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Evaluation of Sediment Management Techniques of Dokan Dam Accomplished with Climate Change Scenarios Using ResCon 2.2 Beta Model

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Abstract

The storage capacity of dams is affected directly by sediment build-up. Drought, heavy rainfall, and catastrophic events in watersheds increase soil washout up to unusual and unbeaten records. Dokan Dam, as a strategic dam in Iraq, plays a vital role in water management with a strong firm with the even worse scenario of an actual predicted sediment rate of 3.8 M m^3/y. Sediment management is an essential process that enhances dam functions. Reservoir conservation model ResCon 2.2 Beta was used to predict and analyse sediment management techniques, taking climate change scenarios into consideration. The model gives a good and acceptable interpretation of the sediment management in both the watershed and the reservoir. Dokan reservoir is a sustainable reservoir within its long-term capacity. Up to four different techniques and 37 different methods were evaluated to reduce the sediment entering the reservoir for up to 300 years. Economic approaches are applied to calculate the basic parameters of sustainable projects. Satellite images, dam operations policy, inflow, and sediment data are used as inputs to calculate the aggregate net present value (NPV) and gross storage capacity. In terms of climate change, results show the watershed management technique is the best option to decrease the soil washout and sediment deposition in the reservoir with a NPV of 24.5 B $ assuming the unit price of water yield is 10 cents, and long-term gross storage capacity is 6.4 BM3. Dokan Dam can be sustained for the applied period in terms of water storage depletion provided there is no structural defect in the dam body. Check dams, reforestation, and vegetation of specific areas in watersheds are necessary to maintain the storage capacity of the dam as much as possible, up to 6 BM3.

Keywords: Dokan dam, washout, ResCon, sedimentation, net present value, watershed

نمذجة طرق معالجة الترسبات في سد دوكان مقرونة بظروف التغيير المناخي في سد دوكان بأستخدام برنامجResCon beta 2.2

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الخلاصة

تتأثر السعة الخزنية للسدود بشكل مباشر بتراكم الرواسب حيث يؤدي الجفاف والأمطار الغزيرة والأحداث الكارثية في المساحات الجابية إلى زيادة انجراف التربة إلى مستويات قياسية غير اعتيادية وغير مسجلة مسبقاً. يلعب سد دوكان، باعتباره سدًا استراتيجيًا في العراق، دورًا حيويًا في إدارة المياه مع السيناريو الأسوأ والذي يمثل معدل الرواسب الفعلي المتوقع وصوله الى الخزان والبالغ ٣,٨ مليون متر مكعب / سنة. تعتبر إدارة الترسبات عملية أساسية تعزز المهام التي تنشأ من اجلها السدود. تم استخدام الموديل الرياضي ResCon 2.2 Beta للتنبؤ بتقنيات إدارة الترسبات وتحليلها في خزانات السدود، مع الاخذ بنظر الاعتبار سيناريوهات تغير المناخ. حيث اعطى الموديل الرياضي تفسيرًا جيدًا ومقبولًا لإدارة الترسبات في كل من المساحات الجابية والخزان.

خزان دكان هو خزان مستدام في حدود قدرته التصميمية من جهة والطويلة المدى من جهة اخرى. تم تقييم ما يصل إلى أربع تقنيات مختلفة و٣٧ طريقة مختلفة لتقليل دخول الترسبات إلى الخزان لمدة دراسة افتراضية تصل إلى ٣٠٠ عام. تم تطبيق الأساليب الاقتصادية لحساب أساسيات المشاريع المستدامة وتم استخدام صور الأقمار الصناعية وسياسة تشغيل السد والواردات المائية وبيانات الترسبات كمدخلات لحساب إجمالي صافي القيمة الحالية (NPV) وإجمالي سعة التخزين.

من حيث تغير المناخ، تظهر النتائج أن تقنية إدارة المساحات الجابية هي أفضل خيار لتقليل انجراف التربة وترسب الرواسب في الخزان مع صافي القيمة الحالية ٢٤,٥ مليار دولار بافتراض أن سعر وحدة المتر المكعب هو ١٠ سنتات، والإجمالي طويل الأجل لسعة التخزين هي ٦,٤ مليار متر مكعب. يمكن الحفاظ على سد دكان للفترة المطبقة من حيث نضوب تخزين المياه بشرط عدم وجود عيب هيكلي في جسم السد. فحص السدود واستعادة الغطاء النباتي والغابات لمناطق محددة في المساحات الجابية ضرورية للحفاظ على السعة التخزينية للسد قدر الإمكان، حتى ٦ مليار متر مكعب.

الكلمات المفتاحية: سد دوكان .. التجريف.. برنامج ResCon..الترسيب..صافي القيمة الحالية...المستجمعات

Introduction

All the reservoirs created by the construction of dams on the rivers are subjected to some degree of sedimentation. Planners and operators of dam projects are challenging the problem of reservoir sedimentation by assessing sedimentation rates and how long time it takes for a reservoir to be affected its useful functions, such as serving useful life. According to ICOLD, within 200 to 300 years, most of the world's reservoirs will be completely filled with sediment (Giri ,et al., 2017). Dams are built to provide a reliable water supply for different purposes, such as irrigation, flood protection, and hydropower generation, which are the most important functions for dams. Generally, dams are constructed on river basins that are subjected to hydrological variation. Engineers and hydrologists are working together for water resources development to ensure maximum water storage in the reservoirs and try to minimize the storage losses due to sedimentation issues and negative impacts. Over time, sediment builds up in reservoirs, which reduces the usable storage volume and minimizes the capability to ensure water for long periods of time. directly impacts hydropower generation, reduces the reliability of different water supplies, flood management, and aquatic habitats.

In this research, the issue of sedimentation for storage dams is being discussed. Dokan dam issues related to storage capacities through the project life are accomplished with climate change. The amount of sediment flowing in a river can be expressed by two terms; either sediment yield, which is the amount of eroded material that completes its journey from the source to the control point (for example, a dam, bridge, or watershed outlet) expressed in tonnes, or specific sediment yield, which is the sediment yield divided by the catchment area over a year and expressed in tonnes/km2/year. Siltation of the reservoir decreased its storage capacity by 28% (Hassan R, et al.,2019) with no action strategy for sediment management. Many factors should be identified in the reservoir sedimentation analysis, which includes the shape of the reservoir, trap efficiency, sedimentation rate, and sediment management process, each river regime has its own response to rainfall, and each catchment area generates a unique sediment composite entering the river channel. Trap efficiency is the most common indicator of the silting process in reservoirs and should be carefully calculated to estimate the other values of the reservoir. On the other hand, the analysis of sediment is important to calculate the different types of "reservoir life". The majority of useful life has been thought of in terms of length of life rather than services to the community (Murthy, 1977a). Reservoirs are widely used widely around the world to provide reliable water for different uses, they are particularly important in those places with high hydrological variabilities, where the amount of inflow varies significantly from season to season and year to year (Annandale, Morris, and Karki, 2016). To keep the project running in the most efficient way and ensure its long serviceability, sedimentation and dead storage filling up are the most affected problems and should be addressed in the designing or operational stages. The cost of dam decommissioning is too high and not preferred as an economical and technical solution. Strategies should be adopted to maintain the capacity of the reservoir and extend the life of the project not only as long as the design life (generally 50-100 years), but more than this. These types of strategies can be listed under "sediment management". Siltation processes have always been crucial challenges for dam owners. 0.5%–1% of the global storage capacity is estimated to be lost due to sedimentation. The loss of storage capacity is much higher than the increase in capacity by adding new reservoirs (Schleiss et al., 2016). In general, sediment management techniques in different types of dams differ. For run off river “ROR” projects, the aim is to improve the operational efficiency of the hydropower plant. Whilst in storage projects is to ensure longevity of project for storing max allowable amount of water.

The aim of this research is to find the optimum sediment management technique that fits the hydrological conditions, climate change scenarios, and operation policies to ensure maximum storage capacity and more economic rewards.

Study Project

Dokan Dam, Iraq's second largest dam, is located in the country's northeastern region, 60 kilometers north-west of Sulaymaniya Figure (1), at the coordinates 35 57'15" N and 44 57'10" E, constructed on the Lesser Zab River, one of the Tigris River tributaries (about 220 km above the confluence point) as the first Iraq’s major project. Consultant services for the project were carried out by Binnie, Deacon & Gourley in 1951. The contract for project implementation was awarded to Group Dumez-Ballot in 1954-1959. The dam is an arch of concrete with a crest length of 360 m and a total height of 116.5 m. The crest level is 516 m.a.s.l. The dam thickness is about 34.3 m at the bottom and 6.2 m at the top. The catchment area of the reservoir is about 11690 km^2, of which 76 % lies in Iraq and 24 % in Iran. The reservoir surface area is 270 km^2 with 6.87 billion m^3 of live storage at 511 m.a.s.l. The average river discharge is 191 m^3/sec at Dokan site (Hassan ,et al., 2017), which shows a decrease of 203 m^3/sec as per the project summary report. Dokan Reservoir is located in the High Zagros Fold-Thrust Zone (HZFTZ) of the Zagros Fold-Thrust Belt (Hassan, R et al. 2017). Many studies and research detailed the geology of the study area (see Sissakian V. et al. 2016).

Figure 1:Dokan dam location (Google earth image)

Dokan Reservoir Trap Efficiency

Brune’s method is likely to be more accurate for systems with well-mixed (Lewis et al., 2013). To determine the trap efficiency of Dokan dam, the data of inflow since the first ponding of the dam in 1959 up to December 31, 2015 is available, with an average daily water inflow to the reservoir of 5686.74 m^3. The reservoir shape and the bends in the river channel before reaching the dam site helped to reduce the velocity of water inflow, which enhanced the silting process of fine particles near the dam body. In other words, the trap efficiency of the reservoir is higher. A trap efficiency analysis was done and the results varied from 97.5–96.9% up to the year 2059, as shown in Figure (2).

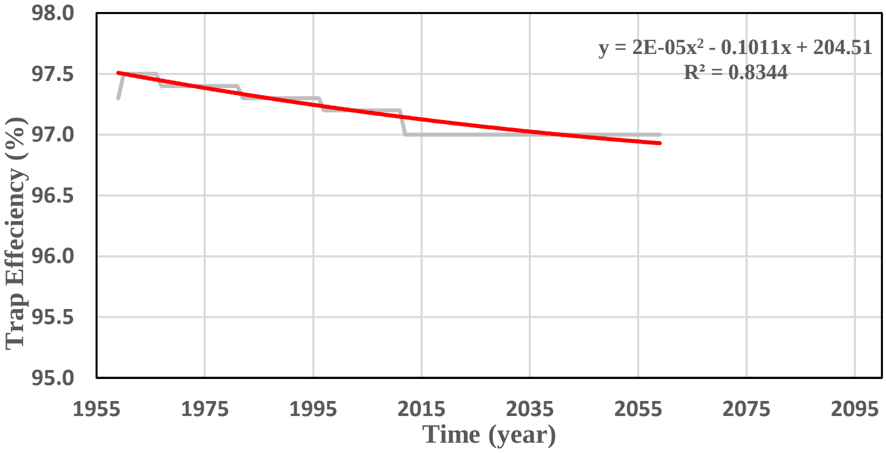


Figure 2:Brune’s Trap efficiency of Dokan dam

Sediment Management Strategies

In terms of sediment management, reservoirs are classified into three major types depending on water turnover rate, which is defined as the ratio between capacity (CAP) and mean annual runoff (MAR). These types are:

1- transparent reservoirs (small-sized reservoirs) as ROR.
2- sorting reservoir (where sediment is trapped in the reservoir, whereas flood water passes).
3- Black hole reservoir (very large storage capacity compared with inflow), as Dokan Dam.

Many factors are involved in choosing the best sediment management strategy, such as geographic location, climatic condition, land use and land cover “LULC”, human activities, sediment mineralogy, reservoir geometry, type and age of dam, appurtenant structures, water use policy, operation rules of the reservoir, and economic value of water. For that, an integrated approach should be adapted to balance the sediment budget across the reservoir (Schleiss, et al., 2016). In order to examine the sustainability of reservoirs, such a type of relationship is expressed in Figure 3, with CAP/MAR in the x-axis and CAP/MAS (where MAS is the mean annual sediment rate) in the y-axis. According to Table (1), the Dokan dam project falls in the highest portion of the curves in the region, i.e., it is highly sustainable due to annual loss, which is considered to be low according to the official estimates (Ali A., et al. 2020), but there is a need to vent the suspended sediment that appears frequently in the reservoir, as Figure (3). According to ICOLD Bulletin 67 (1989), density differences play an important role in the deposition procedure through the formation of turbid density currents in cases of large density differences between impounded and inflowing water. They also play an important role in cases of steep bed slopes and low flow velocities.

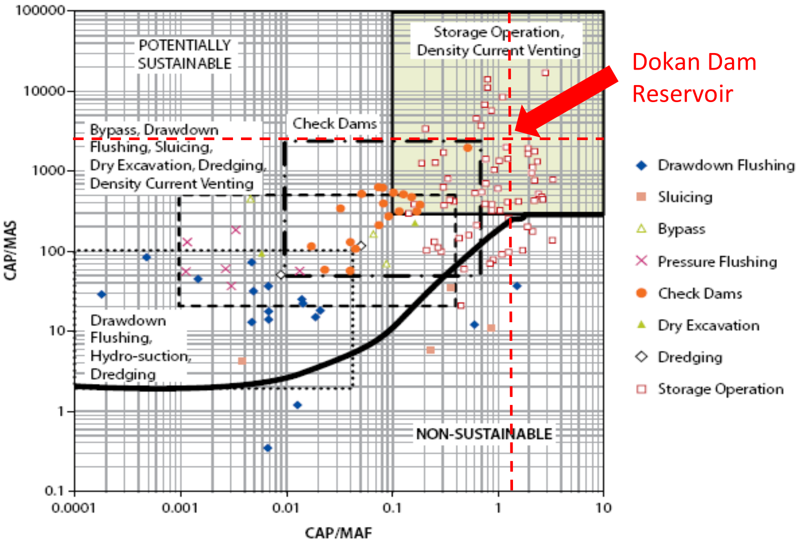


Figure 3: Sustainability of reservoirs (source: Annandale G.W. et al, 2016)

Table 1: Parameters of sustainability of Dokan dam

Capacity (MCM)	8000
Mean annual runoff (MCM)	5686.7
Avg. mean annual sedimentation (MCM)	3.8
CAP/MAR	1.40
CAP/MAS	2105.2

In 2005, Fan Jiahua, UNESCO classified the method of sediment control into three primary methods depending on the location in the river basin:

- In the catchment area of the river (C), forestation, expansion of vegetation, stabilization of slopes, and modification of crop practices are among the activities.
- In the reservoir (R), the bypass tunnel, and flushing with water withdrawal,
- At the dam site (D), increasing the dam height, water jetting to keep sediment under suspension, and increasing outlet levels all contribute to the practices might include one of the above methods or a combination of two or three, as shown in Figure (4) (Kondolf et al., 2014).

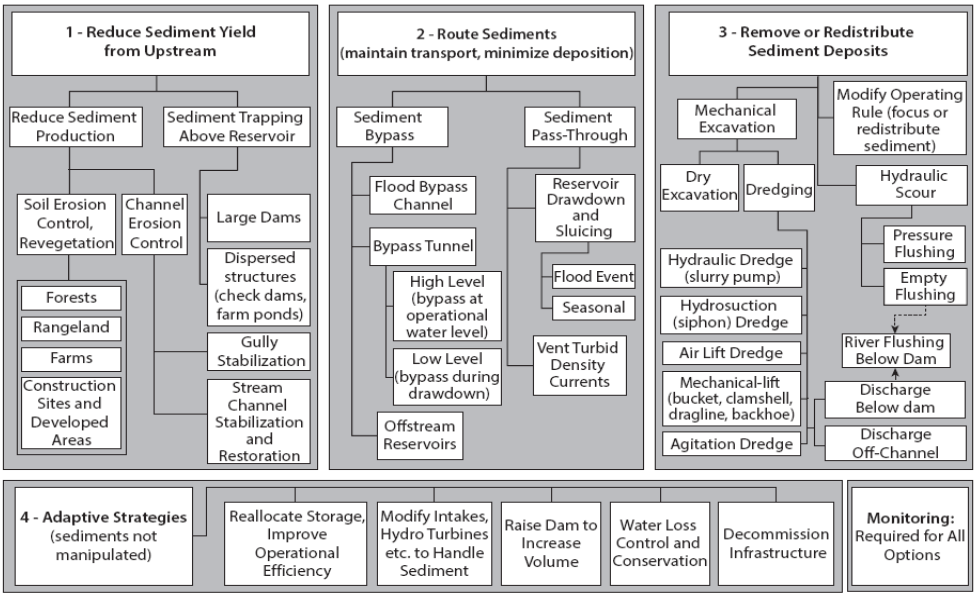


Figure 4: classification of sediment management strategies

RESCON 2.2 Beta Tool

Physically based models are usually used in cases where runoff and sediment load data records are not available. These models are of two types, which are referred to as single storm models and continuous simulation models (M. Ezz-Aldeen, et al., 2018). According to Figure 4, the selection of best practice(s) should not be arbitrary, but rather based on studies and reliable results. Detailed sedimentation studies are not widely available, and they may not be in the public domain, done using computer models to get an understanding of the sedimentation in reservoirs, especially those that were built earlier. When observed data for rate, deposition pattern, and income sediment types is available, models such as MIKE 11, MIKE 21C, and HEC-(series) are commonly used. In the Dokan Dam case, no observed data regarding sedimentation is available, so that makes the challenge higher. Due to the sensitivity of the project, steps should be taken to minimize the sediment problem. Even though the live storage is not affected according to the results of sediment analysis (chapter three), action should be taken to protect the hydropower plant (abrasion of turbine blades) from damage due to sediment passing. Gregory L. Morris (author of Extending Reservoir Life, WB, 2016) suggested using the (RESCON 2.2 Beta) tool for the Dokan dam. It is a computer program designed for use in pre-feasibility studies to rank the economic performance of a selection of sediment management techniques as an indicator of sediment management (Efthymiou ,et al., 2017). The following sediment management strategies are modeled to be considered:

- Flushing
- Hydro-suction (HSRS)
- Traditional dredging
- Trucking
- Sluicing
- By-pass
- Density current venting
- Catchment management

Data

The data required for preprocessing this tool is available and provided by the Iraqi government (MoWR). And it’s quite enough to calibrate and run RESCON 2.2 beta. At each stage of data entry. Thirty-two bottom sediment samples were collected from the bottom of the reservoir using the Van Veen grab. Grain size distribution analyses indicated that the bed of the reservoir was mainly composed of 15% gravel, 14% sand, 48% silt, and 23% clay, respectively. Mud and silt were the main components of the samples (Hassan R., et al. 2016). The next step is the assessment of the effect of different sediment management alternatives on storage development depending on the user with sound engineering knowledge; and current project circumstances for existing projects or the future desired status for "green filed" projects.

The compulsory hydrologic and sediment input includes:

- annual average water inflow
- hydrologic variability coefficient
- Statistical distribution of annual water flow
- mean annual total sediment (suspended load and bed load) inflow to the reservoir.
- selection of the method that will be used for trap efficiency calculation of the reservoir.
- temperature of impounded water as a necessary input for assessment of the technical feasibility of density current venting.

Optional data points, which are not compulsory for the performance of the RESCON 2.2 analysis, are

- grain size distribution of suspended sediment inflow.
- Settling velocities of individual grain classes.

The calculation of the annual benefits from reservoir operation is based on the following compulsory data:

- The unit cost of project implementation is expressed as US $/m3 of reservoir storage capacity.
- Annual (O&M) Costs expressed as % of project cost.
- Unit price value of water yield expressed in US$/$m^3$.

Climate Change parameters

In order to perform a sensitivity analysis, it is necessary to first identify the full range of possible impacts of future climate change on hydrologic indicators influencing the water yield from a reservoir (Efthymiou, et al., 2017). Therefore, it is necessary to determine the impact of climate change on the following parameters:

- Percent of mean runoff change.
- Runoff Variability
- Mean annual sediment inflow

There are different open and dependable sources available for obtaining model projections regarding future climate and hydrologic indicators, but they differ widely in their access complexities and data formats. An assessment concept of the impact of climate change has been recently developed by the World Bank. This concept is capable of predicting six hydrological indicators for more than 8000 river basins worldwide. The mean annual runoff, which affects directly the water yield supplied by the reservoir, is to be a necessary input for the software analysis. It is recommended to retrieve the future runoff using the "Climate Change Knowledge Portal for Development Practitioners and Policy Makers" Figures (5) and (6) that was developed by the World Bank Group. This portal provides data about runoff and temperature using three future emission scenarios: A1b, A2, and B1 using results from 22 different ground circulation models (GSM) for different two periods of (2030–2039) and (2050–2059). This portal give data for the hydrological parameters of different scenarios mentioned as box plot for different hydrological parameters for both basin and country are represent in Figure (7) and (8) for 2030 and 2050 respectively.

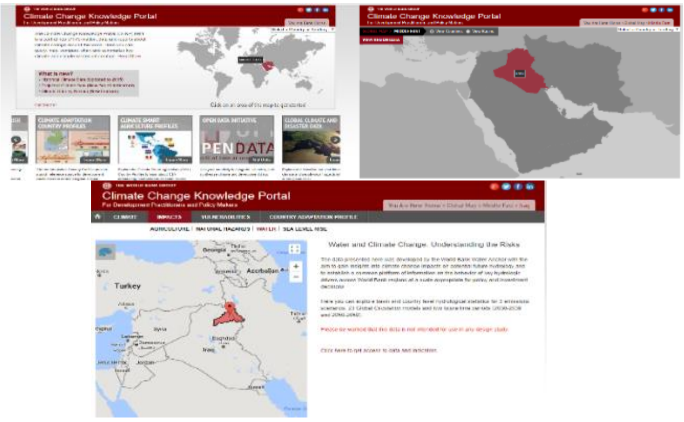
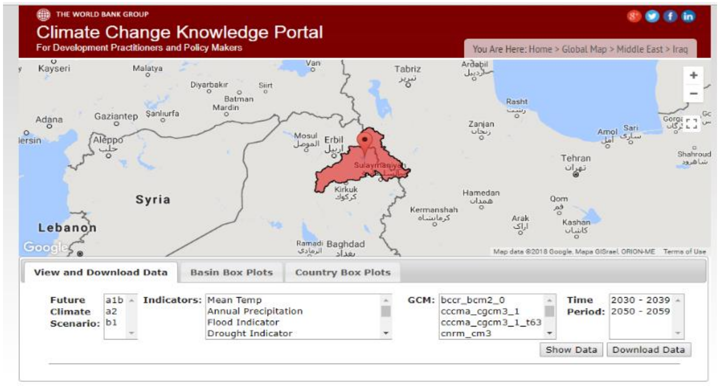


Figure 5: Climate Change Knowledge Portal for Development Practitioners and Policy Makers interference



Future Climate Scenario: a1b, a2, b1

Indicators: Mean Temp, Annual Precipitation, Flood Indicator, Drought Indicator

GCM: bccr_bcm2_0, cccma_cgcm3_1, cccma_cgcm3_1_t63, cnrm_cm3

Time Period: 2030 - 2039, 2050 - 2059

Figure 6: Future climate change scenarios, GCM, indicators, and periods

The impact of climate change on the sediment transported by the river is difficult to assess because it depends on many different parameters. For instance, changes in temperature due to climate change are related to actual evapotranspiration, which directly influences sediment loading. This effect is magnified when reforestation or deforestation occurs in the catchment area of the river (Efthymiou, et al., 2017).

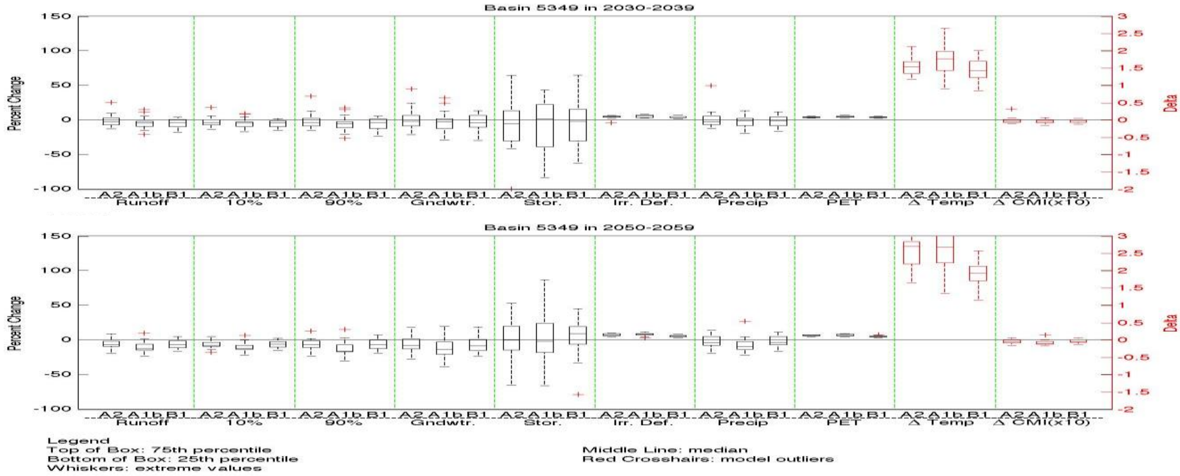


Figure 7: Basin box plot for hydrological parameter in different scenarios for (2030 and 2050)

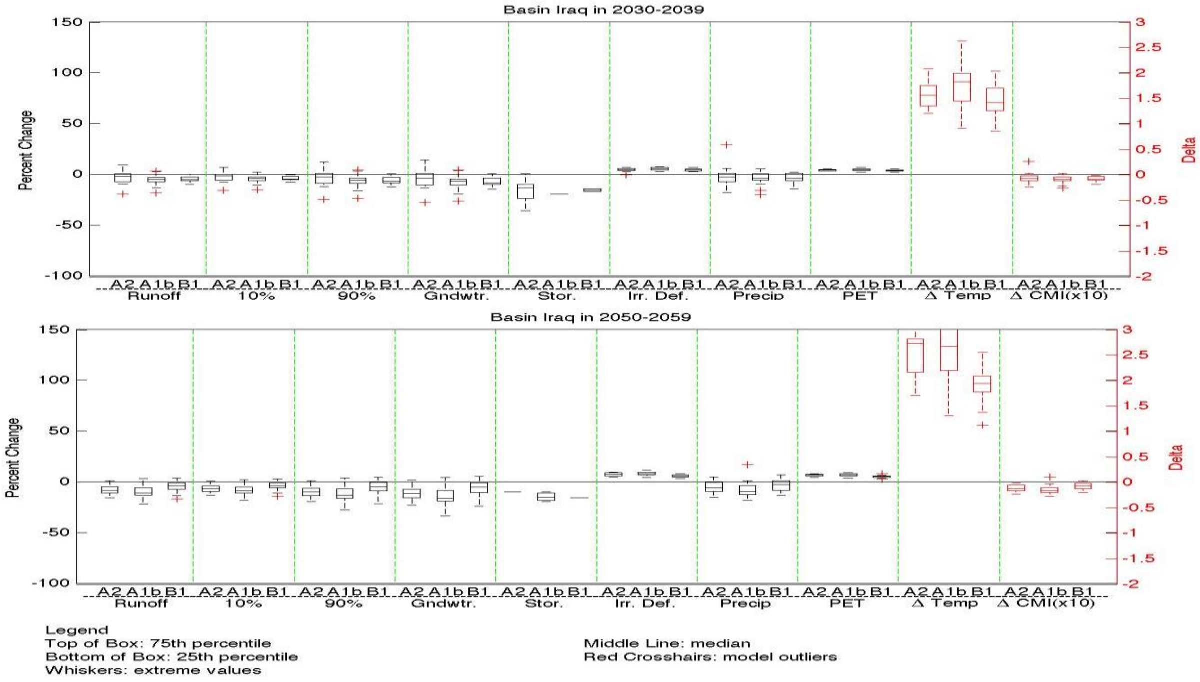


Figure 8: box plot for different hydrological parameters for both basin and country (2030-2050)

Results

Climate change scenario

In terms of climate change, RESCON 2.2 simulates the net present values for future scenarios. A plot of the full possible climate has been adopted as shown in Figure (9). The results are as shown in Figure (10). It can be seen that in each case, even in the driest future, the catchment area management has the higher net present value.

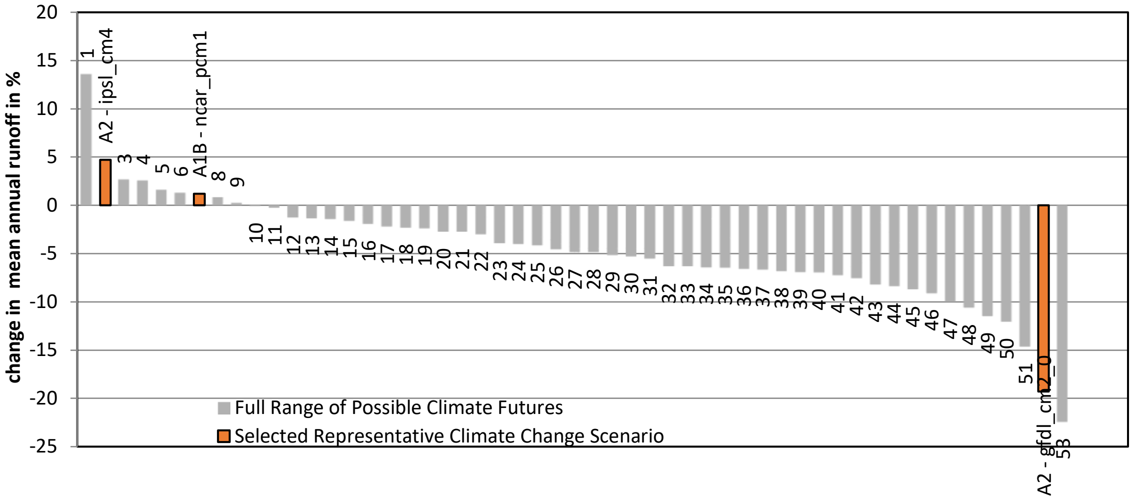


Figure 9: Full ranges of climate change of Dokan dam

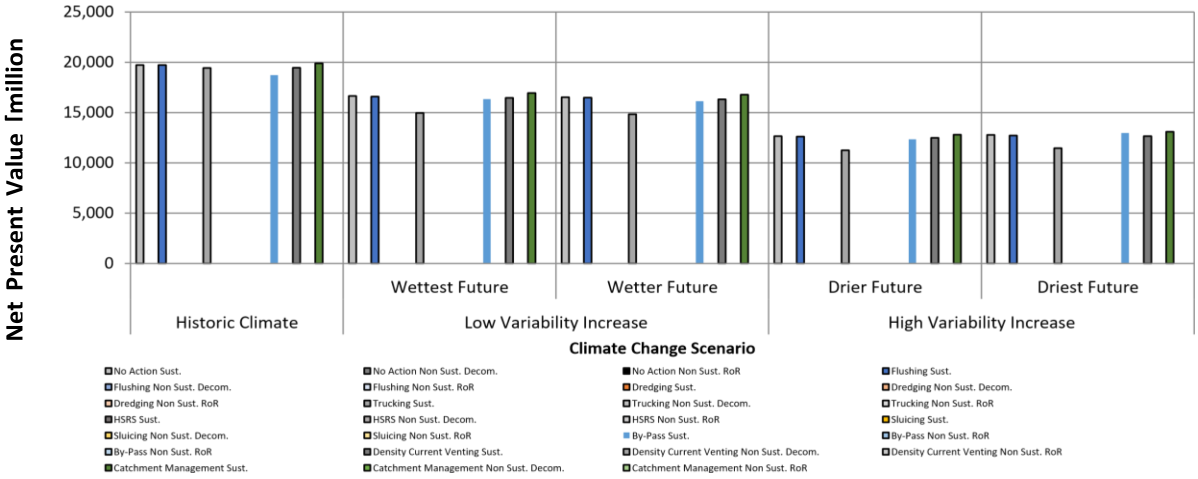


Figure 10: Sediment management techniques with climate change scenarios of Dokan dam

Temporal gross and active storage capacity

As in Table 2, the higher NPV comes with catchment management options such as sediment inflow reduction as well as long-term capacity of 300 years. For sediment routing, D.C.V kept as an effective technique till 175 years of reservoir operation time, which was replaced by a sluicing technique for the remaining 125 years as in Figure (11). For deposition removal techniques, trucking maintains the higher gross storage capacity values, but with less NPV. For live storage, the scenario did not change too much of the gross storage above; it is found that all the sediment management suggested will be able to enhance the live storage capacity after 175 years of the dam operation, as Figure (12) suggests.

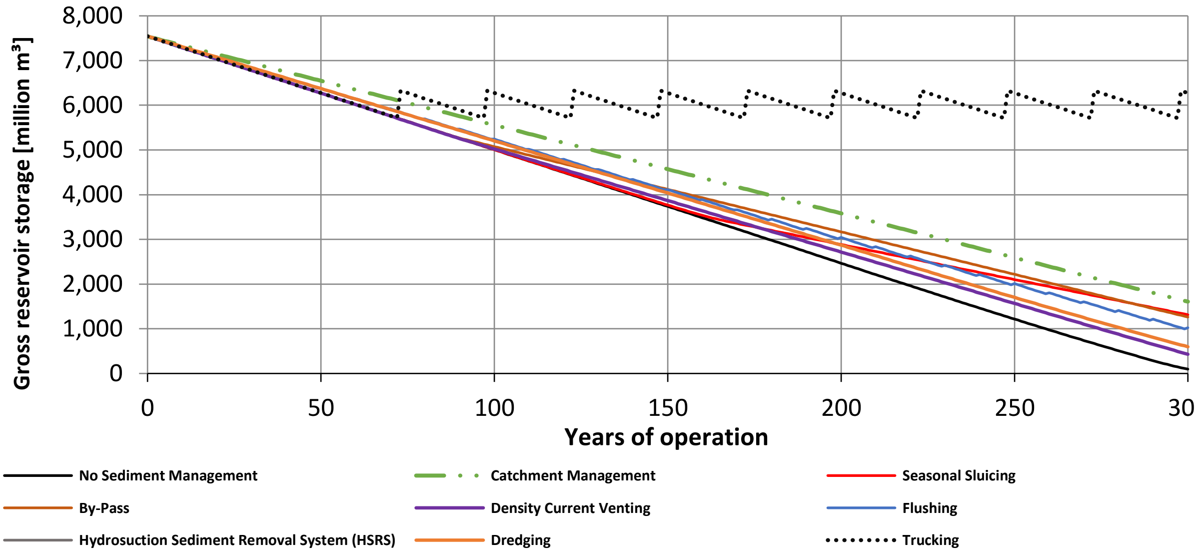


Figure 11: Temporal gross storage capacity development of Dokan dam

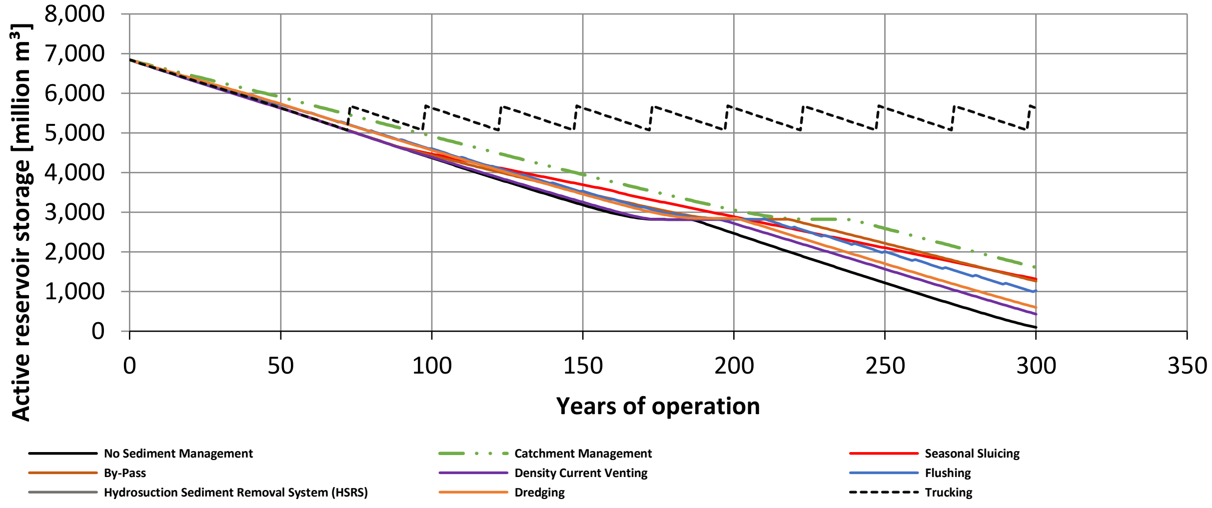


Figure 12:Temporal active storage capacity development of Dokan dam

Temporal development of trap efficiency

In Figure (13), it is found that the trap efficiency in the case of seasonal sluicing of the reservoir drops drastically after 150 years of reservoir operation to reach around 64%, which is a very small percentage. Similarly, but with less effect, density current venting should be maintained at around 88.6% for the next 250 years.

Table 1: Sediment management techniques for predicted actual sediment income of Dokan dam

Sediment Management Strategy				Feasibility	Aggregate Net Present Value	Long Term Reservoir Gross Storage Capacity	Reservoir Lifetime
Method	**Technique**	**Sustainability**	**Action in case of storage elimination**		**[US$]**	**[m^3]**	**[Years]**
	No Action	Sustainable		X	N/A	97,092,682	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	OK	23,956,071,863		
Sediment Inflow Reduction	**Catchment Management**	Sustainable		OK	**24,563,316,342**	**6,389,567,555**	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
Sediment Routing	**Sluicing**	Sustainable		OK	**24,424,840,582**	**1,313,121,286**	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
	By-Pass	Sustainable		OK	22,714,991,570	1,262,447,521	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
	Density Current Venting	Sustainable		OK	23,850,338,004	429,796,517	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
Deposition Removal	**Flushing**	Sustainable		OK	23,808,142,352	1,213,062,824	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
	HSRS	Sustainable		X	N/A	N/A	N/A
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
	Dredging	Sustainable		OK	23,903,759,336	809,897,864	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		
	Trucking	Sustainable		OK	**20,442,869,247**	**6,324,245,756**	> 300
		Non Sustainable	Decommissioning	X	N/A		
			Run-Of-River	X	N/A		

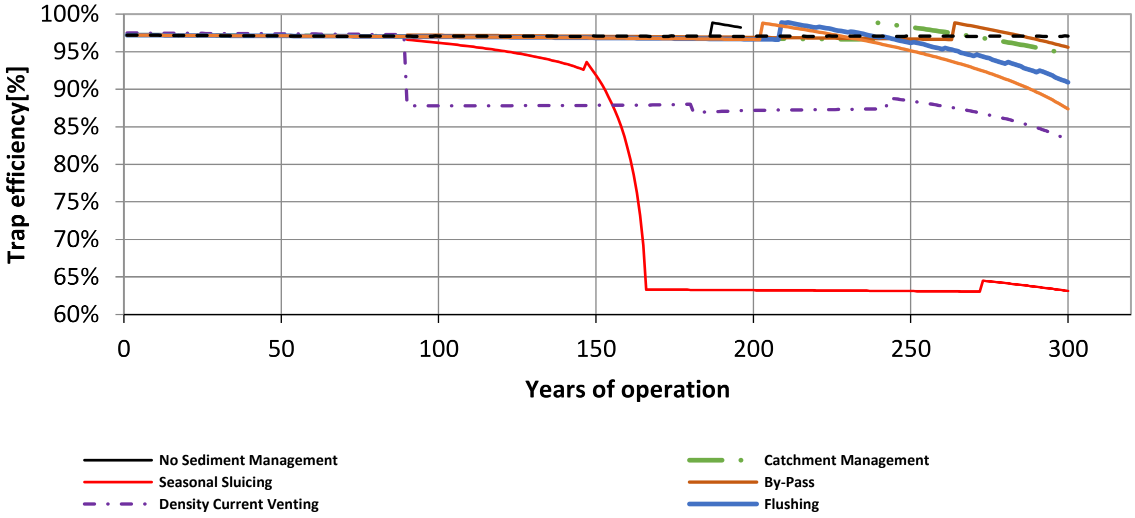


Figure 13: Temporal trap efficiency development of Dokan dam

Temporal development of water yield

The water yield in RESCON 2.2 is calculated based on empirical methods (Efthymiou, et al., 2017). Also, it is considered that the reservoir is in a steady state. The curves shown in Figure (14) are based on a relationship between the "yield", which is the available water for use with certain reliability, and the reservoir capacity, i.e., the quantity of water that gives economic value. Among the different techniques, catchment management has the highest water yield after trucking. Detailed model output for various techniques has been shown in Figures (15, 16, 17, 18, 19, 20, 21, 22, and 23). They show the model output for no-action, catchment management, flushing, dredging, trucking, by-pass, sluicing, D.C.V., and climate change scenario respectively.

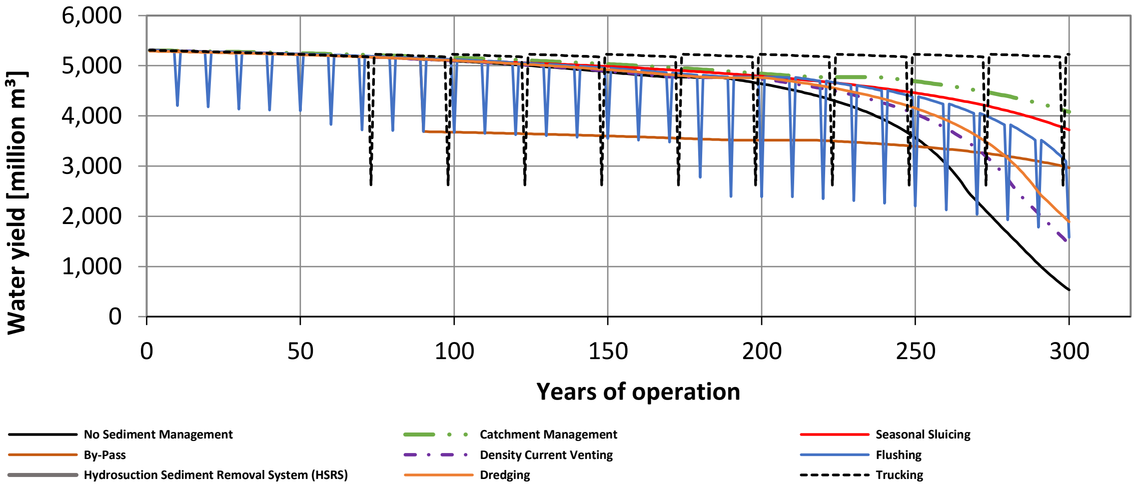


Figure 14: Temporal water yield development of Dokan dam

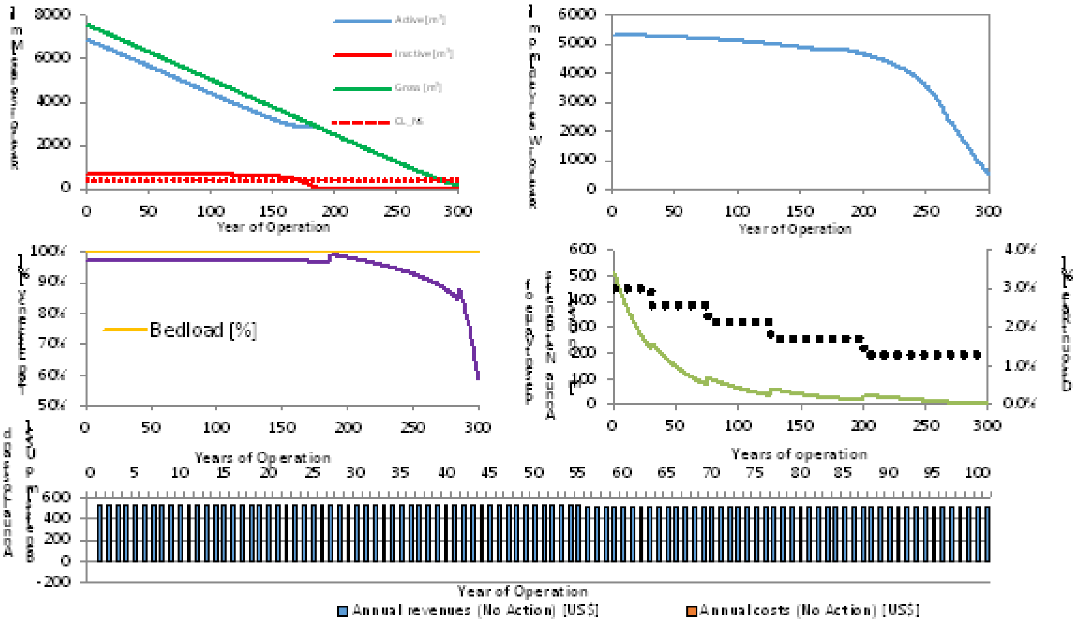


Figure 15: No action technique model output (A-reservoir storage capacities, B: water yield, C: trap efficiency, D: annual net benefit, E: Annual benefit-cost 1diagram)

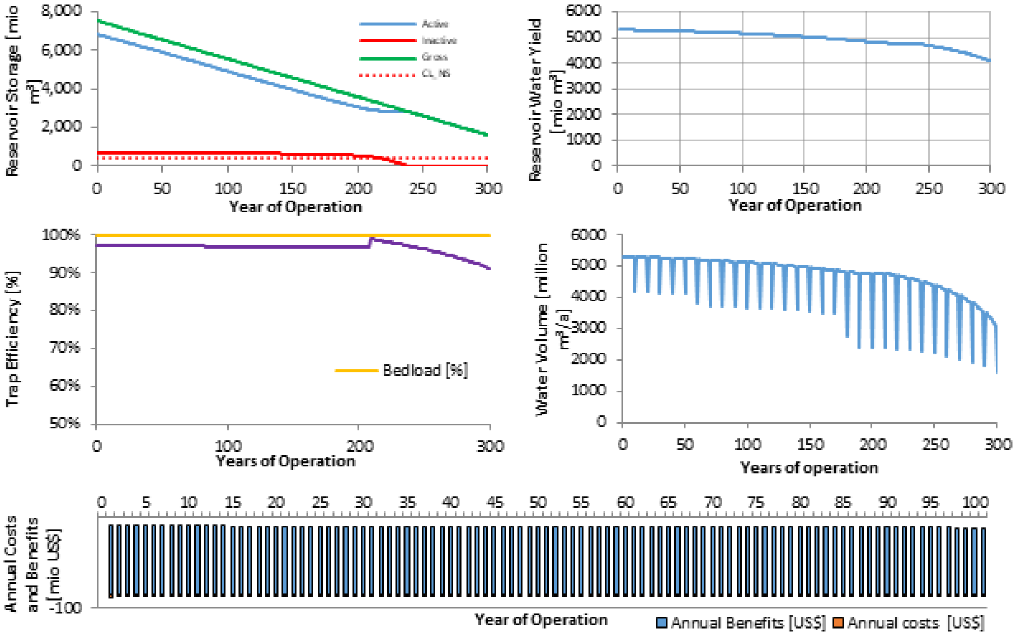


Figure 16: catchment MGM technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E:Annual benefit-cost diagram)

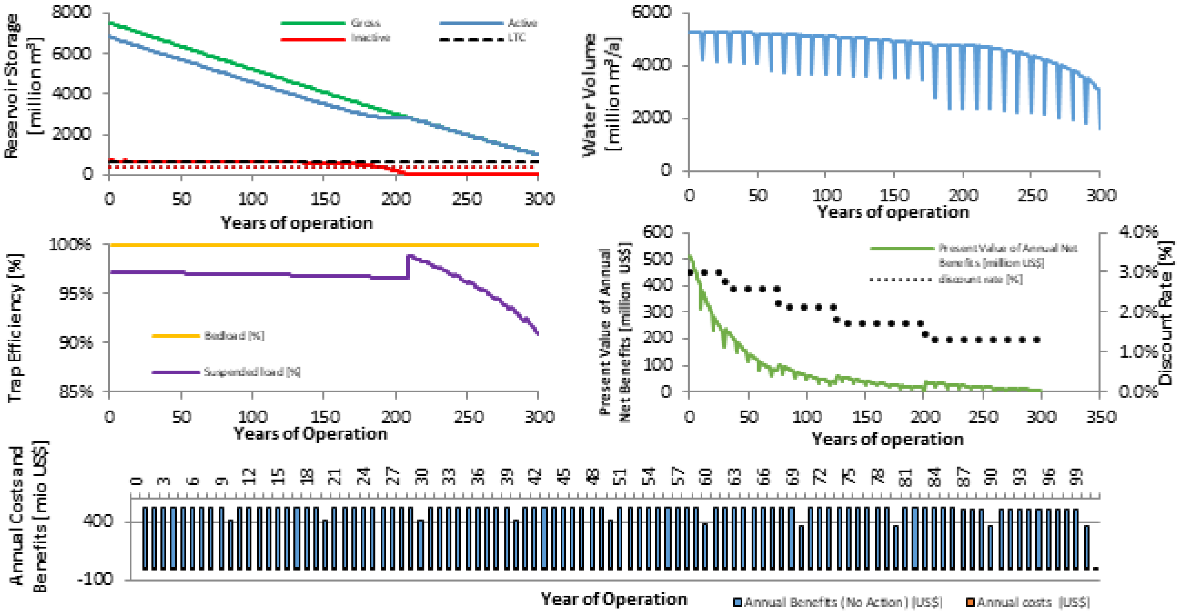


Figure 17: Flushing technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E:Annual benefit-cost diagram)

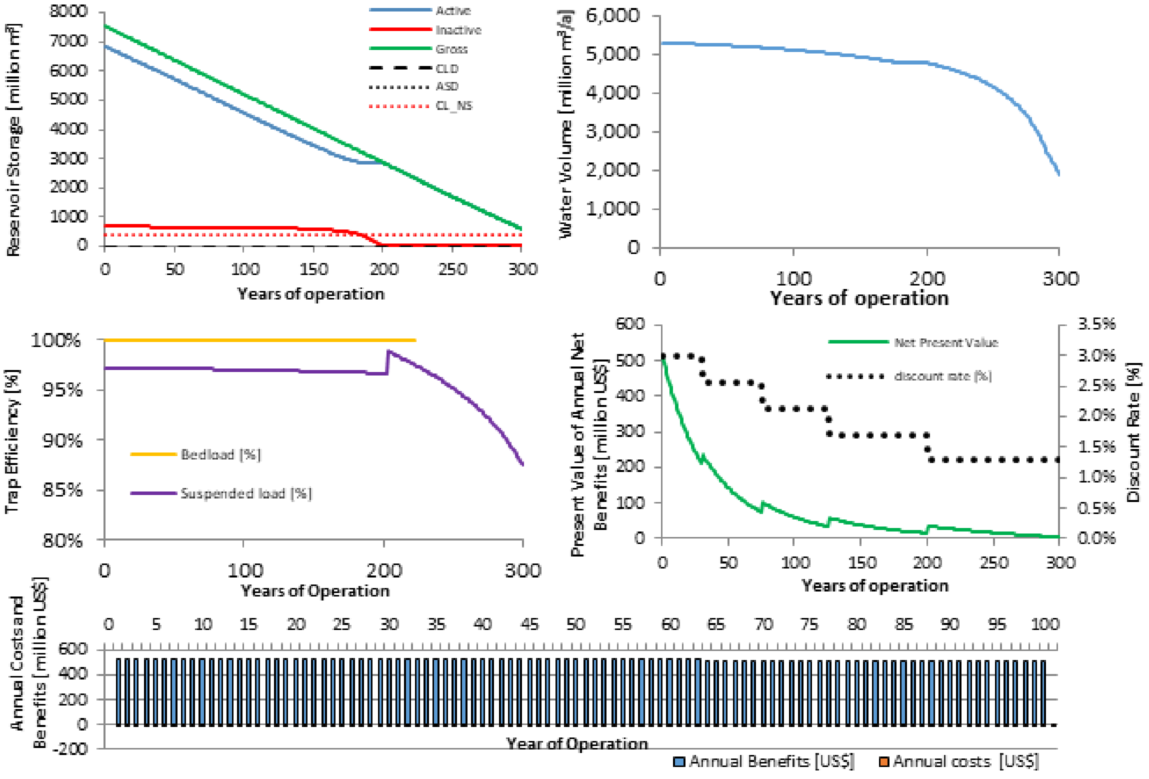


Figure 18: dredging technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E:Annual benefit-cost diagram)

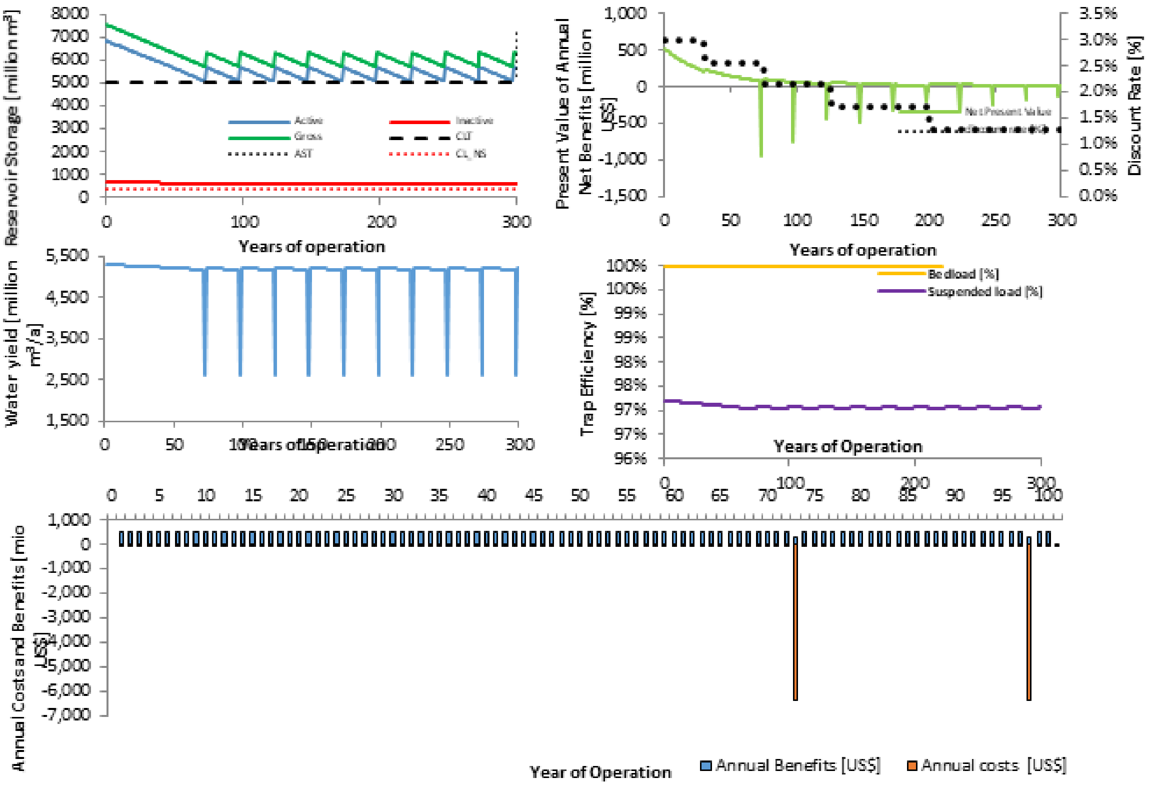


Figure 19: Trucking technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E:Annual benefit-cost diagram)

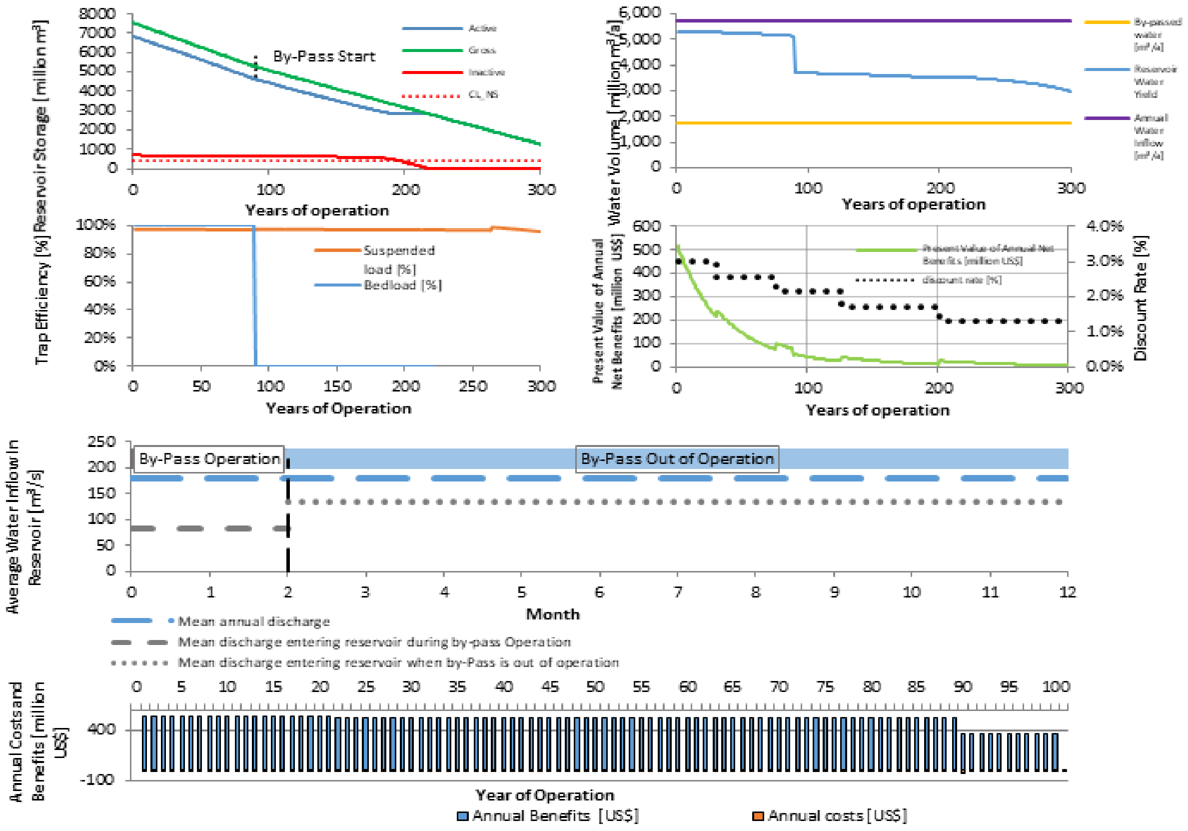


Figure 20: By-pass technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E: By-pass operation rule, and F:Annual benefit-cost diagram

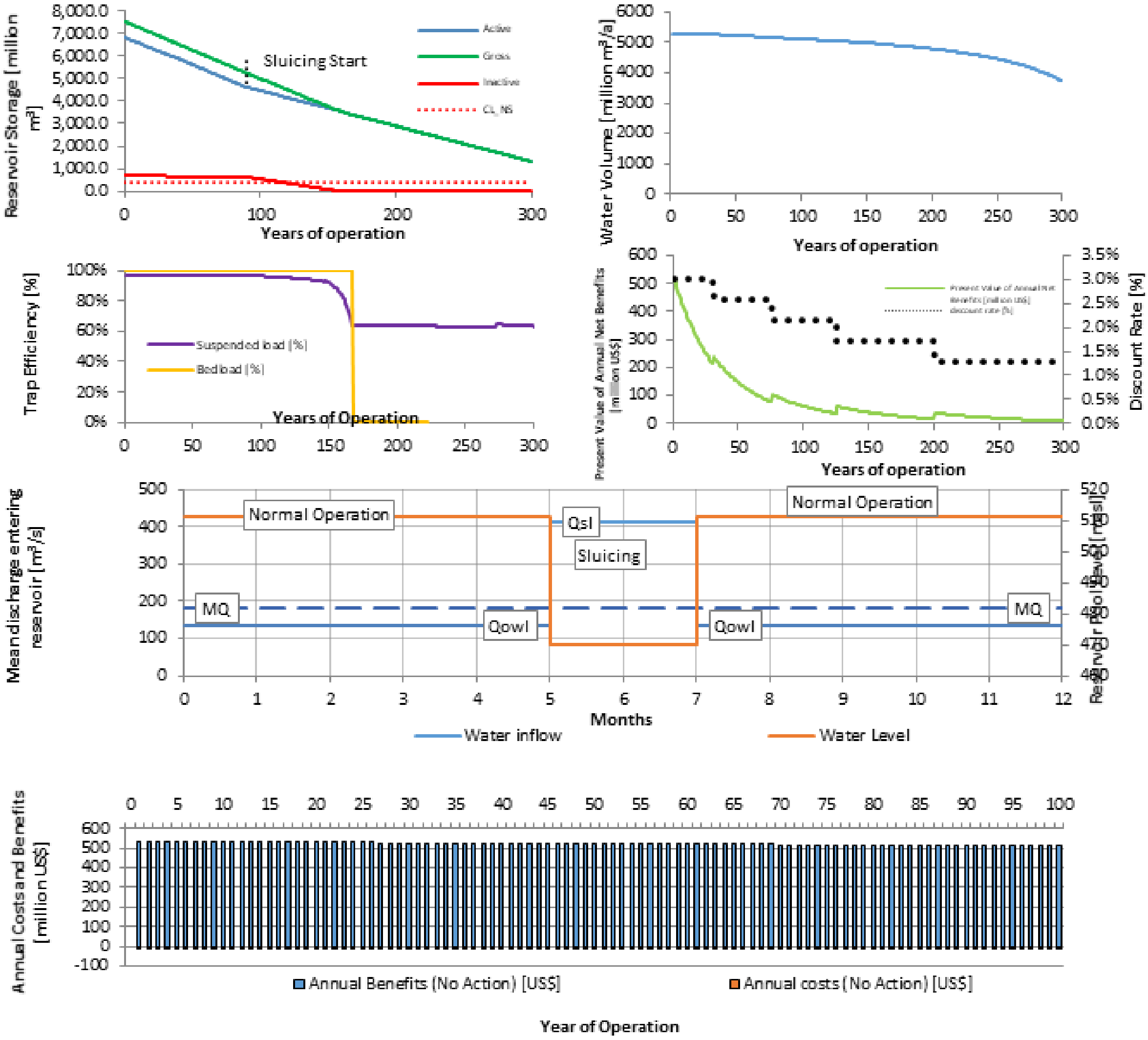


Figure 21: Sluicing technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E: sluicing operation rule, and F:Annual benefit-cost diagram)

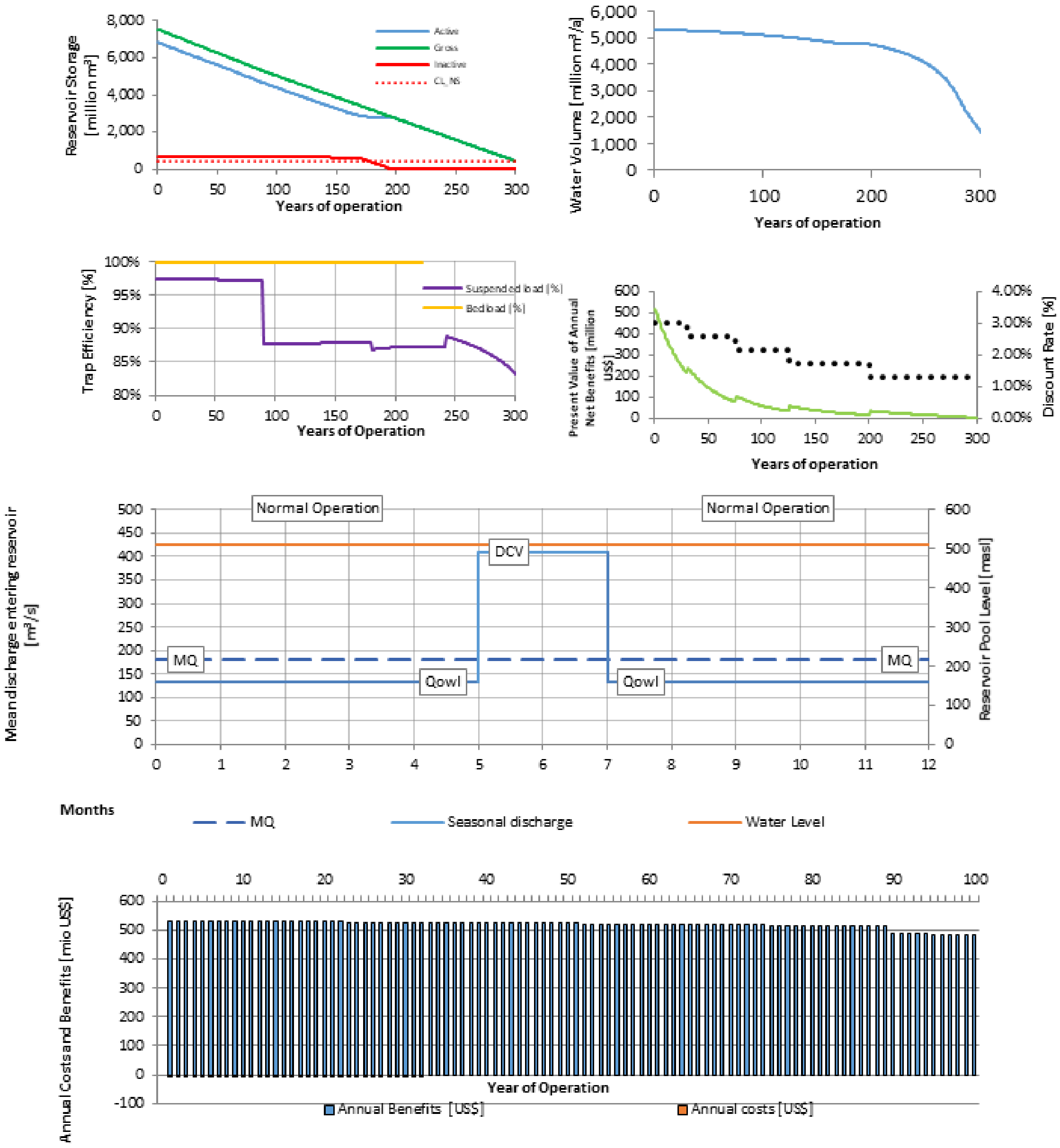


Figure 22: D.C.V. technique model output (A-reservoir storage capacities, B: water yield, C:trap efficiency, D: annual net benefit, E: sluicing operation rule, and F:Annual benefit-cost diagram)

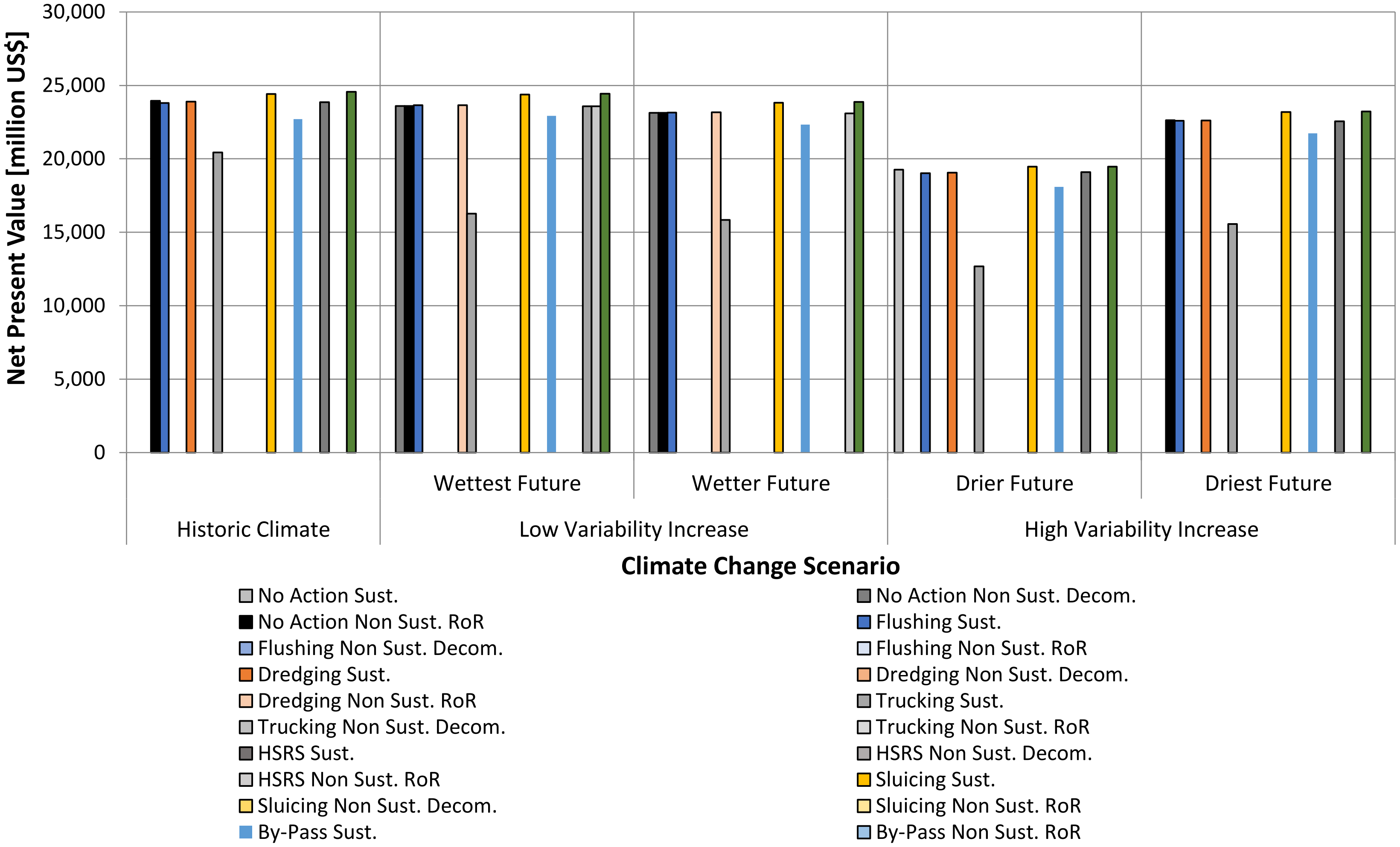


Figure 23: Climate change scenario of Dokan dam with predicted actual of sediment income

Conclusions

Dokan Dam is a sustainable project and can last longer than its design life. This might have a good impact on the water security in Iraq as well as concentrating on the structural issues of the dam. Sedimentation problems are real, and there is a need for action to eliminate them. But at the same time, it does not significantly affect the storage capacities throughout the life-wise period. Total NPV for the time period is 24,563,316,342 US dollars and the long-term capacity of the dam is 6,389,567,555 m3 with the most climate change scenarios. To eliminate the sediment income, catchment area management by the construction of check dams in those areas with high sediment production is the best and most efficient solution. Density current venting can be adopted as a sediment routing technique, while trucking has the highest net present values among the sediment removal techniques as per RESCON 2.2 beta results.

Recommendations

1- Observation data of sediment income in situ is essential for obtaining a comprehensive picture of the material properties.
2- Investment in watershed is necessary and is suggested as part of the dam rehabilitation process.
3- Density current venting should be a part of the dam operation policy to prevent the hydropower turbine's abrasion and damage.
4- Adopting climate change scenarios as a future plan for water use produces results.
5- Re-calculate the total storage capacity of Dokan Dam using new theoretical and practical methods for water resources management.
6- Adopting climate change scenarios as a future plan for water use produces results.
7- Coordinate with the ministry of planning for "water unit price" stored in reservoirs.

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