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IMPROVEMENT IN SYSTEM PERFORMANCE WITH CARRY OVER STORAGES DURING DEFICIT INFLOW PERIODS

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Abstract: Carry-over storages are over-year storages and will be able to hold flows more than the yearly requirement whereas with-in -year storages are provided to take care of seasonal variations of flows. When there are insufficient flows in the initial period the carry over storages will help in meeting the demands of this period as the flows from the previous year are stored in the reservoirs. They will also be helpful in improving the system performance by meeting the demands in deficit years with the carried forward flows. The deficit may be completely wiped out in some years where as in some years the quantum of deficit may reduce. Srisailam and Nagarjunasagar reservoirs in Krishna basin are provided as carry over storages. In this study an effort is made to study the effect of carry-over storages of Srisailam and Nagarjunasagar on the performance of the system of reservoirs Srisailam, Nagarjunasagar and Krishna delta of the Krishna system. The inflows are worked out at Srisailam, Srisailam to Nagarjunasagar, Nagarjunasagar to Prakasam barrage and the total inflows are compared with the demands planned on yearly basis and the success or failure of meeting the demands on annual basis is worked out. The study concluded that the success rates of irrigation at Srisailam, Nagarjunasagar and Krishna delta have improved with carry over storages. The improvement is marginal at Srisailam but more than 13% for Nagarjunasagar and Prakasam Barrage.

Index Terms - Carry-over storage, Irrigation demands, Srisailam, Nagarjunasagar, Prakasam Barrage

I. INTRODUCTION:

The River Krishna rises in the Mahadev range of the Western Ghats near Mahabaleshwar at an altitude of 1337m above sea level and flows through Maharashtra, Karnataka and Andhra Pradesh gathering water on its way from innumerable rivers, streams or tributaries and drops into the Bay of Bengal. River Bhima and Tungabhadra are major tributaries of river Krishna. Main Krishna, Bhima and Tungabhadra constitute the stems of the river Krishna. Jurala,Srisailam, Nagarjunasagar, Krishna delta are the major projects on main Krishna. The srisailam reservoir complex of Srisailam, Nagarjunasagar and Krishna delta has cater to the needs of Srisailam irrigation of 19 TMC for SRBC, 33 TMC of evaporation losses in Srisailam, 280 TMC for irrigation and 16.5 TMC of drinking water to Hyderabad city at Nagarjunasagar,152.2 TMC at Prakasam Barrage (Krishna delta) at 75 % dependability. In this study the TGP project for irrigation of 25 TMC at lower dependability is also considered.

Table-1: The salient features of srisailam and nagarjunasagar in krishna basin

S.No.	Name of the project	Unit	Srisailam	Nagarjuna sagar
1	Sub-basin		K-7	K-7
2	Catchment area	(Sq.Km)	206030	215185
3	Gross storage	(TMC)	308	408.24
4	Live storage	(TMC)	249.99	202.47
5	Dead storage	(TMC)	58.08	205.77
6	F.R.L	M	269.75	179.832
7	M.D.D.L	M	260.3	155.45
8	Crest level	M	252.98	179.832

II. LITERATURE SURVEY:

The aim of the study was to assess the performance of two irrigated schemes in the upper Volta basin one in Burkhana and other in Ghana, through participatory methods to identify constraints and to discuss possible solutions. If the optimal crop management, proper maintenance of the system, marketing facilities are provided then there will be lot of improvement in agricultural production and economic returns and in overall performance of the reservoirs.

Three parameters namely reliability resilience and productivity index were used to study the performance of a reservoir in Karnataka. The performance is evaluated when the reservoir is operated for a standard optimal policy for a sufficient length. The reservoir releases are simulated under each of the three policies using synthetically generated inflows and a comparison is made for the three parameters. It was observed that the policy 3 which incorporates the soil moisture dynamics gives better performance compared to the other two for the three parameters namely reliability, resilence and productivity.(Hydrological sciences,2/1992, PP mazumdar and Vedula)

In this study a monthly time stepped simulation model has been developed and applied for evaluating the performance of the UKAI reservoir in Gujarat. Standard operating policy was considered for operation. The constriction on reservoir maximum levels and sedimentation are considered. The system behaviour is further investigated for reliability resilence, vulnerability and sustainability. The simulated releases are compared to the actual releases and it is observed that the system has fewer deficits but more spills.

The performance and productivity of two small reservoirs was investigated in this study. In the two systems considered there is lot of variability in the availability of water. In one system more water is available resulting in relaxation of management and inefficient irrigation for Tanga system where as in other system there is shortage of water for Weega system. The comparisons indicated better management practices will yield improvement in both the systems.(Irrigation and drainage, 2008, Joshua W. Faulkner et.al)

The objective of the study was to improve the current reservoir simulation module of SWAT for simulating multiple water supply system of agriculture based and reservoir based operating rules. For this purpose auto irrigation is simulated by coupling SWAT and IWRM (Irrigation water requirement model) applying RWL(restricted water level) component operation rules and considering return flows. It was concluded that the combination of IWRM and SWAT provides for a good reference to understand the variations of Agricultural water resources and is expected to support the assessment of multiple water supply capacity. (International SWAT conference,2013, Jog-Yoon-Park et.al)

III. METHODOLOGY FOR THE PRESENT STUDY:

In the present study the inflows are worked out at Srisailam, Srisailam to Nagarjunasagar, Nagarjunasagar to Prakasam barrage and the total inflows are compared with the demands planned on yearly basis and the success or failure of meeting the demands on annual basis is worked out. It is assumed that with in year storages are provided and whenever flows are available in a given year more than the demands they will be met. This will give an idea about the success without carry over storages.

The annual demands of the projects below Srisailam are given below in TABLE 2

Table 2: Annual demands of projects.

Slno	Description	Demand in TMC
1	SRISAILAM Project(SLM)	
	Chennai water sypply(CWS)	15
	Srisailam right branch canal(SRBC)	19
	Evaporation	33
	TGP(only when flow in Krishna is >2293)	25
2	NAGARJUNASAGAR(NSP) project	
	HWS	16.5
	Irrigation	264
	Evaporation	17
3	PRAKASAM Barrage(PB)	
	Irrigation for Krishna delta	152.2

These annual demands are compared with annual flows at each project and the success rates are worked out on annual basis. This will give the success rates of the system without carry over storages. However the flows between Nagarjunasagar and Prakasam Barrage could not be fully utilized as there is no storage at Prakasam Barrage. Therefore only 50 % of generated flows between NSP and PB are considered as useful. Further even when the flows are available on annual basis the flows in the initial period of june and july the flows may not be available causing a failure. This aspect is also considered in the study though this study of scenario1 without carry over storages is on annual basis.

In the 2nd scenario the integrated operation of the system Srisailam, Nagarjunasagar and Prakasam barrage is then done considering the storages of Srisailam and Nagarjunasagar which are carry over storages and the success rates of each component demand is worked out. The success rates of the each demand at all the reservoirs and prakasam barrage is calculated. Both the results are compared and the conclusions are drawn.

Srisailam reservoir receives flows from sub basins K1, K2, K3, K4, K5, K6, K8, K9and part of K7 of Krishna basin. The gauge data at the end of each sub basin is used to estimate the gross flows of that sub basin. The total gross flows of K1 to K6 and k8 to k9 and proportionate flows of K7 up to Srisailam (catchment proportion) are added to get the gross flows at Srisailam. The net flows at Srisailam are worked out as the gross flows minus the planned upstream utilisations including minor irrigation and small projects upstream of reservoir. The gross flows at Nagarjunasagar are estimated by the same procedure by adding the additional component from K7. The gross intermediate flows between Srisailam to Nagarjunasagar are worked out by taking the difference of gross flows of the two reservoirs. The net flows from the catchment between Srisailam to Nagarjunasagar are worked out by deducting the planned demands of the intermediate catchment. Similar exercise is done for the catchment between Nagarjunasagar and Prakasam Barrage. The total flow below Srisailam is worked out by adding these three components. However only 50% of the net flows from Nagarjunasagar to Prakasam Barrage are considered as there is no storage at Prakasam Barrage and there will be inevitable wastage to Sea from this catchment. These inflows are compared with the demands in the first scenario.

The net flows are broken in to monthly flows considering the gauge flow data or reservoir data. The monthly flows are routed through the Srisailam reservoir considering the planned utilisations of that project. The spills from Srisailam and the intermediate gross flows less the minor irrigation and the small projects in the catchment between Srisailam to Nagarjunasagar form the inflows in Nagarjunasagar. These flows are again routed considering the planned utilisations of Nagarjunasagar reservoir to Prakasam Barrage. The reservoir operation is done in monthly timesteps. Success rates of meeting the annual demand at each reservoir are worked out by comparing demand planned and met for all demands.

IV. RESULTS AND DISCUSSIONS

The comparative results year wise for both the scenarios is presented in Table 3. The demands, met without carryover and met with carryover for Srisailam, Nagarjunasagar and Prakasam Barrage are also shown in fig1 to Fig 3.

Table 3

statement showing the demands met with and without carry over storages									
	Srisailam			Nagarjunasagar			Prakasam Barrage		
Year	demand	demand met without carryover	demand met with carryover	demand	demand met without carryover	demand met with carryover	demand	demand met without carryover	demand met with carryover
1961	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1962	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1963	92	92	92.01	297.5	297.5	297.55	152.2	152.2	152.2
1964	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1965	67	67	67.01	297.5	273.959	297.5	152.2	69.35	152.2
1966	67	67	67.01	297.5	186.1579	261.09	152.2	58.45	149.26
1967	92	79.51	79.51	297.5	273.8	290.78	152.2	139.92	139.92
1968	67	67	67.01	297.5	273.3888	297.5	152.2	69.8	152.2
1969	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1970	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1971	67	67	67.01	297.5	297.5	297.55	152.2	97.3	152.2
1972	67	31.94	43.95	297.5	14.92885	88.9	152.2	20	97.25
1973	92	92	92.01	297.5	290.73	290.73	152.2	133.24	133.24
1974	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1975	92	92	92.01	297.5	297.5	297.55	152.2	152.2	152.2
1976	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1977	92	92	92.01	297.5	297.5	297.5	152.2	104.2212	152.2
1978	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1979	92	92	92.01	297.5	297.5	297.55	152.2	152.2	152.2
1980	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1981	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1982	67	67	67.01	297.5	297.5	297.5	152.2	133.5719	152.2
1983	92	92	92.01	297.5	297.5	297.55	152.2	152.2	152.2
1984	67	67	67.01	297.5	297.5	297.5	152.2	59.50307	152.2
1985	67	38.7	38.72	297.5	88.85146	136.69	152.2	69.75	128.85
1986	67	38.7	38.72	297.5	108.4067	115.5	152.2	62.45	87.94
1987	67	33	33	297.5	26.88362	50.25	152.2	45.35	56.6
1988	92	83.7	83.72	297.5	296	295.99	152.2	147.3	147.26
1989	92	92	92.01	297.5	238.7823	297.5	152.2	152.2	152.2
1990	92	92	92.01	297.5	297.5	297.5	152.2	149.3	149.31
1991	92	92	92.01	297.5	297.5	297.55	152.2	152.2	152.2
1992	67	67	67.01	297.5	286.872	297.19	152.2	35.1	147.13
1993	92	79.5	79.51	297.5	290.7	290.73	152.2	131.7	131.74
1994	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1995	67	50.2	50.21	297.5	78.56742	168.54	152.2	84.45	138.54
1996	92	61.8	61.78	297.5	263.6	263.59	152.2	149.5	149.46
1997	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
1998	92	79.5	79.51	297.5	297.5	297.5	152.2	152.2	152.2
1999	67	67	67.01	297.5	297.5	297.55	152.2	152.2	152.2
2000	67	67	67.01	297.5	297.5	297.5	152.2	112.8598	152.2
2001	67	43.3	43.29	297.5	111.5677	158	152.2	45.75	108.75
2002	67	15.91	33	297.5	30.61411	42.5	152.2	34.5	51.13

2003	67	0	33	297.5	0	17	152.2	2.5	4.98
2004	67	61.8	61.78	297.5	195.3	195.29	152.2	88.90023	113.12
2005	92	92	92.01	297.5	290.7	290.73	152.2	127.1	127.11
2006	92	92	92.01	297.5	297.5	297.5	152.2	152.2	152.2
2007	92	92	92.01	297.5	297.5	297.55	152.2	152.2	152.2

Srisailam demand met without and with carry over storage

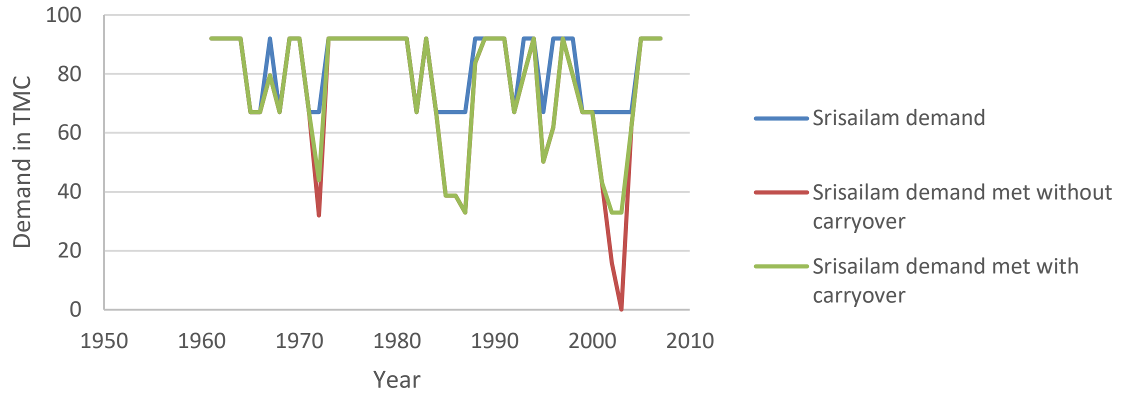
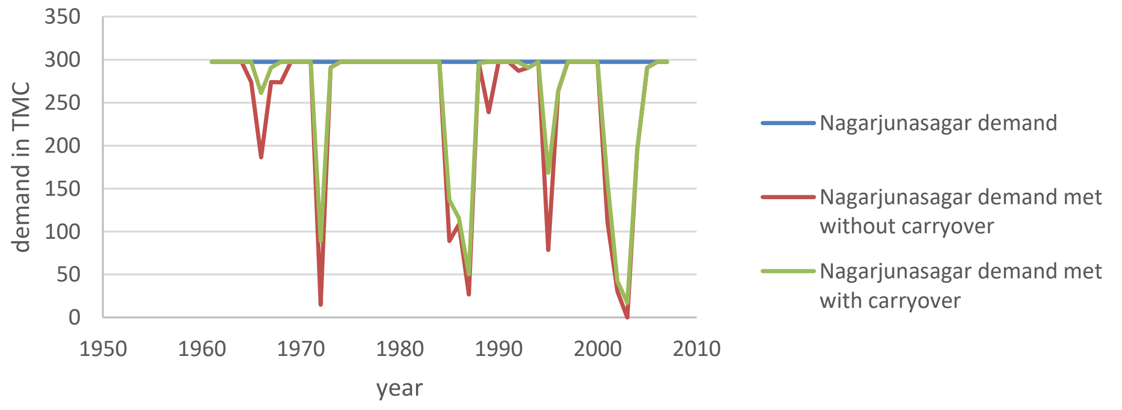
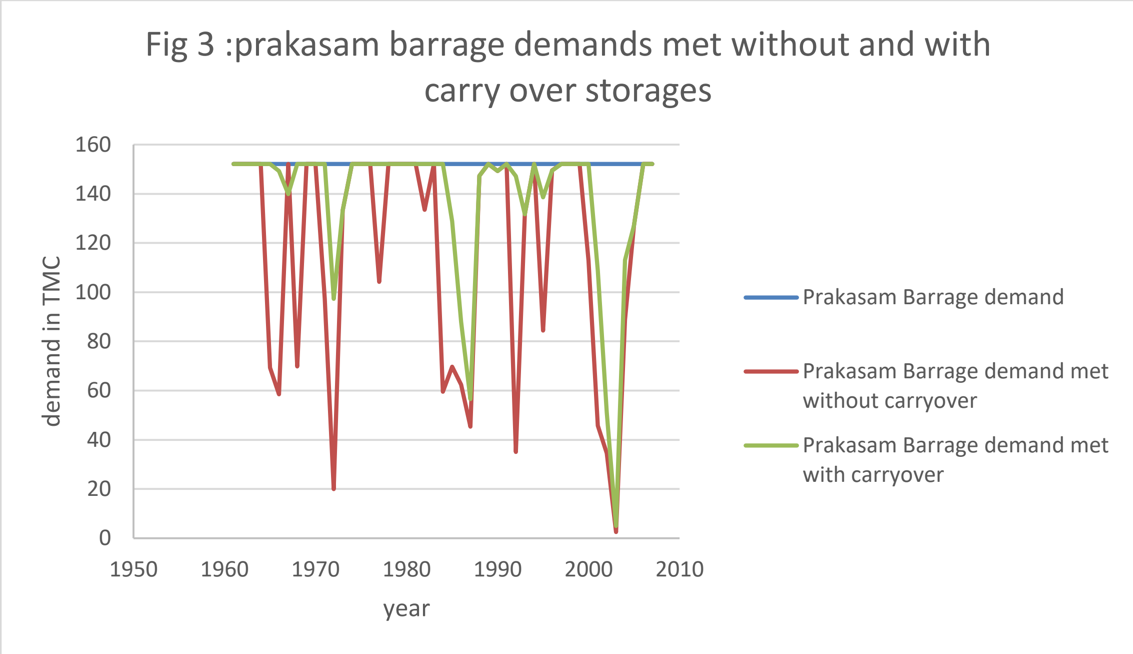


Fig 2 :Nagarjunasagar demand met without and with carry over storage





From the above table the success rates of both the scenarios are worked out and presented below.

SECNARIO1:
Successrate of srisailam including evaporation 67 TMC= 78.7 %
Successrate of srisailam including evaporation and TGP 92 TMC=51.06%
Success rate of NSP including evaporation (297.5 TMC) =57.45 %
Successrate of PB (152.2 TMC) = 49 %

SCENARIO 2 :
Success rate of Srisailam demands (34 TMC) = 78.7%
Success rate of TGP(25 TMC)= 51 %
Successrate of NSP(280 TMC)=63.82%
Successrate of PB(152.2 TMC)=62%

From the above study it could be seen that the SRBC&MWS demand of 34 TMC is met in 78.7 % of time in both the scenarios. AS the quantum of 34 TMC is less compared to inflows there is no necessity of carry over storages for this demand. The SRBC demands can not be met in some years only because the required levels for drawal of SRBC could not be attained.

It could be seen that the demands of Telugu ganga(TGP) which are proposed at Srisailam only when the flows in the entire basin are more than 2293 TMC could be met in 51 % of time in both the scenarios.

The demands of Nagarjunasagar could be met in57.45 % of time where as with carryover storage it could be met in 63.82 % of time showing around 6% improvement.

The planned demands of Prakasam Barrage could be in 49 % of time without carry over. These demands could be met in 62 % of time with carry over storage showing 13 % improvement.

However it could be seen in deficit years more is met with carry over storages though the deficit is not wiped out completely. For Srisailam the demand met in 1972,2002,2003 with carry over are 43.95,33,33 compared to 31.94,15.91 and 0 without carryover. Similarly for NSP and PB the demand met in the deficit years has increased considerably with carry storages. The study also proved the carry over storages are not fully useful in consecutive deficit years.

V. CONCLUSIONS

From the above study it can be concluded that the carry over storages will improve the system performance during deficit years. It is concluded that the carry over storages of Srisailam and Nagarjuna sagar has improved the performance of almost all projects in the system. It can also be concluding there is lot of reduction in deficits with carryover storages even in years when full demand is not met. It can further be concluded that consecutive deficit years will not be fully taken care by carryover storages. It is also clear that with Pulichintala another reservoir proposed below Nagarjunasagar the system will further improve and the demands of irrigation can be met at near 75 % the required level for irrigation.

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