Improving spate flow diversions in spate irrigation intake structures

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1. Introduction

Spate irrigation, a traditional water management system, diverts floodwater from temporal rivers to agricultural fields using simple deflectors of bunds constructed using local materials (Lawrence and Van Steenbergen 2005; Mehari 2007). It is complex and dynamic and has to deal with various flood conditions (small, medium, and large), uneven river beds and banks, and increasing sediment loads (Khan et al. 2014). Spate floodwater contributes a large amount of sediment loads to the agricultural field and plays a vital role in soil fertility enhancement of the agricultural lands (Ratsey 2011; Van Steenbergen et al. 2010; Tesfai and Sterk 2002; Lawrence and Van Steenbergen 2005). Khan et al. (2014) state that ~10% of the floodwater arriving in the field constitutes sediment and the sediment can adversely affect spate irrigation fields.

A spate irrigation system emphasizes on the management of sediment and floodwater (Van Steenbergen et al. 2010; Ratsey 2011). In dry regions, spate irrigation in agricultural areas is better than rain-fed agriculture (Ghahari et al. 2014). Spate irrigation helps alleviate poverty, adapt to climate change, enhance food security, and reduce poverty (Van Steenbergen et al. 2010; Hagos et al. 2014).

Spate irrigation systems are of three types: traditional, upgraded, and modernized (Van Steenbergen et al. 2010) (Figure 1). The traditional system is simple and requires frequent renovations of the diversion structure (Ghebremaryam and Van Steenbergen 2007); its main characteristics are free intake, no head regulator, no sediment exclusion structure, and earth embankment as a bed bar (Ratsey 2011). The upgraded system is the modified version of the traditional one; the modifications include fixed or gated orifices with head regulators for water intake, optional sluice gate, and upstream guide bund support (Ratsey 2011). The modernized system includes advanced spate irrigation structures such as intake with a weir structure, gated orifices, gated sediment excluder (sluice gate), and no upstream guide bund (Van Steenbergen et al. 2010; Ratsey 2011). Mehari et al. (2011) state that, spate modernization should avoid overstretched command area and allow water to downstream in all types of flood events.

The modernized spate irrigation system is less efficient than the traditional one owing to the lack of appropriate design, adoption of conventional irrigation design, low consideration of sediment loads, and exclusion of indigenous spate knowledge (Hiben and Tesfa-alem 2014). Van Steenbergen et al. (2011) state that, unlike conventional spate irrigation systems, the requirement of an appropriate design for specific spate flow, which can deal with the deflection angle of diversion inlets, high sediment loads, and institutional integrations.

Several governmental and non-governmental institutions are trying to develop and modernize spate irrigation systems based on their significance and applicability in drylands. In Ethiopia, spate irrigation is expanding regarding the modernization and development of traditional and new systems, respectively (Erkossa et al. 2014). Raya valley is one of the areas where spate irrigation is commonly practiced. Here, farmers divert floodwater to their farmlands using the traditional spate irrigation system. Over the past decades, governmental and non-governmental organizations were trying to improve and modernize the traditional spate irrigation systems. Many traditional spate schemes were modernized because they did not perform owing to several problems.

The traditional and modern spate irrigation systems in the Raya valley exhibited significant problems in controlling floodwater and managing sediment. The problem of sedimentation is more severe in modern spate irrigation systems than the traditional ones because of the existence of permanent diversion structures and lack of flexibility during high flood events. The problems of the current spate irrigation diversion are structural failures, low floodwater abstraction, and sedimentation. Further analysis is required to increase...
the productivity of spate irrigation schemes. Furthermore, sedimentation problems are not addressed in schemes where sediment management structures, e.g., scour sluice, are incorporated. Farmers completely block these structures to avoid the loss of floodwater as the main intake fails to divert sufficient water toward the command area.

Spate irrigation is different from conventional irrigation systems owing to high volumes of floodwater and sediment concentrations. Therefore, it is important to develop an appropriate design to accommodate incoming sediment and improve floodwater abstraction. In this study, we intend to develop and determine the best intake design for the spate irrigation diversion structure regarding floodwater abstraction and evaluate the impact of the design on sediment management.

2. Methodology

2.1. Study area

The study was implemented in the Dayu spate irrigation diversion structure, which was considered as a representative spate scheme for the Raya valley, Tigray Regional State, Ethiopia (Figure 2). The Dayu spate irrigation structure is positioned at 39°36.2′ east and 12°28.6′ north, with an elevation of 1463 m above sea level. The total catchment area of the Dayu spate watershed is 71.55 km², and the soil geology mainly included silt, clay, and loam. The slope of the catchment ranges from 0° to 47.3°.

The Raya valley covers Raya Alamata and Raya Azebo districts and some eastern escarpment parts of Enda Mekoni, Emba Alaje, and Ofila districts of Tigray Regional State. Topographically, the valley has been categorized as mostly lowland; some parts of it are considered to be highland. The valley is mainly covered by low lands with an altitude of <1500 m above sea level (Figure 3). According to a moisture index criteria (REST 1996), the Raya Valley area is classified as semi-arid and arid types. The valley has a bimodal rainfall pattern, with an average of 486–693 mm annually; this amount of rainfall is not sufficient to grow the required yield. Hence, the shortage of rainfall and its erratic distribution require special attention in developing different irrigation practices to support agricultural production in the valley.

2.2. Design conditions for spate diversion structures

The main variables and/or conditions for the design of spate irrigation structures are river morphology, incoming sediments, river discharges, hydrography, and size of the command area. The river morphology affects the structure owing to its slope, cross-sectional shape, river bathymetry, and bank shape. Moreover, the amount and size of the incoming sediment of the upstream watershed affect the design of the spate structure. The design structure has to accommodate and tolerate high sedimentation. The structures have to withstand various flood conditions, including extreme events. This intake structure has to divert floodwater toward the command area during low, medium, high, and extreme flood events to fulfill the water requirement of the farm.

2.3. River topography surveying

The river topography was surveyed using a total station. The total station measures X, Y, and Z coordinates of a point. The river was surveyed, covering 591 m – 385 m upstream and 206 m downstream of the diversion structure. The survey was conducted depending on the shape of the river banks, and 11 cross sections were considered along the river reach. In addition to the total station, a measuring tape was used to determine structural dimensions of the current diversion.
structure. Based on the surveyed topographic data, cross section, slope, and bathymetry of the river reach and dimensions of the current diversion structure were determined.

### 2.4. Sediment grading and concentration

Sediment samples were collected from representative points on the river reach, i.e., eight sediment samples from three cross sections (upstream, midstream, and downstream) and one sample from the intake of the diversion structure. As the sediments on the riverbed are dominated by coarse bed materials, 1 m$^3$ of the soil sample was manually excavated from each sampling point. According to Lawrence and Spark (2001), for sediment particles of diameter $>$5 mm, a manual sieving method was used; a sample of 2 kg was taken from the sediment particles that passed the 5-mm sieve. Mechanical
sieves were made for the sample in a soil research center laboratory in Mekelle. The sieve sizes used in the field were 5, 25, 50, and 80 mm, whereas sieve sizes 4.75, 2.36, 2.00, 1.00, 0.50, 0.25, 0.106, and 0.053 mm were used for mechanical sieves in the laboratory. The remaining sediment particles per sieve size were weighed. The sediment analysis was used to develop the median diameter ($D_{50}$) and 84% finer ($D_{84}$) of the bed sediment materials in the study area.

The sediment concentration was determined using the Design of Regime Canals (DORC) model of Sediment and Hydraulic Analysis on Rehabilitation of Canals (SHARC). The main inputs of the DORC model are bed material size and river hydraulic parameters (velocity and flow depth). The river hydraulic data were estimated from the alluvial friction predictor part of the DORC model. All methods of alluvial friction predictor (Brownlie; Engelund and Hansen; Van Rijn; and White, Paris, and Bettes) were compared with observed data of the river Dayu (Figure 4). The best fitted alluvial friction predictor for the generation of river hydraulic parameters was the Van Rijn method.

Transported sediment particles in the spate system include bed and suspended loads. The bed load comprises sands, gravels, and boulders, and this can be transported during medium, high, and extreme flood events. The suspended load comprises wash load (silt and clay) and can be transported during flood events. The sediment transport can be affected by catchment characteristics such as slope, soil type, land use, and rainfall intensity. Ratsey (2011) state that, 5–10% of spate flood discharge comprises sediments. Lawrence et al. (2001) state that the Engelund and Hansen method is the best sediment transport predictor in areas that do not have enough data of sediment concentrations. Hence, the sand transport prediction was made using the Engelund and Hansen’s sediment transport predictor method to obtain the sediment load concentration ($Q_s$) of the river in parts per million (ppm).

2.5. River discharge and hydrography

There is no flow and rain gauge in the watershed of the study area, and it was not possible to collect river flow discharge and hydrography data. Therefore, the river discharge was determined using floodwater marking and Manning equations. The floodwater level marking on the river banks was undertaken in the discussion held with experienced farmers and water user association leaders. The farmers agreed to include the average depth of minimum, medium, and maximum flood flow conditions on the river banks. Three representative cross sections with uniform bed levels and river banks were selected from the downstream, middle, and upstream sections of the river reach. The wetted cross sections or hydraulic dimensions of the river were determined based on the floodwater marking and using the total station.

Since there are no discharge data for the study area, the slope area methods of Manning’s and Bathurst’s equations are the two alternatives for the estimation of river discharge. Based on the river bathymetry, water levels, bed-material data, and appropriate Manning coefficients, the floodwater discharge can be determined using Manning’s and Bathurst’s equations.

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$  \hspace{1cm} (1)

$$Q = A D^* (g R S)^{1/2}$$  \hspace{1cm} (2)

$$D^* = 5.62 \log \left( \frac{d}{D_{84}} \right) + 4$$  \hspace{1cm} (3)

Where

- $Q$ = Discharge [m$^3$/s]
- $A$ = Cross section of river [m$^2$]
- $R$ = Hydraulic radius [m]
- $S$ = River slope [m/m]
- $n$ = Manning’s roughness coefficient [-]
- $D*$ = Resistance coefficient (for macro-rough flow) [-]
- $d$ = Average flow depth [m]
- $D_{84}$ = size of bed material with 84 percent is finer [m]
- $g$ = acceleration due to gravity [m/s$^2$]

As Manning roughness coefficient is not known for the study area, it becomes difficult to determine the field level and use Manning equation. According to Arcement and Schneider (1989), for areas with known median size of bed materials, Bathurst formula can be used instead of Manning equation. Bathurst equation is independent of Manning roughness coefficient and dependent on the $D_{84}$ of bed materials. Therefore, the river discharges were calculated using the Bathurst equation; moreover, this was supported by Gebrehiwot et al. (2015).

The flow hydrograph was generated based on the concept of Camacho (1987) and the discussions with the farmers. According to Camacho (1987), the spate flow hydrograph is

![Figure 4. Comparison of depth estimates from different alluvial friction predictors of the DORC model.](image-url)
characterized by fast rising limb and sharply decreasing recession within a very short period of time. The observed data of the hydrograph during low, medium, and high flood events were collected from the discussion held with elder and experienced local farmers. Moreover, the frequency data of flood events during wet, moderate, and dry seasons were obtained from the experienced and water user association leaders.

3. Model setup

The grid and bathymetry of the river bed were prepared from the collected XYZ topographic data. All other inputs for Delft3D were filled accordingly. The flow hydrodynamic model of Delft3D simulated the flow patterns and sediment processes within the river reach and around the diversion intake structure specifically. The Delft3D-RGFGRID model was set up and schematized for the river reach of 591 m. High-quality staggered grids with excellent Orthogonality and aspect ratios were developed to improve the river bathymetry.

A time frame was developed based on Courant (Friedrichs-Levy) number, and 0.01, 0.008, and 0.002 min were used for low, medium, and high flood events, respectively. Initial conditions of water levels and velocity in the U and V directions and sediment thickness were considered based on Delft3D-QUICKIN. The river discharge based on time series and estimated sediment concentrations was used as an upstream boundary condition. Discharge head relations and sediment concentrations were used as boundary conditions for the main intake and downstream, respectively. All physical and numerical parameter inputs like constants, roughness, viscosity, sediment and morphology, drying and flooding check, grid depth, and threshold depths were filled based on the existing conditions.

Different time steps were selected for the simulation of different flood levels to ensure stability. The flow data derived from the hydrograph based on the time series were used as upstream boundary conditions, and a stage discharge relation obtained from Bathurst’s equation was used as a downstream flow condition. There were not enough data for the calibration and validation of Delft3D model for specific locations. Nevertheless, a calibration coefficient of 5.7 was assumed in the sediment transport formula (Kleinhans and van Rijn 2002; Ribberink 1998) for a better prediction in mountainous and rocky catchments.

4. Scenario development

As the major problems of the current spate irrigation structure design were low water abstraction and high sediment accumulation around intake structures; three possible alternatives of intake design structures were developed in addition to the existing condition. The alternative designs were mainly dependent on gate width and deflection angle (Table 1). To recommend the best alternative design or scenario, a simulation model was developed using Delft3D. This model simulates the hydro- and morphodynamics of the river reach and is well-known for river flow and sediment transport simulations.

5. Results and discussions

5.1. River slope and cross section

The average slope of the river was estimated to be 1.1% based on the elevation difference between the bottom and upper reach of the river. As shown in Figure 5, the selected river reach has a wide cross section in the upstream segment and very narrow cross sections in the downstream segment. Large sediments such as boulders and stones were deposited in the upstream segment of the river reach, thereby blocking the scouring process of the river bed and horizontally expanding the river in the upstream segment. As a result, the height of the river bank was smaller compared to that of the downstream segment.

5.2. Sediment grade and load of the river

The sediment grade data collected from the laboratory and the field was merged and prepared to create a sediment grading curve. The curve was obtained based on a log scale (horizontal direction) and a normal scale (vertical direction). The sediment sample collected from the far upstream was coarser than the other samples, while the downstream and intakes were relatively fine bed materials (Figure 6). The median diameter ($D_{50}$) and 84% finer ($D_{84}$) of the bed sediment materials in the river reach are 1.8 and 40 mm, respectively. Based on Gee and Bauder (1986), the sediment in the Dayu river was categorized as coarser sand.

According to Lawrence (2001), Engelund and Hansen’s sediment transport predictor is the best method to determine sediment loads in the river reach. Hence, the method was employed to estimate $Q_s$ (in ppm) of the river. Based on the estimated $Q_s$, a simple power relationship ($Q_s = 1061.2Q^{0.7134}$) with $R^2$ value of 1 was developed to estimate sediment transport concentration for different discharge ($Q$ in m$^3$/s) levels obtained from the catchment. The relationship between the flood discharge ($Q$ in m$^3$/s) and the sediment load (ppm) are presented in Figure 7, and the possible sediment yield from the catchment can be estimated accordingly.

5.3. River discharge and hydrography

The river discharge was determined using Bathurst’s equation (Table 2). The flood frequency and duration of low, medium, and high flood events for wet, moderate, and dry seasons are listed in Table 3. Using the calculated river discharge, flood frequency, and Camacho’s (1987) principles, a flood flow hydrograph was developed for low, medium, and high flood events (Figure 8).

5.4. Flow patterns

The hydraulic behavior of the diversion and intake structures was modeled using the Delft-3D numerical simulation for hydrodynamic components. The flow pattern around the intake in the existing design showed that few and small magnitudes of flow patterns are moving toward the main intake direction (Figure 9(a)). Most of the flood discharge moved directly over
the center of the weir, and the sediment particles deposited at the side of the river, including intake structure. The flow patterns in the second scenario exhibited the high velocity of water toward the intake structure (Figure 9(b)). They can divert floodwater for irrigation. The flow patterns in the third scenario moved toward the intake, and the velocity was directed toward the intake; the water levels were high, which could divert a sufficient volume of floodwater (Figure 9(c)). The flow patterns in the third scenario are more concentrated compared with the second scenario, but they are little bit deflected.

The flow patterns in the fourth scenario showed that the water velocity was directed toward the main intake structure (Figure 9(d)). In this scenario, the velocity and water levels were high, which could divert a sufficient volume of water.
The flow patterns were directed toward the intake with a deflection angle greater than that of the third scenario. Moreover, Neary et al. (1999) state that the current lateral intake designs show flow patterns with the possibility of silt accumulation near the main diversion structures. This has been supported by Ma and Zhou (2001), who states that the diversion angle of an intake structure has significant impact on sediment control when the sediment accumulation is reduced around the intake structure. Pirestani et al. (2011) recommend a deflection angle of 115°–135° for better sediment and spate flow management.

### 5.5. Erosion and sedimentation

The sedimentation behavior of the diversion and intake structures was modeled using the Delft-3D numerical simulation for morphodynamic components. The sediment accumulation around the intake structure for all scenarios was determined based on the simulation results of the morphodynamics of Delft3D. During high flood events, in all the scenarios, a huge amount of sediment particles accumulated around the intake structure (Figure 10). The sediment accumulation during the low flood event for the first and second scenarios did not create sedimentation, while the third and fourth scenarios

### Table 2. Discharge calculations in cross section one (X-1).

<table>
<thead>
<tr>
<th>Flow type</th>
<th>Head (m)</th>
<th>Area (m²)</th>
<th>Perimeter (m)</th>
<th>R (m)</th>
<th>S (m³/m)</th>
<th>Dₜₐ (m)</th>
<th>Bathurst's Q (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.52</td>
<td>5.84</td>
<td>22.32</td>
<td>0.26</td>
<td>0.011</td>
<td>0.04</td>
<td>8.58</td>
</tr>
<tr>
<td>Medium</td>
<td>0.85</td>
<td>26.68</td>
<td>72.97</td>
<td>0.37</td>
<td>0.011</td>
<td>0.04</td>
<td>9.39</td>
</tr>
<tr>
<td>High</td>
<td>1.45</td>
<td>75.85</td>
<td>88.33</td>
<td>0.86</td>
<td>0.011</td>
<td>0.04</td>
<td>11.48</td>
</tr>
<tr>
<td>Extreme</td>
<td>1.66</td>
<td>95.03</td>
<td>96.54</td>
<td>0.98</td>
<td>0.011</td>
<td>0.04</td>
<td>11.81</td>
</tr>
</tbody>
</table>

### Table 3. Farmer’s observation to river flow hydrograph.

<table>
<thead>
<tr>
<th>Flow type</th>
<th>Wet season</th>
<th>Moderate season</th>
<th>Dry season</th>
<th>Duration time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>30</td>
<td>19</td>
<td>11</td>
<td>1 Repair</td>
</tr>
<tr>
<td>Medium</td>
<td>16</td>
<td>11</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

The flow patterns were directed toward the intake with a deflection angle greater than that of the third scenario. Moreover, Neary et al. (1999) state that the current lateral intake designs show flow patterns with the possibility of silt accumulation near the main diversion structures. This has been supported by Ma and Zhou (2001), who states that the diversion angle of an intake structure has significant impact on sediment control when the sediment accumulation is reduced around the intake structure. Pirestani et al. (2011) recommend a deflection angle of 115°–135° for better sediment and spate flow management.

### Figure 8. River flow hydrograph of the Dayu spate irrigation scheme.

![River flow hydrograph of the Dayu spate irrigation scheme.](image)

### Figure 9. Flow patterns of the flood for all scenarios during high flood events.

a) Scenario one/existing condition

b) Scenario two

c) Scenario three

a) Scenario four
had sediment thickness up to 3 cm per flood (Table 4). During the medium flood condition, the sediment accumulation reached 25, 26, 26, and 28 cm for the third, first, fourth, and second scenarios, respectively. This shows that all scenarios can accumulate similar amounts of sediment while they are diverting different volumes of floodwater. During the high flood condition, the accumulation around the main intake reached 34, 41, 46, and 48 cm for the second, first, fourth, and third scenarios, respectively. Similar results have been reported by Lawrence (1987), who states that sedimentation occurs in the upstream segment of weir structures and canal systems. Therefore, it is not possible to optimize sedimentation using an appropriate intake design of spate irrigation. It is necessary to introduce and accompany the selected design with specific sediment control mechanisms.

5.6. Intake discharge and floodwater abstraction

The intake flood hydrograph was developed based on the Delft3D simulation results of depth-averaged velocity and water levels in the intake structure. Moreover, the intake discharge was calculated from the intake flow hydrograph. The intake discharge was calculated by multiplying velocity (m/s) and wetted area (m²). Figure 11 shows that change in the intake width from 3 to 5 m for all the flood conditions causes a significant intake discharge. With the same intake width, the intake abstraction discharge can be increased by changing the deflection angle from 120° to 150°.

5.7. Total floodwater abstraction with respect to seasons

It is important to determine the optimum volume of floodwater to be diverted from the incoming flood. The total water abstraction per season was determined using Table 3 and Figure 10. Improving the current intake design considering deflection angles (120°–150°), the total water abstraction can be enhanced by 24% (Table 5). Increasing the current intake width to 5 m at 120° and 150° can improve the total floodwater abstraction by 88% and 111%, respectively. Mehari et al. (2013) state that widening of intakes and main canals can enhance the performance of spate irrigation structures.

As listed in Table 6, the fourth scenario can divert more floodwater and irrigate more lands, followed by the third and second scenarios, respectively. The first scenario is the current or existing condition that diverts a minimum volume of water in wet, moderate, and dry seasons. Gebrehiwot et al. (2015) state that the current spate intake design offers high sedimentation and low spate flow.

6. Conclusions

After the developments of alternative designs for better flood and sediment managements and the evaluation of the alternative designs using Delft3D model simulation for hydrodynamics and morphology in relation to sediment and spate flow, we have drawn the following conclusions:

- An alternative design of 5-m-wide intake of the spate irrigation structure with a deflection angle of 150°.
directed toward the river diverts the maximum volume of floodwater – 6.87, 5.02, and 3.03 Mm$^3$ for wet, moderate, and dry seasons, respectively. This can improve the total water abstraction by 103%, 100%, and 99% for wet, moderate, and dry seasons, respectively. Based on these results, the irrigation command area can also be increased accordingly. Therefore, the main intake design with a width of 5 m and a deflection angle of 150° can be the best alternative regarding the spate flow management.

- In the case of sedimentation, all scenarios are very sensitive, but intake dimensions at 150° exhibit relatively uniform distribution along the cross sections around the intake structure. Since the bed level increments are distributed through the immediate upstream area of the diversion, the volume of water to be diverted may not be minimized significantly.
- Sediment accumulations are not significantly different for all scenarios, and this creates difficulties in decision-making. The high volumes of water for the third and fourth scenarios can compensate for high sedimentation. Regardless of the complex nature of spate irrigation, improving water abstraction by 111% without significant increment in sedimentation can have a positive implication for withstanding the problem of sedimentation in the spate irrigation diversion structure.
- Considering only design, an intake width of 5 m and a deflection angle of 150° can be recommended for better management of spate flow and sediments.

### Table 5. Total water to be diverted under all scenarios per flood type.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake discharge (m$^3$/s) at pick period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2.6</td>
<td>3.1</td>
<td>4.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Medium</td>
<td>6.6</td>
<td>8.4</td>
<td>12.6</td>
<td>13.7</td>
</tr>
<tr>
<td>High</td>
<td>13.5</td>
<td>17.1</td>
<td>22.8</td>
<td>24.4</td>
</tr>
<tr>
<td>Average</td>
<td>7.6</td>
<td>9.5</td>
<td>13.4</td>
<td>14.5</td>
</tr>
<tr>
<td>Total water to be diverted (m$^3$)</td>
<td>19,442</td>
<td>24,369</td>
<td>40,203</td>
<td>55,113</td>
</tr>
</tbody>
</table>

### Table 6. Total volume of water to be diverted per season.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Season type</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total water to be diverted (Mm$^3$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet</td>
<td>3.39</td>
<td>4.12</td>
<td>6.20</td>
<td>6.87</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>2.52</td>
<td>3.05</td>
<td>4.54</td>
<td>5.02</td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>1.52</td>
<td>1.84</td>
<td>2.74</td>
<td>3.03</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>2.5</td>
<td>3.0</td>
<td>4.5</td>
<td>5.0</td>
<td></td>
</tr>
</tbody>
</table>

N.B. PI means: Percentage of increment from scenario one/current condition.
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Disclosure statement

No potential conflict of interest was reported by the authors.

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