2005	2006	2007	2008	2009	2010	2011
	9.30	19.05	11.00	16.96	6.75	11.82	10.65
	2012	2013	2014	2015	2016	2017	
	10.25	17.25	18.93	23.68	25.08	25.77	

Table 4. Statistical Analysis Total Industrial water River Nile State

Expected Population	P %age Probability	Years	Foster I	Foster III	Hazin	Fuller	Average
2209122	20	5	21.13	21.10	21.42	24.76	22.10
2886931	5	20	27.15	27.10	27.44	32.41	28.52
12029844	1	100	32.78	32.89	31.63	41.30	34.65
113046820	0.1	1000	39.69	39.84	35.23	54.00	42.19

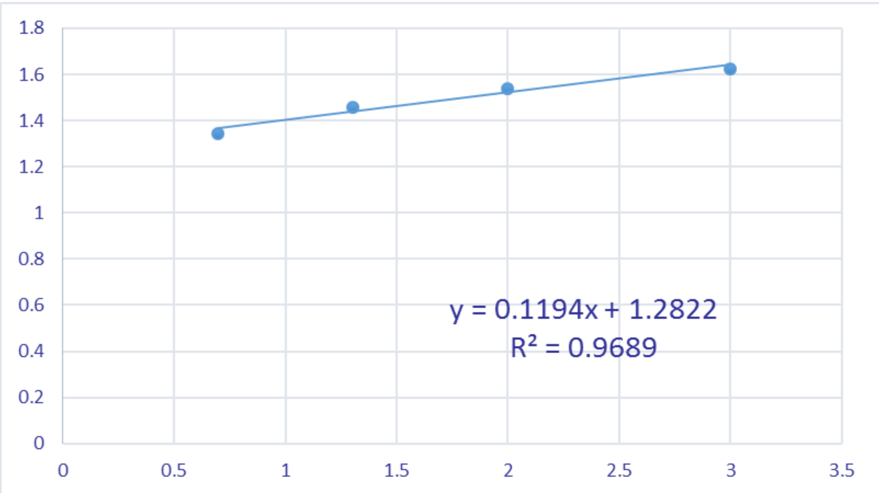

Figure 4. Log Log Total Industrial Water River Nile State Average

Investigation of WRM:-

It is well known and logical to assume that the consumption of water to be 137.5,137.5 and 1375 liters per person per day respectively in arid and semi arid regions as that of the River Nile State.

According to the above analysis of the three types of water domestic, agricultural and industrial the following calculations are conducted as shown in table (5).

Table 5. Estimated Water Resources Using the Concept of WRM

Item	Recurrent Period	Type of water	Probability %	Quantity m m^3	Population
1	5	Domestic Water	20	14.33	2209122
	20		5	19.12	2886931
	100		1	23.66	12029844
	1000		0.01	29.17	113046820
2	5	Agricultural Water	20	1.65	2209122
	20		5	2.20	2886931
	100		1	2.75	12029844
	1000		0.01	3.45	113046820
3.	5	Industrial Water	20	22.10	2209122
	20		5	28.52	2886931
	100		1	34.65	12029844
	1000		0.01	42.19	113046820

Exanimation of table (5) depicts the summary of the total water available within the River Nile State. Table (6),is obtained from table (5) as calculated to obtain the result of **(IWRM)** from the **(WRM)** concept.

Table 6. Result of (IWRM) From (WRM) Concept.

Item	Recurrent Period	Probability %	Total Quantity Domestic + Agricultural + Industrial m m^3	Population	Share per Person m m^3
A.	5	20	38.08	2209122	17.23
B.	20	5	49.84	2886931	17.26
C.	100	1	61.06	12029844	5.08
D.	1000	0.01	74.81	113046820	0.663

The domestic water analysis being part of the second category of the types of water was carried out. It was conventionally referred to as **Integrated Water Management (IWM)**. The average value of the statistical relevant parameter given as the total discharge (Q), was obtained using equation (1).The steps of the analysis conducted the remainder of the other equations, the last one of which was Fuller equation (10).

IV. CONCLUSION

- ✓ River Nile State has 50 % 0f the Sudan water resources, while its area is less than 70 % of the Sudan area.
- ✓ River Nile State is reach in minerals and industry resources, especially in cement and gold.
- ✓ Atbara River annual share of the River Nile discharge yield approach about 14 milliards, approximately about 17 % of its flow.
- ✓ After the construction of Tekazi dam the discharge at Girba Gauging Station has an unmeasured increase, the flow became continuous all the year while there was no flow in the period from February to May.

V. RECOMMENDATIONS

- ✓ Proper management utilization of the River Nile State water resources can be directed to reduce desert encroachment enhance cement industries and gold mining.
- ✓ Lack of discharge measurement data in both the main Nile and Atbara River formed a bottle neck against the development of the River Nile State.
- ✓ The increased discharge from Tekazi dam has improved the situation at both New Halfa Scheme especially during May for sugar demand and increasing the potentiality downstrean in the River Nile State.
- ✓ Evapotranspiration being greater than effective rain is a problem hat requires future research and solution.

VI. REFERENCES

[1]. W.B.Snellen . A.Schrevel -IWRM for sustainable use of water -2004

[2]. Professor: Hussein Suliman Adam -Agroclimatology Crop Water Requirement & Water Management- 2nd Edition- June 2014.

[3]. H.A.J. Van Lanen, N. Wanders, L.M. Thllaksen, and A.F. Van Loon -Hydrological drought across the world: impact of climate and physical catchment structure -May 2013.

[4]. Dr. Bruce Keith, MAJ James Enos, Cadets Benjamin Garlick, Giancarlo Simmons, Daniel Copeland, and Mario Cortizo -Limits of population growth and water resource adequacy in the Nile river basin 1994-2100-July 2013.

[5]. Andrew Garth -Analyzing data using SPSS- (A practical guide for those unfortunate enough to have to actually do it.)-Sheffield Hallam University, 2008

[6]. Sudan in figurers -2014 source Central Bureau of Statistics (CBS)

[7]. Dr: Isam Mohamamed Abd Elmagid-Prof Abbas Abdalla -Hydrology- Published by Sudan Uneversity of science -2002

Appendix I Hazen Table

$C_s{}'$	%age probability										
	99	95	80	50	20	5	1	0.1	0.01	0.001	0.0001
0	-2.11	-1.64	-0.92	0	0.92	1.64	2.08	2.39	2.53	2.59	2.62
0.2	-1.91	-1.56	-0.93	-0.05	0.89	1.72	2.25	2.66	2.83	2.94	3.00
0.4	-1.75	-1.47	-0.93	-0.09	0.87	1.79	2.42	2.95	3.18	3.35	3.44
0.6	-1.59	-1.38	-0.92	-0.13	0.85	1.85	2.58	3.24	3.59	3.80	3.92
0.8	-1.44	-1.30	-0.91	-0.17	0.83	1.90	2.75	3.55	4.00	4.27	4.34
1.0	-1.30	-1.21	-0.89	-0.21	0.80	1.95	2.92	3.85	4.42	4.75	4.95
1.2	-1.17	-1.12	-0.86	-0.25	0.77	1.99	3.09	4.15	4.83	5.25	5.50
1.4	-1.06	-1.03	-0.83	-0.29	0.73	2.03	3.25	4.45	5.25	5.75	6.05
1.6	-0.96	-0.95	-0.80	-0.32	0.69	2.07	3.40	4.75	5.67	6.25	6.65
1.8	-0.87	-0.87	-0.76	-0.35	0.64	2.10	3.54	5.05	6.08	6.75	7.20
2.0	-0.80	-0.79	-0.71	-0.37	0.58	2.13	3.67	5.35	6.50	7.25	7.80

Foster Table 2

$C_s{}'$	%age probability								
	99	95	80	50	20	5	1	0.1	0.01
0	-2.32	-1.64	-0.84	0	0.84	1.64	2.32	3.09	3.70
0.2	-2.18	-1.59	-0.85	-0.03	0.83	1.71	2.48	3.39	4.20
0.4	-2.04	-1.53	-0.85	-0.06	0.82	1.76	2.64	3.72	4.72
0.6	-1.92	-1.47	-0.85	-0.09	0.81	1.81	2.80	4.08	5.30
0.8	-1.80	-1.41	-0.85	-0.12	0.79	1.86	2.97	4.48	6.00
1.0	-1.68	-1.34	-0.84	-0.15	0.76	1.90	3.15	4.92	6.74
1.2	-1.56	-1.28	-.83	-0.18	0.74	1.94	3.33	5.40	7.66
1.4	-1.46	-1.22	-0.82	-0.20	0.71	1.98	3.50	5.91	8.66
1.6	-1.36	-1.16	-0.81	-0.23	0.67	2.01	3.69	6.48	9.79
1.8	-1.27	-1.10	-0.79	-0.25	0.64	2.03	3.88	7.09	11.00
2.0	-1.19	-1.05	-0.77	-0.27	0.61	2.05	4.07	7.78	12.60
2.2	-1.11	-0.99	-0.75	-0.29	0.57	2.07	4.27	8.54	14.30
2.4	-1.03	-0.94	-0.73	-0.31	0.53	2.08	4.48	9.35	--
2.6	-0.97	-0.89	-0.71	-0.32	0.49	2.09	4.68	10.15	--
2.8	-0.91	-0.84	-0.68	-0.33	0.45	2.09	4.89	11.20	--
3.0	-0.84	-0.79	0.66	-0.34	0.41	2.08	5.11	12.30	--
3.2	-0.78	-0.74	-0.64	-0.35	0.37	2.06	5.35	13.50	--
3.4	-0.73	-0.69	-0.61	-0.36	0.32	2.04	5.58	--	--
3.6	-0.67	-0.65	-0.58	-0.36	0.28	2.02	5.80	--	--
3.8	-0.62	-0.61	-0.55	-0.36	0.23	1.98	6.10	--	--
4.0	-0.58	-0.56	-0.52	-0.36	0.19	1.95	6.50	--	--
4.5	-0.48	-0.47	-0.45	-0.35	0.10	1.79	7.30	--	--
5.0	-0.40	-0.40	-0.39	-0.34	0.00	1.60	8.20	--	--

Foster Table 3

%age probability

C_s'	99	95	80	50	20	5	1	0.1	0.01	0.001	0.0001
0	-2.33	-1.64	-0.84	0	0.84	1.64	2.33	3.09	3.73	4.27	4.76
0.2	-2.18	-1.58	-0.85	-0.03	0.83	1.69	2.48	3.38	4.16	4.84	5.48
0.4	-2.03	-1.51	-0.85	-0.06	0.82	1.74	2.62	3.67	4.60	5.42	6.24
0.6	-1.88	-1.45	-0.86	-0.09	0.80	1.79	2.77	3.96	5.04	6.01	7.02
0.8	-1.74	-1.38	-0.86	-0.13	0.78	1.83	2.90	4.25	5.48	6.61	7.82
1.0	-1.59	-1.31	-0.86	-0.16	0.76	1.87	3.03	4.54	5.92	7.22	8.63
1.2	-1.45	-1.25	-0.85	-0.19	0.74	1.90	3.15	4.82	6.37	7.85	9.45
1.4	-1.32	-1.18	-0.84	-0.22	0.71	1.93	3.28	5.11	6.82	8.50	10.28
1.6	-1.19	-1.11	-0.82	-0.25	0.68	1.96	3.40	5.39	7.28	9.17	11.21
1.8	-1.08	-1.03	-0.80	-0.28	0.61	1.98	3.50	5.66	7.75	9.84	11.96
2.0	-0.99	-0.95	-0.78	-0.31	0.61	2.00	3.60	5.91	8.21	10.51	12.81
2.2	-0.90	-0.89	-.75	-0.33	0.58	2.01	3.70	6.20	--	--	--
2.4	-0.83	-0.82	-0.71	-0.35	0.54	2.01	3.78	6.47	--	--	--
2.6	-0.77	-0.82	-0.68	-0.37	0.51	2.01	3.87	6.73	--	--	--
2.8	-0.71	-0.71	-0.65	-0.38	0.47	2.02	3.95	6.99	--	--	--
3.0	-.67	-.66	-0.62	-0.40	0.42	2.02	4.02	7.25	--	--	--