Supplementary S2 to "Impounding reservoirs – benefits and risks"
Extended summary of scientific publications on the retention function of reservoirs

Research paper	Size of the reservoir under analysis	Study area	Result
C2.1 - Water resources management			
[44]	6 reservoirs, of which 3 have large capacity and 3 have very large capacity.	The article proposes an alternative procedure for operating reservoirs in the Nakdong River catchment (South Korea) It also estimates the water demand of the different sectors (social, industrial and agricultural).	The anticipatory response scheme introduced in the event of a potential drought risk makes it possible to take preventive measures to store and secure more water resources. Depending on the stage of risk involved, the optimum reduction in water availability for the sector in question was determined, which can, however, be avoided or delayed by applying the criteria developed in the research.
[45]	3 reservoirs with a large capacity.	Using three (independent) reservoirs in Italy as an example, the operation of a model that can be used as a tool to reduce water shortages and help identify mitigation measures is presented.	The model created allows the risk of scarcity to be calculated for the system for which it was designed. A weather forecast or data simulating climate change can be used as input data. It was highlighted that the model produces results that are easy to interpret and preserves the physical meaning of the parameters obtained. An analysis of its application to multiple reservoir systems was identified as future research to develop the model's capabilities.
[46]	A reservoir with a very large capacity.	The parameter "drought limited water level" (DLWL) was considered as the water level conditioning the operation of the reservoir during dry periods. The Meishan reservoir (China) was taken as a case study.	The model considered the variability of inflow to the reservoir and the potential use of the stored water. For different scenarios, an innovative dynamic DLWL optimisation scheme was proposed to maximise the economic benefits of irrigation opportunities and energy production.
[47]	8 reservoirs with a small capacity.	This paper assesses the rationale for constructing eight small retention reservoirs in the Barycz River catchment area (Poland). A research procedure using multivariate statistical techniques was applied.	The analysis carried out showed which reservoir locations are the most favourable in terms of hydrological indicators, water quality, construction safety, as well as water storage and expected lifetime. The latter ranged from 18 to 340 years, depending on the capacity of the reservoir and its location in the river course: the higher up, the greater the potential for rapid siltation
[48]	A review article based on a large dataset.	This paper reviews more than 300 publications in the field of IT support for reservoir management and operations. The focus is on the formulation of the operations design problem.	It was shown which computer methods perform best on selected computational problems. It was also noted that there is a significant positive impact of an increasing hydrometeorological dataset on the quality of models (despite ongoing climate change). It was found, however, that the challenge is currently limited practitioner confidence in innovative models.
[49]	A reservoir with a small capacity.	This paper describes a study carried out for the Qionglin Reservoir (Kinmen Island,	Numerous investigations were carried out that successively ruled out areas of potential water leakage, such as through the dam and overflow structure or through the bottom of

		Taiwan), which has not filled with water to its intended level since 1983 and for which leakage was suspected.	the reservoir. It was also shown that water level fluctuations in the reservoir are typical of other facilities in the region. A key role for seepage was therefore ruled out. The implementation of the field studies indicated that the problem with achieving higher damming levels is mainly due to changes in the topography and shape of the catchment as a result of human activities.
[50]	A reservoir with a small capacity.	The possibility of building reservoirs in poechore was analysed, taking the Riyadh region (Saudi Arabia) as an example.	In addition to the possibility of using surface reservoirs, the use of underground facilities (fully or partially) storing water in confined aquifers was proposed. Appropriate management was pointed out as key to the effective use of storage reservoirs, which is particularly important in arid regions.
[51]	9 reservoirs, mostly with a large capacity.	The history of the development of agriculture and irrigation systems in the Ili River basin now running through China and Kazakhstan is discussed. Changes in the region caused by the construction of the Kapchagai reservoir (Kazakhstan) and a system of smaller facilities upstream (China) are described.	Over the years, different factions have gained dominance over the Ili River area, resulting in cyclical destruction and reconstruction, and ultimately in the modernisation of the irrigation system and the cultivation of a variety of crops. The operation of old damming facilities, the diversion of tributaries, the intensive exploitation of the soil and its declining fertility now creates the need for investments to ensure the economic viability of the continued operation of agriculture in this region. The effectiveness of these measures depends on the cooperation of China and Kazakhstan.
[52]	15 reservoirs with small and large capacities.	The article analyses the potential for restoring water resources in the reservoirs in Crimea (a disputed territory between Russia and Ukraine). The reservoirs have been severely depleted as a result of increased water consumption, climate change and the cut-off of water supply from mainland Ukraine.	Based on satellite imagery, it was estimated that over the period 2015–2021, the water surface area of the reservoirs in Crimea decreased by an average of 34%. To reverse this trend, attempts were made to artificially influence atmospheric conditions and locally induce intense rainfall. Two situations were identified where it was possible to provoke rain, one of which led to flooding in the city of Simferopol. However, the intended increase in the water level in the reservoir of the same name was not achieved. The lack of fresh water negatively affects agricultural productivity and soil quality, leading to financial losses and changes in traditional agriculture.
C2.2 - Climate change impacts			
[53]	A reservoir with a very large capacity.	This paper describes a study of the impact of Nierji Reservoir (China) on the regulation of flows below the dam. Atmospheric observations from 1980 to 2013 were analysed and 9 different climate change scenarios were extracted to assess the reservoir operation.	For each scenario, the Hydroinformatic Modelling System (HIMS) model was applied, distinguishing two periods–before and after the reservoir's construction. The results indicated that, with a significant increase in average temperature and a decrease in average rainfall frequency, the Nierji reservoir could effectively mitigate the negative impact of these changes on downstream flow stability.

[54]	5 reservoirs, most with a large capacity.	A hydrological simulation mapping potential changes in climate and land use was carried out, and principles for a reservoir system in the Hanjiang River catchment (China) were proposed to mitigate the potentially negative effects of these changes.	The model showed that realistic climate change scenarios will result in significant changes in the average flows in the Hanjiang River, which is particularly true for low flows in the dry season, which could be reduced by up to 30%. The proposed alternative reservoir operation rules to the standard ones (based on limited water release) offer the possibility to better adapt the system to changing environmental circumstances.
[55]	4 reservoirs with a large capacity.	The impact of climate change on the operation of four large reservoirs in the Seine basin (France) was analysed. Tree-Based Model Predictive Control (TBMPC) was used.	The results indicated that climate change could have an impact on the more frequent occurrence of low water levels and the intensification of drought. Simulations suggest that the frequency of periods when water restrictions are needed will increase from 1 or 2% to 5%.
[56]	The analyses involve hypothetical reservoirs where capacity was a variable value.	The performance of two reservoirs with the potential to be created in the Sabor River catchment (Portugal) was analysed. Data adjusted for potential change in temperature and precipitation norms were entered into the Soil and Water Assessment Tool (SWAT) model.	The model results show that for this region, only the existence of a system of two reservoirs will comprehensively solve the water supply problem. It has been shown, however, that designing the facilities based on current hydrometeorological norms may result in reservoirs with parameters that will not adequately fulfil their function in the future, that is, with advancing climate change.
[57]	A reservoir with a very large capacity.	This paper proposes the use of a hydrological model to assess the performance of the Dokan reservoir in the Lasser Zab River catchment (Iraq). Different scenarios were assumed, with the extreme one assuming a future decrease in rainfall intensity of 40% and an increase in evapotranspiration of 30%.	It has been shown that potential changes in precipitation and evapotranspiration standards will significantly affect the inflow to the reservoir and the ability to use the stored water effectively. In the extreme scenario, inflow will be reduced by 56–58%. In addition to the deterioration of the facility's ability to store water for domestic use, climate change was also found to increase the risk of facility failure.
[58]	A reservoir system with a large capacities. No exact data on the number of facilities.	This paper presents the results of a hydrological model considering evapotranspiration and outflow from a reservoir system on the Jaguari River (Brazil).	For the model, an increase in temperature between 1 and 5°C and higher atmospheric CO_2 concentrations were assumed. The results indicate that, under these conditions, a decrease in precipitation frequency results in a slight decrease in evaporation and a large decrease in reservoir runoff values (the opposite for an increase in precipitation frequency). It was also found that higher CO_2 concentrations can have a key effect in lowering mean evapotranspiration.

[59]	A reservoir with a large capacity.	The use of two different artificial intelligence-based models was evaluated: Radial Basis Function Neural Network (RBF-NN) and Support Vector Regression (SVR). The models were used to predict evaporation intensity from Layang Reservoir (Malaysia).	To develop an effective model to predict evaporation intensity without availability of all hydrometeorological parameters, two alternative scenarios were adopted using different input data, including different prediction intervals. The RBF-NN model was found to be more accurate, but requires further modifications to achieve high accuracy.
[60]	A review article based on a large dataset.	The feasibility of using different "shade covers" to reduce evaporation from the surface of the retention basins was assessed.	It was pointed out that floating or suspended covers are important in reducing evaporation and improving water quality. However, it was noted that the energy, raw material and water consumption and the overall cost of producing the covers can sometimes be disproportionate to the benefits achieved. It was emphasised that this area requires more research, also in the context of application on large reservoirs.
C2.3 - Sediment accumulation			
[61]	A reservoir with a very large capacity.	Hydrographic measurements on tributaries and Geographic Information System (GIS) technology were used to assess reservoir siltation on the Seyhan River (Turkey).	The study methodology used determined that the reservoir capacity was reduced by 0.3% between 2005 and 2017, representing a value of more than 2 million cubic metres of water.
[62]	5 reservoirs with a small capacity.	Based on existing data, interviews with facility managers and photographic documentation, the siltation process of reservoirs in Hawaii (the USA) was analysed and assessed.	The study showed that of all the reservoirs analysed (166 sites), 40% are affected by excessive sediment accumulation, of which 40% are greater than 1.23 million cubic metres in size. It was noted that in the study region, no effective measures were being taken that could reduce siltation.
[63]	A reservoir with a large capacity.	Using the example of the large Pentecoste Reservoir (Brazil), the effectiveness of a simplified bathymetric survey method using remote sensing was analysed. The degree of siltation and the morphological parameters and water balance of the site were studied.	The simplified and relatively inexpensive method was contrasted with the conventional method, which requires the reservoir to be filled and was estimated to cost US$6 million to implement for the study site. The proposed remote sensing method produced data that, despite being subject to error, demonstrates the potential applicability of the method on a wider scale for economically viable and continuous monitoring of water availability in a significant number of reservoirs prone to siltation.
[64]	A reservoir with a large capacity.	The use of the Soil and Water Assessment Tool (SWAT) model to describe the phenomenon of bottom sediment transport in the Koga River (Ethiopia), on which the reservoir is located, was analysed.	The results of the calibrated SWAT model were compared with data obtained by developing a sediment classification curve created from field observations. It was shown that the annual mean sediment transport values obtained by both methods are similar, however, the SWAT model additionally allows the identification of key erosion sources in the catchment.

[65]	9 reservoirs, mostly with a very large capacity.	Changes in the morphology of the Min River bed (China) under the influence of catchment development, including reservoirs and other factors, were analysed. Climate change was also considered and resolved, what is mainly responsible for the negative impacts on the river regime.	Reservoirs along the upper reaches of the Min River were found to have an effect on increasing low flows and decreasing flood flows. This could have positive economic and social significance, as well as offsetting the threat from potential climate change. However, it was noted that the dams on the river almost completely stop the movement of sediment. This, combined with the expansion of vegetation and sand extraction downstream, contributed to a significant intensification of the erosion process and a local decrease in the river water level of up to 4.68 m over 67 years. The analysis indicated that human activity was the main contributor to this state of affairs.
[66]	A review article based on a large dataset.	The article looks at the phenomenon of siltation of reservoirs through the prism of the measures carried out to level this phenomenon, both now and in historically distant times.	The authors argue that many patterns of actions with their roots in antiquity continue to be practised today, an example being the decommissioning/abandonment of hydraulic facilities with functionality impaired by sedimentation. This creates pressure for the construction of new facilities, in potentially inferior locations. It was also noted that the issue of siltation is not properly considered at the planning stage, and this could allow facilities with a longer maximum lifetime to be built.
[67]	A review article based on a large dataset.	Experiences on the problem of siltation of reservoirs due to sediment accumulation are collated and summarised. Remedial measures taken at various locations around the world are presented, and relevant recommendations are made.	Three groups of remedial actions were identified: (1) reducing sediment inflow from the catchment by trapping or preventing erosion, (2) reducing siltation of the reservoir by using bypass channels or flushing out already accumulated sediment, (3) restoring the site by excavation and dredging operation. It was assessed under what circumstances the method could be applied. It was concluded that decisions made at the planning stage of reservoir construction are crucial for the subsequent management of sediment transport.
[68]	A reservoir with a large capacity.	Based on a 2D numerical model, a scheme for sediment flushing from a reservoir created by a damming weir on the Saalach River (Germany) was proposed.	Circumstances were found to exist to allow effective sediment transport through the hydroelectric power station located at the weir, but the problem is the large volumes of sediment from the larger fraction. Particularly effective is the prolonged scouring of sediment through the opening of the weir gate valves. It is the timing of this process that is key so that the sediment passes beyond the damming structure rather than accumulating directly in front of it. It was suggested that a numerical model could be helpful in determining the optimum time to achieve the greatest sediment transport efficiency.