PROBABILITY OF FAILURE TO ADHAIM RESERVOIR

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Abstract

In this study,the Moran steady –state method of capacity - yield analysis is applied to the Adhaim reservoir. The ultimate objective is applied to find the probability distribution of the reservoir contents (including the probability of failure)undergiven release rules.

According to previous studies on reservoir behavoir in the U.K. Australia and some other countries, it way found that theNormal ,Log normal , Gamma and Pearson type III distributions appear better than the other theoretical distributions in describing the empirical distributions of inflow data in this study two statistical distribution have been abopted for the analysis the Gamma distribution and Pearson type III distributions.

1. Introduction

Morans Method requires the division of the resevoir contents into a number - size "states" usually in the range of 10 to 20 [1].

Than , starting with a given state , the probability of finishing in particular distribution.

In the present study , the Adhaim reservoir capacity of 1150×10^{6} million cubic meter is divided into eleven equal states as shown in figure 1 .

The Moran approach involves constuction a probability transition matrix to describe all the possible "beginning" and "end of year"storage combination . Thes matrices have the property of attaining a steady state ,that is,the individual columns of the matrix tend to become identical after repeated annual transitions ,this means that the contents of a reservoir after a period of,at most,twenty years become independent of the initial contents[2].

Moran assumed that inflow occurred only during the wet season , and that water was released only at a difinite time each year during the dry season [3].

In Iraq the approximate wet and dry periods seems to be November April and May October respectively.

2. In flow of the Adhaim reservoir

Records of mean monthly flows of the Adhaim river are listed in table (1) . The values given in the table for the period 1937 to 1965 represent the flows at Injana ganging station [4],while those for period 1966 to 1993 corresponding to flows at Narrows station . Both stations are located upstream of the dam site , the Injana station being the nearest to the dam . Narrows station is located about 4 kilometers upstream of the Injana station.

The drain water of the drainage system contributes to the total inflow to the reservoir by the amounts given in table (2a).

The operation study of the Adhaim reservoir [5] suggested that certain quantities of water should be drawn from the Lesser Zab river to contribute to the total inflow to the Adhaim reservoir of 100 % and 130% are given in table (a).

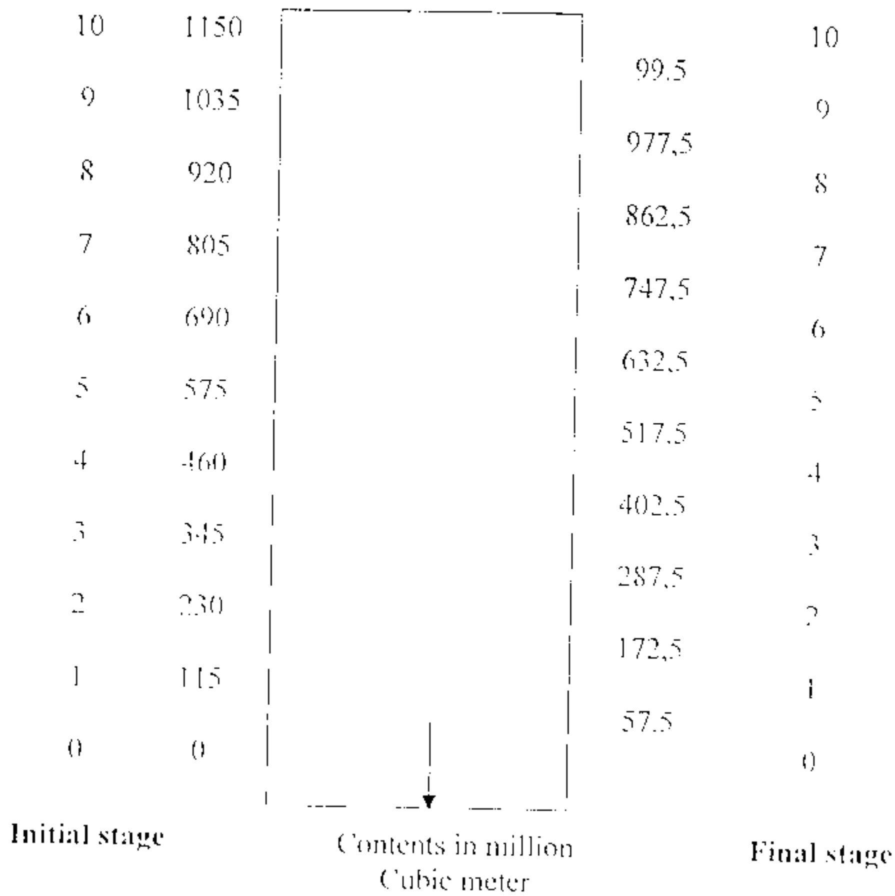

Figure 1.Dsiviton of reservoir Finite states

Table(1)Mean Natural Inflow to Adhaim Reservoir (in cumecs).

Year	Oct.	Nov.	Des.	Jan	Feb.	Mar.	Apr.	May	Jon.	Jul.	Aug.	Sep.	Mean
1937	9	27	7	118	136	93	24	10	5	6	6	6	40
1938	6	10	93	95	104	50	134	9	3	3	1	4	43
1939	4	9	27	117	252	75	32	11	5	3	3	3	45
1940	3	26	17	33	133	96	31	8	46	3	4	3	30
1941	3	3	16	34	34	47	6	4	4	7	7	7	15
1942	8	11	5	14	23	432	46	9	3	3	5	6	22
1943	3	4	13	41	25	27	11	4	5	4	4	1	12
1944	3	18	4	162	29	16	12	7	6	4	3	1	22
1945	2	18	5	162	31	17	14	8	4	1	4	4	23
1946	5	48	33	115	106	230	97	31	0	1	0	0	58
1947	0	0	12	13	14	25	3	1	4	0	0	0	6
1948	4	6	14	7	10	8	36	9	2	3	3	3	9
1949	3	3	14	17	33	243	75	13	2	0	0	0	34
1950	0	0	107	115	111	82	14	24	0	0	0	0	31
1951	1	2	3	13	50	10	3	2	1	0	0	0	7
1952	1	3	5	5	22	31	8	6	4	0	0	0	7
1953	1	1	150	98	153	152	51	8	1	2	1	1	53
1954	2	30	9	11	52	165	113	7	3	0	0	0	32
1955	0	2	11	21	8	2	12	16	1	2	2	3	7
1956	3	9	24	7	14	11	26	5	26	0	0	1	8
1957	1	1	7	14	66	198	157	125	3	0	4	2	31
1958	2	11	24	64	28	10	2	1	1	0	0	0	12
1959	2	5	15	4	10	79	30	19	2	1	1	1	14
1960	2	1	2	27	6	8	10	1	1	1	0	1	5
1961	1	203	40	172	14	11	58	15	1	1	1	1	43
1962	1	23	81	62	16	6	14	3	1	1	1	1	18
1963	1	11	9	26	76	30	74	124	9	2	1	1	30
1964	5	3	19	26	41	15	8	2	1	1	1	1	10
1965	1	1	3	65	14	11	69	8	1	0	0	0	14
1966	1	2	1	10	87	52	9	2	0	0	0	0	14
1967	11	1	3	4	52	31	6	4	0	0	0	0	10
1968	0	48	59	3	18	4	113	27	3	0	0	0	23
1969	0	19	64	168	71	109	170	45	6	3	1	2	55
1970	2	18	22	67	14	36	5	1	2	1	1	1	11
1971	1	3	8	3	6	32	189	9	5	4	3	3	22
1972	3	10	25	45	74	151	103	91	15	7	4	4	41
1973	5	33	33	19	48	42	18	12	3	2	1	1	18
1974	1	6	8	5	86	448	186	12	2	2	2	2	67
1975	2	14	90	31	84	60	47	30	7	2	1	1	31
1976	0	1	31	50	82	72	86	27	7	3	3	0	30
1977	2	3	4	27	30	30	23	7	3	1	0	0	9
1978	0	8	24	27	15	35	3	2	2	2	1	2	10
1979	4	5	141	81	19	11	6	5	5	2	1	1	23
1980	6	4	42	17	28	41	18	4	0	2	1	1	13
1981	1	8	18	121	25	75	28	9	5	1	1	2	25
1982	3	3	49	154	61	67	73	57	8	4	3	2	40
1983	21	34	14	19	24	18	16	8	2	2	1	1	13
1984	2	2	4	4	4	17	20	4	1	1	1	1	5
1985	2	79	21	13	70	13	17	3	2	1	1	1	20
1986	1	3	18	3	63	6	22	11	2	1	1	1	11
1987	2	13	8	2	6	13	4	2	2	2	2	1	5
1988	5	6	114	63	78	249	31	25	4	2	2	3	49
1989	10	9	91	23	22	71	26	10	6	9	9	7	24
1990	6	26	47	19	54	42	11	4	6	7	9	9	20
1991	8	5	6	10	61	103	13	10	9	3	4	5	20
1992	9	21	104	49	159	124	35	28	13	6	10	11	47
1993	12	46	138	100	50	39	124	61	16	11	11	11	52
Mean	3	16	34	51	53	68	45	18	4	2	2	2	24.8

Table (2a) Mean Monthly Return Flow and Transfer Flow from Lesser Zab to Adhaim Reservoir in cumecs

Month			Return flow	Total Additional Flow	
	Toz Chai	Canal flow			
Oct.	16.72	22.45	4.28	21.00	26.37
Nov	12.18	17.91	2.28	14.46	20.19
Des.	6.15	11.88	-	6.15	11.88
Jan	5.41	11.14	-	5.41	11.14
Feb.	11.31	17.04	1.20	12.51	18.24
Mar.	14.09	19.82	4.40	18.49	24.22
Apr.	25.12	30.85	4.98	30.10	35.83
May	24.92	30.65	5.31	30.23	35.96
Jon.	22.88	29.61	9.30	32.18	37.91
Jul.	20.58	26.31	11.19	31.77	37.50
Aug	18.62	24.35	7.06	25.68	31.41
Sep.	19.15	24.88	2.08	21.23	26.96
Total	197.13	265.89	52.08	249.21	317.97
Mean	16.43	22.16	4.34	20.77	26.50

Table (2a) Mean Monthly Water Demand Requirement Down Stream of Adhaim Dam in Cumecs

Month	Dhuloiya Demand		Block 7	Small Farm	Comp. Water	Total Water Requirement	
	100*C.I	130*C.I				100*C.I	130*C.I
Oct.	11.45	13.86	16.14	3.18	1.0	30.7	38.94
Nov	3.80	4.67	11.65	1.18	1.0	17.57	18.44
Des.	2.62	3.79	2.29	0.35	1.0	6.26	7.43
Jan	1.47	2.75	2.29	0.39	1.0	5.15	6.43
Feb.	9.63	11.53	6.91	0.97	1.0	18.51	20.41
Mar.	10.07	14.48	13.95	1.70	1.0	26.72	31.13
Apr.	14.91	21.80	21.68	2.21	1.0	39.71	64.60
May	20.78	27.74	16.86	8.93	1.0	41.57	84.26
Jon.	32.98	43.33	22.90	3.90	1.0	61.78	87.13
Jul.	23.49	37.10	2.46	4.44	1.0	53.84	76.00
Aug	15.35	26.63	17.39	4.05	1.0	37.97	49.06
Sep	17.85	22.57	8.11	2.74	1.0	29.10	34.2
Total	164.52	229.79	165.63	26.83	12.0	368.71	434.25
Mean	13.69	19.15	13.80	2.24	1.0	30.71	36.19

C.I= Crop Intensity

Comp = Compensation Water = Sanitation Water

3. Water demand

The estimated mean water requirements are tabulated in table (2b).

4. Effect of Meteorological on Processes on the Reservoir Storage:

Evaporation decreases reservoir storage while precipitation increases it. Observations for the Adhaim area reveal that evaporation rate exceeds precipitation rate considerably for most of both the wet and dryseasons are shown in table (3).Themethod which is used in this study to compute the net seasonal deceas in storage due to evaporation and precipitation is illustated as follows [6]:

$V=A(E-P)$

Where :

V=Volumetric decrease in storage (m^3)

A Area of water surface(m^2)

E=Evaporation (m)

P=Precipitation (m)

Decrease in storage for the wet season

$63.5*10^6(0.478 - 0.295) = 11.62 * 10^6\ m^3$

Decrease in storage for the dry season

$= 63.5*10^6(1.622 - 0.023) = 101.53 * 10^6\ m^3$

Month	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Wet Season	Dry Season
Precipitation (mm)	7	34	48	63	49	62	39	16	0	0	0	0	295	23
Evaporation (mm)	145	79	37	40	61	110	151	236	328	362	331	227	478	1622

Table (3) Mean monthly precipitation and free – water surface evaporation from adhaim reservoir .

5. Obtain the transition matrix:

From past inflow records , the probability distribution of future inflow is deduced by fitting a theoretical distribution to the inflow values . Then starting with reservoir contents at a base year , the contents of reservoir become independent of the initial contents [7]:

Tow satisfied distribution are fitted in this study Gamma distribution and Pearson distribution type III [8]. The Year is divided into two season wet and dry . For Adhaim reservoir , the moment estimates of location and dispersion parameters of net addition to storage (N.A.S.) values are as follow :

5-1 Wet season

1. Mean of (N.A.S.) = Mean inflow – (Demand +Evaporation – precipitation)

$$= 1013.52*10^6 - [340.2*10^6 + 11.62*10^6]$$
$$= 661.7*10^6\ m^3$$

2. Standard deviation of (N.A.S.) = standard deviation of inflow

= $470.457 * 10^6\ m^3$. The next step is obtain the probability distribution of net addition storage byy using Gamma distribution and Pearson type III distribution. The distribution function F(x) of Gamma distribution [8] is

$$F(x)=\frac{1}{y^b\Gamma(b)}\int_0^x x^{(b-1)}\exp(-x\setminus y)dx$$

Where :

y= scale parameter

b= shapa parameter

The distribution function F(x) of Pearson type III distribution [9] is

$$F(x)=\frac{1}{|y|\Gamma(b)}\int_{x_0}^{x}\left[\frac{x-x_0}{y}\right]^{b-1}\exp\left[\frac{-x-x_0}{y}\right]dx$$

Where :

x_0 = Lower boundary

The fitting of a distribution requires the estimation of its parameter From the observed values by using maximum likelihood method [9]

	Gamma		Pearson type III		
	y	b	x_0	y	b
Wet season	9.863	23.464	12.10	0.804	34.966
Dry season	4.604	24.587	- 233.950	5.889	0.076

Table 4 and table 5 showed the values of probability of net addition to storage for both wet and dry season by Gamma

5-2 Seasonal transition matrices (Gamma) Distribution

A Seasonal transition matrices which gives the probability of the reservoir being in any of the states of storage the end of the season if the season begins with the reservoir being in each of the stroage states table (6) represent the wet season matrix and table (7) represent thr dry season matrix [10 ,11]

5-3 Annual transition matrix (Gamma distribution)

A combination of the two half – yearly matrices , by multiplication , gives the yearly transition matrix table (8).

5-4 Attainment of steady – state probabilities (Gamma distribution)

To attain the steady – state probabilities , In this study the method of powering up the transition matrix is used table [9] represent the steady – state matrix (the eight year matrix)from this matrix we found that the probability of failure is 3% which is the commonly acceptable range (1-5) % [1] by the same way Pearson type III distribution is used and we found that the probability of failure is 6.3 which is slightly more than acceptable range.

Table (4) probability of N. AS. based on Gamma Distribution for the wet season

N.A.S. X $M^3 * 10^6$	$Z = \frac{x - \bar{x}}{s}$ $\bar{x} = 661.7$ S=470.457	F (x)	P Probability That	Storage increase In the range
			0.799	>1092.5
1092.5	0.9157	0.8201		
			0.0711	977.5 to 1092.5
977.5	0.6713	0.7490		
			0.0837	862.5 to977.5
862.5	0.4268	0.6652		
			0.0929	747.5 to862.5
747.5	0.1824	0.5724		
			0.0971	632.5 to 747.5
632	- 0.0621	0.4753		
			0.0956	517.5 to 632.5
517.5	- 0.3065	0.3796		
			0.0888	402.5 to 517.5
402.5	- 0.5510	0.2908		
			0.0776	287.5 to 402.5
287.5	- 0.7945	0.2132		
			0.0640	172.5 to 287.5
172.5	-1.0389	0.1492		
			0.0497	57.5 to172.5
57.5	-1.2843	0.0995		
			0.0364	-57.5 to57.5
-57.5	-1.5287	0.0632		
			0.0251	-172.5 to -57.5
-172.5	-1.7732	0.0381		
			0.0163	-285.5 to 172.5
-287.5	-2.0176	0.0218		
			0.0100	-402.5 to - 287.5
-402.5	-2.2621	0.0118		
			0.0058	-517.5 to 402.5
-517.5	-2.5065	0.0061		
			0.0031	-63205 to - 517.5
-632.5	-2.7509	0.0030		
			0.0016	-747.5 to 632.5
-747.5	-2.9954	0.0014		
			0.0008	-862.5 to – 747.5
-862.5	-3.2398	0.0006		
			0.0004	-977.5 to – 862.5
-977.5	-3.4843	0.0002		
			0.0002	1092.5to977.5
-1092.5	-3.7287	0.0001		
			0.0001	<- 1092.5

Table (5) probability of N.AS. based on Gamma Distribution for the dry season

N.A.S. X $M^3 * 10^6$	$Z = \frac{x - \bar{x}}{s}$ $\bar{x} = -303.456$ S= 88.07	F (x)	P Probability That	Storage increase In the range
			0.0000	>1092.5
1092.5	15.8506	1.000	0.0000	977.5 to 1092.5
977.5	14.544	1.000	0.0000	862.5 to977.5
862.5	13.2390	1.000	0.0000	747.5 to862.5
747.5	11.9332	1.000	0.0000	632.5 to 747.5
632	10.6275	1.000	0.0000	517.5 to 632.5
517.5	9.3271	1.000	0.0000	402.5 to 517.5
402.5	8.0159	1.000	0.0000	287.5 to 402.5
287.5	6.7101	1.000	0.0000	172.5 to 287.5
172.5	5.4043	1.000	0.0000	57.5 to172.5
57.5	4.0986	1.000	0.0026	57.5 to57.5
-57.5	2.7928	0.9974	0.0659	-172.5 to -57.5
-172.5	1.4870	0.9315	0.4415	-285.5 to - 172.5
-287.5	0.1812	0.5719	0.1228	-402.5 to 287.5
-402.5	-1.1246	0.1304	0.0074	-517.5 to 402.5
-517.5	-2.4303	0.0075	0.0001	-63205 to - 517.5
632.5	-3.7361	0.0001	0.0000	-747.5 to – 632.5
-747.5	-5.0419	0.0000	0.0000	-862.5 to – 747.5
-862.5	-6.3477	0.0000	0.0000	-977.5 to – 862.5
-977.5	-7.6535	0.0000	0.0000	1092.5to977.5
-1092.5	-8.9592	0.0000	0.0000	<- 1092.5

Table (6) Wet season Matrix (Gamma Distribution)

State		Initial										
		0	1	2	3	4	5	6	7	8	9	10
Final	Contents ($m^3 10^6$)	0	115	230	346	460	575	690	805	920	1053	1150
0	>57.5	0.100	0.063	0.083	0.022	0.012	0.006	0.003	0.002	0.001	0.000	0.000
1	57.5 -172.5	0.05	0.036	0.025	0.016	0.010	0.006	0.003	0.002	0.001	0.000	0.000
2	172.5-287.5	0.064	0.050	0.036	0.025	0.016	0.010	0.006	0.003	0.002	0.001	0.000
3	287.5-402.5	0.078	0.064	0.058	0.036	0.025	0.016	0.010	0.006	0.003	0.002	0.001
4	402.5-517.5	0.089	0.087	0.064	0.058	0.036	0.025	0.016	0.010	0.006	0.003	0.002
5	517.5-632.5	0.096	0.098	0.078	0.064	0.050	0.036	0.025	0.016	0.010	0.006	0.003
6	632.5-747.5	0.097	0.096	0.089	0.078	0.064	0.050	0.036	0.025	0.016	0.010	0.006
7	747.5-862.5	0.093	0.097	0.096	0.089	0.078	0.064	0.050	0.036	0.025	0.016	0.010
8	862.5-977.5	0.084	0.093	0.097	0.096	0.089	0.078	0.064	0.050	0.036	0.025	0.016
9	977.5-1092.5	0.071	0.084	0.093	0.097	0.096	0.089	0.078	0.064	0.050	0.036	0.025
10	>1092.5	0.180	0.251	0.335	0.428	0.0525	0.620	0.709	0.778	0.851	0.900	0.037

Table (7) Dry season Matrix (Gamma Distribution)

State		Initial										
Final	Contents ($m^3 10^6$)	0 0	1 115	2 230	3 345	4 460	5 575	6 690	7 805	8 920	9 1053	10 1150
0	<57.5	1.000	0.997	0.931	0.572	0.138	0.007	0.000	0.000	0.000	0.000	0.000
1	57.5 -172.5	0.000	0.003	0.025	0.360	0.442	0.123	0.007	0.000	0.000	0.000	0.000
2	172.5-287.5	0.000	0.000	0.003	0.066	0.360	0.442	0.123	0.007	0.000	0.000	0.000
3	287.5-402.5	0.000	0.000	0.000	0.003	0.066	0.360	0.442	0.123	0.007	0.000	0.000
4	402.5-517.5	0.000	0.000	0.000	0.000	0.003	0.066	0.368	0.442	0.123	0.007	0.000
5	517.5-632.5	0.000	0.000	0.000	0.000	0.000	0.003	0.066	0.360	0.442	0.123	0.007
6	632.5-747.5	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.066	0.360	0.442	0.123
7	747.5-862.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.066	0.360	0.442
8	862.5-977.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.066	0.36
9	977.5-1092.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.066
10	>1092.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0026

Table (8) Annual (one year) matrix (Gamma Distribution)

State final	Initial 0	1	2	3	4	5	6	7	8	9	10
0	0.266	0.193	0.134	0.089	0.056	0.034	0.020	0.012	0.006	0.003	0.001
1	0.084	0.073	0.059	0.045	0.033	0.022	0.014	0.009	0.005	0.003	0.002
2	0.092	0.084	0.073	0.059	0.045	0.033	0.022	0.014	0.009	0.005	0.003
3	0.096	0.092	0.048	0.073	0.059	0.045	0.033	0.022	0.014	0.009	0.005
4	0.093	0.096	0.092	0.084	0.073	0.059	0.045	0.033	0.022	0.014	0.009
5	0.087	0.095	0.097	0.095	0.087	0.076	0.063	0.050	0.038	0.028	0.021
6	0.090	0.108	0.124	0.136	0.144	0.148	0.148	0.146	0.141	0.137	0.133
7	0.111	0.148	0.188	0.231	0.237	0.311	0.346	0.374	0.397	0.412	0.424
8	0.070	0.096	0.127	0.161	0.196	0.229	0.261	0.288	0.310	0.326	0.339
9	0.012	0.017	0.022	0.029	0.035	0.041	0.047	0.052	0.056	0.060	0.062
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table (9) Eight year (steady – state) matrix (Gamma Distribution)

State final	Initial 0	1	2	3	4	5	6	7	8	9	10
0	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
1	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
2	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
3	0.030	0.030	0.030	0.030	0.030	0.029	0.029	0.030	0.029	0.029	0.029
4	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
5	0.055	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
6	0.141	0.141	0.141	0.141	0.141	0.140	0.141	0.141	0.141	0.141	0.141
7	0.350	0.350	0.350	0.349	0.349	0.349	0.348	0.349	0.349	0.348	0.348
8	0.268	0.267	0.267	0.267	0.267	0.266	0.266	0.266	0.266	0.266	0.266
9	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table (10) Observed and theoretical ch-square values

Type of distribution	Gamma			Pearson		
Season	No. of degree of Freedom	Theoretical X^2 at % 10 level	Observed X2	No. of degree of Freedom	Theoretical X^2 at % 10 level	Observed X2
Wet	5	9.236	21.817	4	7.779	3.59
Dry	3	6.25	44.62	4	7.779	4.572

Table (11) Observed and theoretical kolonogrovs test staties Dn

Type of distribution	Gamma			Pearson		
Season	Sample size (n)	Theoretical Dn at % 10 level	Observed Dn	Sample size (n)	Theoretical Dn at % 10 level	Observed Dn
Wet	57	0.162	0.152	56	0.163	0.068
Dry	57	0.162	0.232	56	0.163	0.072

6. Testing the Goodness of fit

The goodness of fit of a probability distribution can be tested by comparing the theoretical and sample values of the relative frequency or the cumulative frequency function . Two indices of goodness of fit ,namely the Chi-square and the Kolomogrov-smirnov indices , are calculated and the results are presented on the hypothesis of Gamma and Pearson distribution in table (10) and table (11).

7.Conclusions:

1. In case of Gamma distribution, the probability is 2.9 % which falls within a commonly acceptable range of (1-5)%.
2. In case of Pearson distribution, the probabilityof failure is 6.3 %, which is slightly .more than the range.
3. The Chi-square and the Kolomogrov-smirnov shown that , the two distribution are accepted only for wet season , this mean that the goodness of fit tests alone are unsatisfactory for judging the best fit distribution, also from the results, we can see the Gamma distribution is preferred to Pearson type III distribution.

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الخلاصة

في هذه الدراسة طبقت طريقة موران الحالة الثابتة على خزان العظيم أن الغاية الأساسية هو إيجاد التوزيع الاحتمالي لمحتويات الخزان وبضمنها احتمالية الفشل.

ونسبة إلى الدراسات السابقة في بريطانيا واستراليا وبعض الدول الأخرى وجد بأن التوزيع الطبيعي والتوزيع الطبيعي اللوغارتمي وتوزيع كاما وتوزيع بيرسون النوع الثالث كانت ملائمة اكثر من التوزيعات النظرية الأخرى.في هذه الدراسة طبقنا توزيعين إحصائيين هما توزيع كاما وتوزيع بيرسون النوع الثالث.