Determining the changes of the river in heads of watershed areas using HEC-RAS (Dez watershed case study)
Siamak Ahmadi Fard, Amin Baghbanzadeh Dezfooli, Mohammad Hassan Ayazi

ABSTRACT
Sediment is one of the natural and challenging phenomena in river engineering studies. This is especially in arid and semi-arid without ground cover and where there is torrential rain, much of the soil transferred downstream because of the effect of the shearing pressure in water flow direction. Because of the transfer of the bulk of sedimentary materials either in suspension or as bedload established significant impact on river morphology and hydraulic behavior which made the process of its studying in river engineering projects inevitable. Considering the importance of this issue and its impact on maintenance management and utilization of renewable water resources in arid and semi-arid areas in general and its consequences in the dam reservoir not only can reduce their useful volume but also can enter the networking draining downstream and create disorders in natural ecosystems of that area which lead to instability of structures on the one hand and the increasing costs on the other hand during the flood. In this article changes in cross sections in Dez, Ceazar and Bakhtiari Rivers which are main inputs to the Dez dam, in 1373 by the HEC-RAS software and sediment transportation methods (Ackers and White, Englund Hansen, Copland, Toffaliti, Yang) modeled and the results compared with data obtained from hydrography operations in hydrological stations. The results show Kenny floor in Ceazar and Bakhtiari rivers and sedimentation in parts of Dez River.

KEY WORDS: Methods of sediment transportation, Kenny floor, changes in cross sections, HEC-RAS software.

INTRODUCTION
Rivers in effect of erosion and sedimentation are undergoing constant changes. Recognition of such changes for the purpose of organizing and securing the river against the results obtained is very important. Among studies and understanding changes induced from erosion and sedimentation processes in rivers affected by various factors, hydraulic modeling of flow and sediment transportation in rivers is a mathematical model (RAS., 2009). In this study, first we introduce the heads of Dez River and Dez dam.

BakhtiariRiver (Zalaki):
This branch as the main head of Dez River with 41% of the watershed of Dez, provides 55% of the river flow. The catchment area of this river is 6400 square kilometers which about 6390 square kilometers are mountainous region and the rest is plain. The average annual discharge of river within 30 years is 71601 million cubic meters. Average discharge of this river has been reported 160 cubic meters per second (Karduni, 1380).

Ceazar River:
This river is one of the major heads and constituent of Dez River which collects water from vast areas, from cities such as Aliogudarz, Boroujerd, and eastern parts of Khorramabad. It should be mentioned that in some sources after Doroud, Ceazar is also called Dez. But here we have called the confluence of Ceazar River with Bakhtiari River, Dez River. Ceazar is about 210 km long

Its catchment area is 9200 square kilometers which largely consists of mountainous areas and small part of it consists of plains of Broujerd, Doroud, Azna and Aliogudarz. Ceazar has permanent and plenty of water with snow-rain diet. Ceazar average discharge has been reported 116 cubic meters per second and maximum discharge at the moment was 3271 cubic meters per second which suggest severe flooding in heavy rain cases or
when snow is melting. This head is made up of the connecting of several rivers with 32% of the catchment area of Dez River, provides 45% of Dez River discharge. This river carries out about 27% of Dez reservoir sediment.

**Dez River:**

Writers in Greek books called it Gebrates but in Abadani accent was known as Jundishapour and since it were near to Dezful castle known as Dez or Abdiz. This is one of the main branches of Karoon which collects the water of vast areas of Lorestan province, parts of Isfahan and Dezful and brings into Karoon River, and also has particular importance in providing major parts of agricultural needs of Khouzestan which increased after the construction of Dez dam. Dez River is formed of two major branches of Bakhtiari orAbzalaki and Ceazar River. Average annual during 22 years reported 2784 million cubic meters discharge, in 64-65 about 7680 million cubic meters and its average discharge 260 million cubic meters per second (Karduni, 1380).

**Preparing input’s data model:**

Evaluation of river sediment of reservoir and rivers in mathematical methods requires comprehensive and varied information. In addition to the geometric and hydrology data about the input of reservoir and characteristics of the entry sediment, we need comprehensive information in the following field:

1. The geometric characteristics of Dez catchment.
2. The flow rates in the river heads.
3. The daily temperature.
4. Mechanical analysis of soil.
5. Statistical figures of sediment flow.

**Geometric characteristics of the studied cross section:**

To investigate the status of sediment in parts of river which are the entering tributaries to the Dez reservoir dam, four sections which are the heads of the rivers Dez, Ceazar and Bakhtiari were studied, cross section data of these stations received from Water and Power Authority. These stations include:

1. Sepiddasht station (Ceazar River)
2. Tang panj station (Ceazar River)
3. Tang panj station (Bakhtiari River)
4. Tale zang station (Dez River)

**Mechanical analysis of the soil of the riverbed:**

Mechanical analysis of the soil of the heads’ riverbed in hydrological stations, Tale zang, Ceazar Tang panj, Ceazarsepiddasht done by samples and different parameters such as weight of the sediment, the sediment percentage, the percentage of particles smaller than any size, and the percentage of the total remaining against the specified size, are calculated.

**Statistics of the water flow-sediment flow (Ahmadi fard, 1390):**

Several studies done by the scientific expertise and resources, including the US Department of Civil and Reclamation (USBR) led to the conclusion that the following relationship established between discharge and suspended material:

\[ Q_s = aQ_w^b \]

In above equation, \( Q_s \) is the discharge of suspended materials in terms of tones per day, \( Q_w \) the flow in cubic meters per second, \( a \) and \( b \) are constant coefficients of the equation. Equation (1) is in fact the result of the function of linear regression of Log flow and the logarithm of the rate of the suspended solids. Usually the mean obtained from the relationship between the water flow and sediment flow is less than the observed data. Also as the calculation of the correlation coefficients performed according to the logarithmic conversion and using the least squares method, scattering the data will be around the best fit asymmetric line and the interval of the best fit asymmetric line and the interval of the upper confidence will be more than the lower confidence. It is represented by figures (1) and (2). In figure (1) USBR equation of Dezriverin Tale zang station with field data (water flow-sediment flow) in normal coordinates is shown. Also in figure (2) the relationship between water flow and sediment flow is shown in logarithmic coordinates. World Food and Agriculture Organization (FAO) along with US Land Development Organization (USBR) represented the relationship between water flow and sediment of suspended solids as follow:

\[ a' = \frac{\bar{Q}_s}{(\bar{Q}_w)^b} \]

Which in this equation:

\( \bar{Q}_s \) is the average of sediment flow observed during the period in terms of tons per day.

\( \bar{Q}_w \) is the average of the observed flow rate during the period in terms of cubic meters per second.
b= symbol of the main equation USBR (symbol of equation 1).

Using coefficients $a'$ instead of coefficient $a$ to modify obtained figures and closing the results of equation (2) to the reality. Based on the above mentioned, given by (FAO) as follows:

$$Q_s = a'Q_w^b$$  \hspace{1cm} (3)

It is notable that exceptional database with high sedimentation in water flow and sediment flow create a great impact on the increase of the coefficient. As in equation (2), change of denominator is much more limited than the numerator, and this is one of the weaknesses of the reformed FAO method. In figure (3) the diagram of water flow- sediment flow by USBR modified FAO method and non-linear regression method of DezRiver in Talezang station is shown. Non-linear regression curve obtained from upper flows is higher than the USBR of linear method and even higher than the reformed method of FAO, but in lower flows is lower than reformed curve FAO and higher than the reformed curve of USBR. However seems that the difference between FAO reformed method and obtained non-linear regression curve at high flow rates is due to the incorrect measurement in the field. It should also be noted that in hydrometric station at high flow rates due to the high speed of flow is not possible to have a deep sampling from the entire river’s profile but towards the surface. It seems that sediments measured at high flows were less than the actual amount. In this study at 4 hydrometric stations of Dez River and its heads by using the measured data of water flow-sediment flow at these stations and using excel, SPSS software, different equations between water flow and sediment flow obtained which is according to table 1 and then the data analyzed and examined equations obtained by non-linear regression.

![Fig. 1: water flow-sediment flow curve of Talezang station in normal coordinates.](image)

**HEC-RAS model validation and analysis of the results:**

Generally two methods were used for validation. The first method is observation, where sections obtained from hydrographic operations and software will be drawn on one graph. If they match, that section and thus its equation will be selected. In chart (1) the cross section of Bakhtiari River in Tang panj station, in years 1363 to 1373 drawn according to hydrographic data provided by Water and Power Authority of Khouzestan. By using software in examining the validation in this section it is concluded that from methods’ choice for the sediment transport, White and Acker, Copeland methods do not show appropriate results. Chart (2) is the outcome of the actual data of cross section of Ceazar River in Tang panj station indicates Kenny floor in riverbed while significant erosion was not observed. Also results indicate the inefficiency of Acker and White, England and Hansen methods in sediment transport calculations. Chart (3) is the result of hydrography operation in Ceazar River, Sepiddasht station which indicates the border’s erosion and riverbed erosion at the studied station. The results achieved from software application shows that the only way for sediment transport England and Hansen methods in this section has similar results with actual data, of course Copeland, Acker and White from Laursen also shows results close to reality. Chart (4) shows the cross section of Dez River at Talezang station which indicates that during the investigation (1363 to 1373) no significant changes happened in cross section of Dez River in hydrometric station of Talezang and sedimentation is seen in some places. Also results concluded from software application indicate the effectiveness of sediment transport methods Acker and White, Copeland from Laursen in anticipating the riverbed. Finally these charts suggest that the results of sediment transport, strongly depends on the choice of the type of sediment transport. Care must be taken that the hydraulic conditions and riverbed’s particles in each method will have significant changes in results. Generally it can be said that each method has the ability to model riverbed with specific mechanical analysis of soil. This study showed that from
mentioned methods, Copeland method is more matched with actual measurements of cross sections and shows a better performance for validation.

![Fig. 2: water flow-sediment flow curve of Tale zang station in Logarithmic coordinates.](image)

**Fig. 2:** Water flow-sediment flow curve of Tale zang station in Logarithmic coordinates.

![Fig. 3: Water flow-sediment flow curve of Tale zang station according to USBR, FAO and linear regression.](image)

**Fig. 3:** Water flow-sediment flow curve of Tale zang station according to USBR, FAO and linear regression.

![Diagram 1: calibration of HEC-RAS model with observational sections of Bakhtiari River in Tang panj station.](image)

**Diagram 1:** Calibration of HEC-RAS model with observational sections of Bakhtiari River in Tang panj station.
Diagram 2: Calibration of the HEC-RAS model with observational sections of Ceazar River in Tang panj station.

Diagram 3: Calibration of HEC-RAS model of Ceazar River in Sepiddasht station.

Diagram 4: Calibration of HEC-RAS model of Dez River in Tale zang station.
Table 1: The mean flow and information related to watershed stations of Dez.

<table>
<thead>
<tr>
<th>Row</th>
<th>River</th>
<th>Station</th>
<th>Station code</th>
<th>Area $m^2$</th>
<th>Flow $m^3/s$ (maximum)</th>
<th>Flow $m^3/s$ (minimum)</th>
<th>Flow $m^3/s$ (average)</th>
<th>Sediment flow $l/s/A$</th>
<th>Coefficient</th>
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<tbody>
<tr>
<td>1</td>
<td>Sezar</td>
<td>Sepiddasht</td>
<td>3-3-2-13</td>
<td>7134</td>
<td>102.58</td>
<td>19.40</td>
<td>46390</td>
<td>6.57</td>
<td>0.45</td>
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<tr>
<td>2</td>
<td>Sezar</td>
<td>Tangpich</td>
<td>3-3-2-15</td>
<td>9020</td>
<td>243.11</td>
<td>25.74</td>
<td>104.15</td>
<td>11.32</td>
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<td>3</td>
<td>Dez</td>
<td>Talezang</td>
<td>3-3-2-16</td>
<td>16103</td>
<td>527.37</td>
<td>27.54</td>
<td>269.27</td>
<td>16.69</td>
<td>0.39</td>
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<tr>
<td>4</td>
<td>Bakhtiari</td>
<td>Tangpich</td>
<td>3-3-2-10</td>
<td>6390</td>
<td>721.23</td>
<td>80.53</td>
<td>150.17</td>
<td>23.50</td>
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Table 2: Coefficient of flow-sediment flow according to USBR, FAO, SPSS methods

<table>
<thead>
<tr>
<th>Station</th>
<th>$R^2$ (USBR)</th>
<th>$R^2$ (SPSS)</th>
<th>Coefficient (b) (SPSS)</th>
<th>Coefficient (a) (SPSS)</th>
<th>Coefficient (a) (USBR)</th>
<th>Coefficient (b) (USBR)</th>
<th>Coefficient (a) (FAO)</th>
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<tr>
<td>Talezang</td>
<td>0.79</td>
<td>0.89</td>
<td>2.785</td>
<td>0.0006</td>
<td>0.065</td>
<td>2.119</td>
<td>0.170</td>
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<td>Bakhtiari</td>
<td>0.78</td>
<td>0.58</td>
<td>1.948</td>
<td>0.603</td>
<td>0.098</td>
<td>2.194</td>
<td>0.218</td>
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<tr>
<td>Sezar Tangpich</td>
<td>0.79</td>
<td>0.82</td>
<td>1.653</td>
<td>2.627</td>
<td>0.444</td>
<td>1.901</td>
<td>1.000</td>
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<tr>
<td>Sezar Sepiddasht</td>
<td>0.75</td>
<td>0.91</td>
<td>2.051</td>
<td>0.590</td>
<td>0.751</td>
<td>1.843</td>
<td>3.780</td>
</tr>
</tbody>
</table>

REFERENCES


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