METHODOLOGY TO DEAL WITH COMPUTED NEGATIVE INFLOWS IN INDIAN RESERVOIRS

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ABSTRACT

For developing the operation policies for a reservoir for conservation or flood control purpose, historical inflows into the reservoir forms an important input. In most of the Indian reservoirs, the inflows into the reservoir are not directly measured. Rather, continuous observations of reservoir levels at the dam site are made and reservoir inflows are computed indirectly using the water balance equation along with recorded outflows from the reservoir, precipitation inputs and evaporation losses from the reservoir water spread area. These computations, sometimes, result in negative inflow estimations which may be because of several reasons, such as a small error in the measurement of reservoir level, wrong consideration of reservoir storage at any elevation, error in recording of outflows or other variables etc. This inconsistency of inflow data needs to be handled before using the flow data for further analysis.

This paper describes a few methodologies which can be used to adjust such computed negative inflows for a reservoir. Generalized computer program has been developed for this purpose and embedded in the NIH_ReSyP software so that it is easy for the field officials to use the program and adjust the negative inflows.

Keywords: Reservoir, inflow computation, negative flows, *NIH_ReSyP* software

INTRODUCTION

India is bestowed with rich water resources but more than 80% of the annual rainfall over this country falls in the four monsoon months from June to September. Because of the high time and space variability of rainfall and uncertain nature of monsoon, it is imperative to utilize the available water resources in the optimal and efficient manner and reservoirs play an important role in such conservation and management. The principal function of a reservoir is to regulate the natural stream flow by storing surplus water in the rainy season and releasing the stored water in the dry season to supplement the natural river flow. Reservoirs are the most effective means of changing temporal and spatial availability of water. More than 4500 major and medium dams have already been constructed all over the country to tap the available water resources so that the water can be utilized in accordance with the requirements of mankind.

Inflow to a reservoir is the basic input which is required to develop the optimal operation policy for a reservoir or a system of reservoirs. However, for a large number of Indian reservoirs, the reservoir inflow is not measured directly. Rather, reservoir level is measured at daily or sub-daily time step. In most cases, the working table (at daily/10-daily/monthly time step) of a reservoir on a particular day shows the reservoir level along with data related to releases from reservoir for different purposes, spill from the reservoir, evaporation loss, and the rainfall inputs. However, for operation and other analytical studies of reservoirs, it is required to know the quantum of water entering into the reservoir in a specified time step (daily/10-daily/monthly).

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Knowing the inputs as mentioned above, the reservoir inflow can be estimated using the water balance equation for the reservoir in conjunction with the reservoir elevation-area-capacity table. For each reservoir elevation, corresponding reservoir area and the volume of water in the reservoir is estimated from the EAC table. Next, the water balance equation, as specified below, is used to estimate the inflow term:

$$I_t = S_{t+1} - S_t + Rel_t + Spil_t + Evap_t - Rf_t + Seep_t \quad ...(1)$$

where S_t represents storage, I_t represents inflow volume, Rel_t represents total release for different purposes, $Spil_t$ represents spill from reservoir, $Evap_t$ represents evaporation loss volume, Rf_t represents rainfall volume over reservoir surface, and $Seep_t$ represents seepage loss out of the reservoir during time step 't'. At any time step, the evaporation loss '$Evap_t$' is a function of the water spread area of the reservoir while the seepage loss '$Seep_t$' depends on the head of reservoir surface above the reservoir bottom. These data are generally obtained from the agencies responsible for management of reservoirs.

In general, net inflow to a reservoir from the upstream catchment is estimated from the outflows and losses from the reservoir, rainfall occurrence over the water spread area and the changes in reservoir storage. In such cases, reservoir storage is estimated using the reservoir level data and elevation-storage curve for the reservoir. Generally, the inflows to a reservoir site should be positive or at the minimum zero. However, sometimes these computations lead to negative inflow estimations (Jain and Singh, 2003) which may be because of any or more of the following reasons:

a) A small error (of the order of mm) in the measurement or recording of reservoir level data can result in huge variation in the reservoir volume estimation. Further, strong winds over reservoir surface can also cause errors in correct measurement of reservoir level at dam site.
b) Wrong consideration of reservoir capacity at particular elevations due to non-availability of latest elevation-area-capacity curves after accounting for sedimentation.
c) Since inflows are computed from the observations of various variables, such as storage capacities at beginning and end of a time step, releases for various purposes, various losses/ gains (evaporation, seepage, and rainfall over reservoir water spread), spill from reservoir etc., an error in any of these observations or their entry can result in negative inflows.

Here, it needs to be mentioned that from the available data/record, it is generally not possible to ascertain the exact cause of negative inflow assessment. Further, negative inflows are conceptually not possible and they need to be corrected/adjusted (Wurbs, 2012) before using the inflow series for reservoir related analysis. This paper describes some methodologies which can be adopted for the adjustment of negative inflows so that the inflow series can be used for further analysis. A case study of a reservoir in the Maharashtra State is being used for demonstration. Further, a generalized module for such analysis has been incorporated in the NIH_ReSyP software (Goel et. al, 2013) which is briefly described.

METHODOLOGY TO DEAL WITH NEGATIVE INFLOWS

In different methodologies to deal with negative inflows, the reservoir mass balance is conserved in a water year in all the cases. Further, if the negative inflows in a hydrological year exceed the positive values, then all the inflow values in the hydrological year are taken as zero. The methodologies differ in the adjustment of negative inflows either in the values that are most adjacent to the location of occurrence of negative inflow or within the whole water year. Further, negative inflow can be revised as zero or as a long-term average. Based on these options, the following methodologies have been suggested for the adjustment of negative inflows:

Method –I: Negative inflow modified as '0' and adjustment in whole year depending on magnitude

In this method, the negative inflow occurring at a time step is modified as zero and the sum of negative values in a water year (June – May as per Indian conditions) is adjusted in the positive values in the water year in proportion to their magnitude. Thus, water balance is conserved in a hydrological year.

In this method, it is assumed that larger inflow values cause higher magnitude of error in flow estimation and hence the negative inflow adjustment is as per the magnitude of positive values. However, if the negative inflows in a hydrological year exceed the positive values, then all the inflow values in the hydrological year are taken as zero.

Let the magnitude of the sum of the total positive and total negative inflows during a water year are A and B, respectively. Then, the adjusted flow during a month is:

$$I_{adj,t} = I_t - (I_t / A) * B, \text{ if } I_t \geq 0 \quad \ldots(2)$$

$$I_{adj,t} = 0, I_t < 0 \quad \ldots(3)$$

where $I_{adj,t}$ is the adjusted inflow in the time step t, and I_t is the computed inflow.

Method –II: Negative inflow modified as '0' and adjustment in adjacent values in accordance with their magnitude

In this method, the negative inflow occurring at a time step is modified as zero and the negative value at a time step is adjusted in the most adjacent positive values in proportion to their magnitude. However, the adjustment is made only in the adjacent values of the same hydrological year.

In this method, it is assumed that adjacent values (measurement or recording errors in various associated variables) are the main cause of error in inflow estimation and hence the negative inflow adjustment is made in the nearest adjacent values (forward and backward) as per the magnitude of positive values. However, there could be several possibilities of a negative inflow value succeeded by a positive or negative inflow values. The procedure begins with the earliest observed negative inflow value and moves sequentially in chronological order. The procedure adopted to solve various situations is described below through mathematical representation. Let I_t^- be the first observed negative inflow.

i) If a negative value is preceded and succeeded by positive value

In this case, the negative value is compared with the sum of preceded and succeeded positive inflow value and the negative value is restored to zero. For the negative inflow I_t^- occurring in a time period 't', let the preceding and succeeding values of positive inflow be I_{t-1}^+ and I_{t+1}^+ respectively. Negative value is compared with sum of preceding and succeeding positive values, i.e. $(I_{t-1}^+ + I_{t+1}^+)$. Negative inflow I_t^- is then adjusted with the adjacent inflows as follows:

If $I_t^- < I_{t-1}^+ + I_{t+1}^+$, then negative inflow is adjusted with I_{t-1}^+ and I_{t+1}^+ in proportion to their individual magnitudes, and the adjusted values of inflow become:

$$I_{t-1,adj}^+ = I_{t-1}^+ - (I_{t-1}^+ / I_{t-1}^+ + I_{t+1}^+) * I_t^- \quad \ldots(4)$$

$$I_{t,adj}^- = 0 \quad \ldots(5)$$

$$I_{t+1,adj}^+ = I_{t+1}^+ - (I_{t+1}^+ / I_{t-1}^+ + I_{t+1}^+) * I_t^- \quad \ldots(6)$$

If $I_t^- > I_{t-1}^+ + I_{t+1}^+$, then negative inflow is adjusted with next preceding and next succeeding values also. The inflows are adjusted as follows:

$$I_{t-2,adj}^+ = I_{t-2}^+ - (I_{t-2}^+ / \sum_{k=1}^{2}(I_{t-k}^+ + I_{t+k}^+) * | I_t^- | \quad \ldots(7)$$

$$I_{t-1,adj}^+ = I_{t-1}^+ - (I_{t-1}^+ / \sum_{k=1}^{2}(I_{t-k}^+ + I_{t+k}^+) * | I_t^- | \quad \ldots(8)$$

$$I_{t,adj}^- = 0 \quad \ldots(9)$$

$$I_{t+1,adj}^+ = I_{t+1}^+ - (I_{t+1}^+ / \sum_{k=1}^{2}(I_{t-k}^+ + I_{t+k}^+) * | I_t^- | \quad \ldots(10)$$

$$I_{t+2,adj}^+ = I_{t+2}^+ - (I_{t+2}^+ / \sum_{k=1}^{2}(I_{t-k}^+ + I_{t+k}^+) * | I_t^- | \quad \ldots(11)$$

If still the value of negative inflow cannot be adjusted with two preceding and two succeeding positive values, then it is adjusted considering further next set of preceding and succeeding positive values and so on. However, the adjustment is made only within a hydrological year.

ii) If a negative value is succeeded by negative value

In this case, the negative value is compared only with the preceded positive values. Let the preceding value of positive inflow be I_{t-1}^{+} and the succeeding value of negative inflow be I_{t+1}^{-}, for the negative flow I_{t}^{-} occurring in a time period 't'.

If $I_{t}^{-} < I_{t-1}^{+}$, then I_{t}^{-} is simply adjusted to the preceded positive inflow value, i.e.,

$$I_{t-1,adj}^{+} = I_{t-1}^{+} - | I_{t}^{-} | \quad \ldots(12)$$

$$I_{t,adj}^{-} = 0 \quad \ldots(13)$$

If $I_{t}^{-} > I_{t-1}^{+}$, then I_{t}^{-} is adjusted in various preceded positive values (in the ratio of their magnitude) till the sum of preceded positive values is more than the negative inflow value. This way, the procedure tries to adjust the negative inflow values from their most adjacent positive inflow values and in ratio of their magnitude without changing the volume of flow within a year.

Method –III: Negative inflow modified as minimum of (long-term average at that time step and average of the adjacent positive values) and adjustment in whole year in proportion of positive values

In this method, the negative inflow occurring at a time step is not modified as zero but taken as the minimum of the long-term average value at that time step and the average of the positive adjacent (forward and backward) values. The sum of the negative value and the positive value considered at the time step is adjusted in the positive values of that hydrological year in the proportion of their magnitude as per Equation – 2. Thus, water balance is conserved in the hydrological year.

In this method, it is assumed that negative inflow at a time step occurs because of some discrepancy (in measurement or recording of various associated variables) at that time step and the negative value should not be modified as zero. In view of no information of the likely inflow at that time step, inflow is taken as the minimum of the long-term average value at that time step and the average of the positive adjacent values. The total inflow added at the time step (sum of the negative flow and the positive flow considered) is adjusted in the whole hydrological year in proportion to the magnitude of positive values.

CASE STUDY OF DHOM RESERVOIR IN MAHARASHTRA STATE

While carrying out a study related to project-wise water availability and integrated operation analysis of major projects in Krishna river basin, a number of inconsistencies related to negative flows in reservoirs have been observed (Jain et. al, 2018). A case study of Dhom reservoir in the Upper Krishna sub-basin of Krishna river basin in the Maharashtra State is presented here. A map of Upper Krishna sub-basin and location of the Dhom reservoir is shown in Figure – 1.

Figure – 1: Location of the Dhom reservoir in Upper Krishna sub-basin

This project was commissioned in the year 1976. The catchment area at the project site is 194.36 sq. km. The monthly working table at the project site is available from September, 1976 to May, 2008. The working table contains the reservoir levels at the beginning and end of each month, water diverted for various purposes and evaporation losses from the reservoir. Water is mainly used from the project for right bank canal, lift irrigation, domestic and industrial water supply and misc. other demands. The rainfall data at the reservoir surface is obtained from the gridded IMD rainfall series based on the location of project. The MDDL and FRL for the project are at levels 725.40 m and 747.70 m respectively. Elevation-area-capacity table for the project is available. The seepage loss has been taken as 2 mm per day at FRL and 1 mm per day at MDDL with linear variation at intermediate levels.

Based on the reservoir water balance as discussed above, the monthly inflows at the dam site (inclusive of rainfall gain and evaporation and seepage losses) and from the u/s catchment (after accounting for the rainfall gain and evaporation and seepage losses) have been computed. The computations at the dam site and from u/s catchment for the hydrological years 1993 and 1994 (from June, 1993 to May, 1995) are presented in Table – 1.

Table – 1

Working table for Dhom reservoir and computation of inflow from u/s catchment and at dam site

Month	Res_lev (m)	Res_Rel (MCM)	Res_Spil (MCM)	Evp_Dep (m)	RF_Dep (mm)	Res_Stor (MCM)	Evp_Los (MCM)	Sep_Los (MCM)	RF_Gain (MCM)	Comp-Inf from Cat (MCM)	Comp-Inf at dam (MCM)

Jun-93	731.960	17.079	0.000	0.141	427.400	109.841	1.711	0.523	5.185	38.885	43.548
Jul-93	734.040	3.869	13.449	0.053	407.700	134.599	0.862	0.793	6.634	158.600	164.441
Aug-93	742.940	14.718	57.473	0.073	280.500	280.860	1.560	1.187	5.995	163.401	168.209
Sep-93	747.400	19.096	15.694	0.091	180.800	375.318	2.143	1.361	4.257	37.072	39.967
Oct-93	747.530	3.329	20.950	0.134	424.000	378.352	3.183	1.378	10.072	22.035	30.729
Nov-93	747.670	22.885	0.000	0.155	47.200	381.619	3.601	1.337	1.097	6.171	5.931
Dec-93	746.780	22.775	0.000	0.119	88.500	361.064	2.637	1.253	1.961	4.272	4.980
Jan-94	745.860	27.920	0.000	0.134	0.000	340.632	2.831	1.173	0.000	3.863	2.691
Feb-94	744.530	32.382	0.000	0.159	0.000	312.572	3.165	1.077	0.000	3.771	2.694
Mar-94	742.880	42.825	0.000	0.238	0.000	279.719	4.400	0.957	0.000	4.770	3.813
Apr-94	740.530	45.177	0.000	0.232	33.500	236.307	3.895	0.821	0.563	3.952	3.693
May-94	737.840	47.364	0.000	0.352	57.200	190.928	4.885	0.629	0.794	-19.486	-19.320
Jun-94	732.800	4.493	0.000	0.084	687.800	119.358	1.200	0.655	9.823	87.965	97.133
Jul-94	739.050	0.949	268.133	0.044	775.100	210.798	0.790	0.917	13.921	325.218	338.222
Aug-94	742.850	6.126	45.663	0.081	271.200	279.148	1.742	1.197	5.833	149.966	154.602
Sep-94	747.610	23.986	132.536	0.122	246.000	380.219	2.837	1.339	5.721	138.950	143.332
Oct-94	746.920	33.440	0.000	0.156	122.300	364.192	3.449	1.249	2.704	5.666	7.121
Nov-94	745.570	30.635	0.000	0.162	0.000	334.424	3.367	1.146	0.000	4.057	2.911
Dec-94	744.080	48.780	0.000	0.203	0.000	303.333	3.909	1.025	0.000	5.633	4.608
Jan-95	741.580	32.259	0.000	0.187	10.600	255.252	3.325	0.902	0.189	3.384	2.671
Feb-95	739.730	30.314	0.000	0.256	0.000	222.338	4.226	0.801	0.000	3.931	3.130
Mar-95	737.840	51.870	0.000	0.291	0.000	190.928	4.252	0.671	0.000	1.889	1.218
Apr-95	734.140	41.802	0.000	0.329	16.300	136.024	3.874	0.502	0.192	6.902	6.592
May-95	730.740	30.919	0.000	0.264	84.200	96.940	2.391	0.356	0.763	-0.468	-0.061

It is seen from the last two columns that during the monsoon season, rainfall over the reservoir water spread area contributes to the net inflow at dam site resulting in increased flow as compared to the inflow from u/s catchment while during the non-monsoon season, the losses in form of evaporation and seepage reduces the net inflow at dam site in comparison to inflow from u/s catchment. During May 1994 and May 1995, negative flows have been observed which could be due to one or more reasons as discussed above. However, it is very difficult to decipher the nature and quantity of the exact cause of negative flow. Thus, various options, as mentioned above, have been used to settle the negative flows while maintaining the annual water balance of the reservoir. In Opt-1, negative flow is modified as '0' and adjustment is made in the whole year depending on flow magnitude in different months. In opt-2, negative flow is modified as '0' and adjustment is made in adjacent values (within same hydrological year) in accordance with their magnitude while in Opt-3, the negative flow is modified as minimum of the (long-term average at that time step and average of adjacent positive values within same hydrological year) and adjustment is made in whole year in proportion to magnitudes of inflows in different months. The results of analysis for the three options are presented in Table – 2 and plotted in Figure – 2.

Table – 2

Adjustment of computed negative inflows under various options

Month	Comp-Inf from Cat (MCM)	Adj-Inf with Opt-1 (MCM)	Adj-Inf with Opt-2 (MCM)	Adj-Inf with Opt-3 (MCM)
Jun-93	38.885	37.190	38.885	36.413
Jul-93	158.600	151.683	158.600	148.515
Aug-93	163.401	156.275	163.401	153.011
Sep-93	37.072	35.455	37.072	34.714
Oct-93	22.035	21.074	22.035	20.634
Nov-93	6.171	5.902	6.171	5.778
Dec-93	4.272	4.086	0.237	4.001
Jan-94	3.863	3.695	0.214	3.618
Feb-94	3.771	3.607	0.209	3.532
Mar-94	4.770	4.562	0.264	4.467

Apr-94	3.952	3.780	0.219	3.701
May-94	-19.486	0.000	0.000	8.925
Jun-94	87.965	87.909	87.965	86.839
Jul-94	325.218	325.011	325.218	321.054
Aug-94	149.966	149.870	149.966	148.046
Sep-94	138.950	138.861	138.950	137.171
Oct-94	5.666	5.663	5.666	5.594
Nov-94	4.057	4.055	4.057	4.005
Dec-94	5.633	5.629	5.633	5.560
Jan-95	3.384	3.382	3.384	3.341
Feb-95	3.931	3.929	3.931	3.881
Mar-95	1.889	1.888	1.889	1.865
Apr-95	6.902	6.897	6.434	6.813
May-95	-0.468	0.000	0.000	8.925

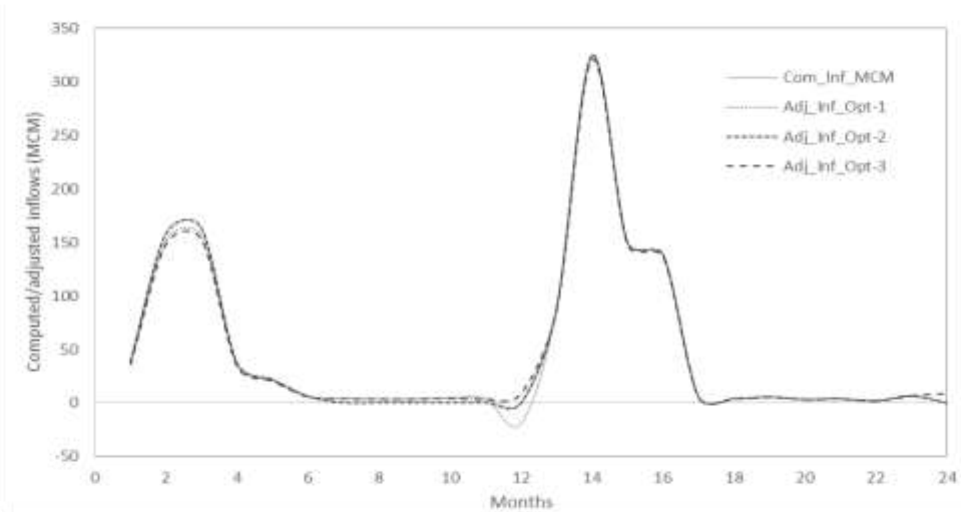


Figure – 2: Computed and adjusted reservoir inflows during June 1993 to May 1995

In addition, the results of analysis for the net inflows at dam site and the computed inflows from u/s catchment along with their adjustment as per opt-3 is presented in Table – 3 and plotted in Figure – 3.

Table – 3

Adjustment of computed negative flows from catchment and at dam site under Opt-3

Month	Comp-Inf from Cat (MCM)	Net comp-Inf at dam (MCM)	Adj-Inf from Cat with Opt-3 (MCM)	Net Adj-Inf at dam with Opt-3 (MCM)
Jun-93	38.885	43.548	36.413	40.916
Jul-93	158.600	164.441	148.515	154.505
Aug-93	163.401	168.209	153.011	158.046
Sep-93	37.072	39.967	34.714	37.552
Oct-93	22.035	30.729	20.634	28.872
Nov-93	6.171	5.931	5.778	5.572
Dec-93	4.272	4.980	4.001	4.679
Jan-94	3.863	2.691	3.618	2.528
Feb-94	3.771	2.694	3.532	2.532
Mar-94	4.770	3.813	4.467	3.583
Apr-94	3.952	3.693	3.701	3.470
May-94	-19.486	-19.320	8.925	9.119
Jun-94	87.965	97.133	86.839	95.962

Jul-94	325.218	338.222	321.054	334.145
Aug-94	149.966	154.602	148.046	152.738
Sep-94	138.950	143.332	137.171	141.604
Oct-94	5.666	7.121	5.594	7.036
Nov-94	4.057	2.911	4.005	2.876
Dec-94	5.633	4.608	5.560	4.552
Jan-95	3.384	2.671	3.341	2.638
Feb-95	3.931	3.130	3.881	3.092
Mar-95	1.889	1.218	1.865	1.203
Apr-95	6.902	6.592	6.813	6.512
May-95	-0.468	-0.061	8.925	9.119

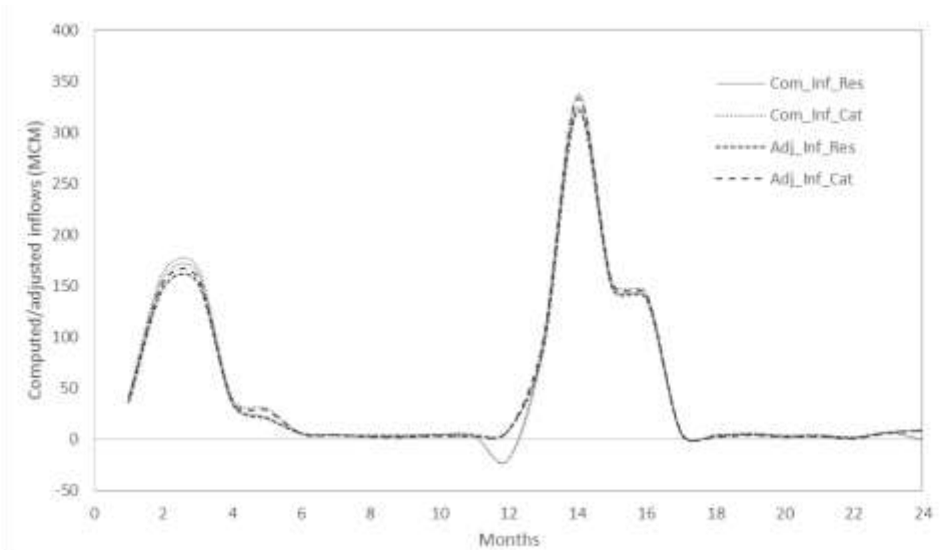


Figure – 3: Plot of adjusted negative flows from catchment and at dam site under Opt-3

DEVELOPMENT OF A MODULE FOR *NIH_ReSyP* SOFTWARE

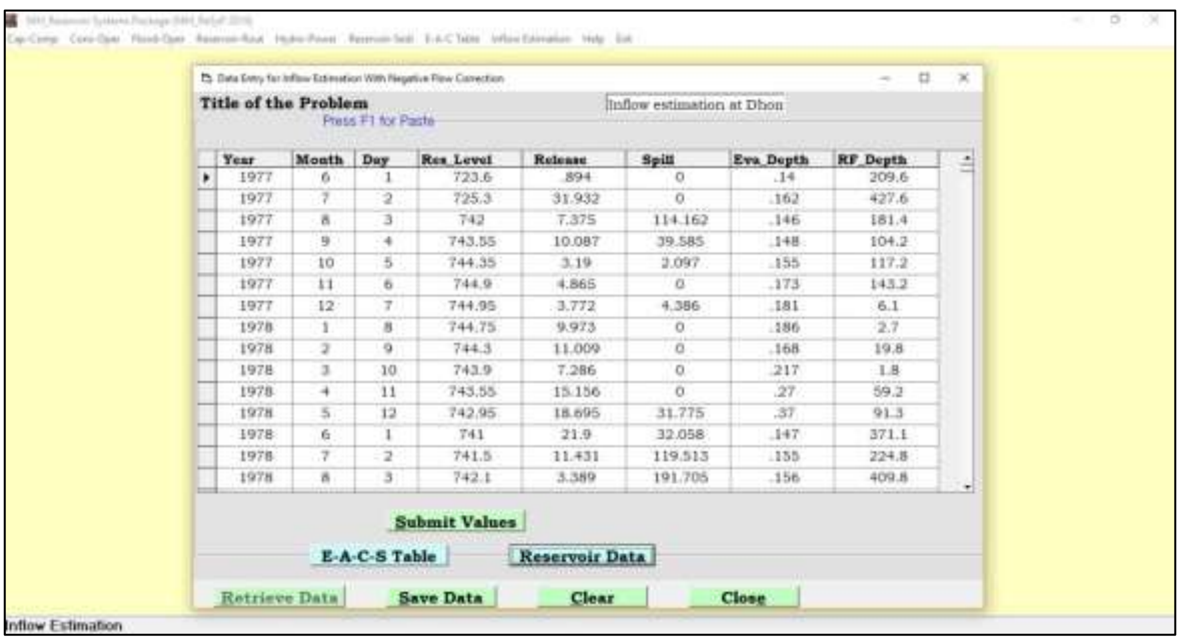
In view of the importance of reservoir operation problem in Indian context and due to the non- availability of a generalized software for reservoir analysis, the National Institute of Hydrology (NIH), Roorkee developed a generalized software named "SRA – Software for Reservoir Analysis" for reservoir analysis [Jain et. al (1996)] for carrying out various kind of reservoir analysis. Subsequently, a WINDOWS based graphical user interface, named "*NIH_ReSyP* – Reservoir Systems Package", has been developed in Visual BASIC platform (Goel et. al, 2013) to provide a user-friendly environment for carrying out various hydrological analyses related to reservoirs. Opening banner of the software is shown in Figure – 4.

Figure – 4: Opening banner of NIH_ReSyP software

The software is a comprehensive and easy-to-use menu-driven interactive package with on line help to guide the user for various kind of reservoir related analysis. Various analytical modules available in the software include reservoir capacity computation using sequent peak analysis, reservoir storage-yield-reliability analysis, reservoir routing, hydropower analysis, reservoir sedimentation, approximation of elevation-area-capacity table, initial rule curve derivation, and operation of a multi-reservoir system for conservation and flood control purposes. Data forms have been designed for various modules so that it becomes easy for the analyst to prepare the data files and obtain the outputs.

The software is being updated continuously. Under this exercise, a module for adjustment of computed negative flows has been incorporated in NIH_ReSyP. Opening data form for the inflow estimation module is shown in Figure – 5 while a data form for specifying the working table and other related data is shown in Figure – 6. Various options of negative flow adjustment, as mentioned above, have been provided. After preparing the data file, the program file is run and the results in the tabular form are displayed.

Figure – 5: Opening data form for inflow estimation module



Year	Month	Day	Res_Level	Release	Spill	Eva_Depth	RF_Depth
1977	6	1	723.6	.894	0	.14	209.6
1977	7	2	725.3	31.932	0	.162	427.6
1977	8	3	742	7.375	114.162	.146	181.4
1977	9	4	743.55	10.087	39.585	.148	104.2
1977	10	5	744.35	3.19	2.097	.155	117.2
1977	11	6	744.9	4.865	0	.173	143.2
1977	12	7	744.95	3.772	4.386	.181	6.1
1978	1	8	744.75	9.973	0	.186	2.7
1978	2	9	744.3	11.009	0	.168	19.8
1978	3	10	743.9	7.286	0	.217	1.8
1978	4	11	743.55	15.156	0	.27	59.2
1978	5	12	742.95	18.695	31.775	.37	91.3
1978	6	1	741	21.9	32.058	.147	371.1
1978	7	2	741.5	11.431	119.513	.155	224.8
1978	8	3	742.1	3.389	191.705	.156	409.8

Figure – 6: Reservoir data form for Inflow estimation module

CONCLUSION

In many of the Indian reservoirs, the inflows into the reservoir are not directly measured in the upstream. Rather, continuous observations of reservoir levels at the dam site are made and reservoir inflows are computed indirectly using the reservoir water balance equation along with recorded outflows from the reservoir, precipitation inputs and evaporation losses from the reservoir water spread area. These computations, sometimes, result in negative inflow estimations which may be because of several reasons, such as error in the measurement of reservoir level, wrong consideration of reservoir storage at any elevation, error in recording of outflows or other variables etc. This inconsistency (negative values) of inflow data needs to be processed and corrected before using the inflow series for further analysis. This paper describes few methodologies which can be used to adjust such computed negative inflows for a reservoir without affecting the water availability of the project. The methodologies differ in the adjustment of negative inflows either in the values that are most adjacent (preceding or succeeding) to the location of occurrence of negative inflow or within the whole water year. Further, negative inflow can be revised as zero or as a long-term average at the time step under consideration. A generalized computer program has been developed for this purpose and embedded in the NIH_ReSyP software so that it is easy for the field officials to use the program and adjust the negative inflows for a project.

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