

Supplementary S3 to “Impounding reservoirs – benefits and risks”

Extended summary of scientific publications on environmental and social impacts of reservoirs

Research paper	Size of the reservoir under analysis	Study area	Result
C3.1 - Environmental impact			
[69]	A review article based on a large dataset.	The publication considers the relevance and scope of carrying out a post-development environmental impact assessment and comparing it with the predictions made at the planning stage.	It was concluded that the post-project environmental impact assessment should focus on: temperature and water quality in the regulated watercourse, variability in the hydrological regime and in the populations of fauna and flora, interference in terms of geology and landscape, as well as damage to infrastructure and migration or displacement of people.
[70]	A review article based on a large dataset.	The publication provides a comprehensive review of more than 650 articles on the environmental impact of various water facilities and systems, including artificial reservoirs.	In terms of reservoirs, it was found that the main environmental risks arising from the creation of these facilities are: overuse and poor management, unsustainable stocking with fry, as well as water pollution and fluctuations in water levels, the latter of which limits vegetation growth and biodiversity in the coastal zone, ultimately affecting the entire local ecosystem. A lower diversity of fauna and flora was indicated compared to natural lakes.
[71]	A reservoir with a very large capacity.	Publications on the environmental impact of river dams were reviewed, particularly in terms of hydrology, geomorphology, and ecosystem impacts. Much attention was given to the Three Gorges Dam on the Yangtze River (China).	Based on the literature review, it was concluded that to develop an appropriate forecasting strategy for environmental impact assessment of reservoirs. It is necessary to intensify research on the pro-environmental management of the facility and the impact of dams on downstream biota populations.
[72]	3 reservoirs with a very large capacity.	The publication analyses the environmental impact of the construction of three dams on two tributaries (Zeya and Bureya) of the Amur River (Russia–China border). Recommendations for optimal environmental flows were developed.	It was emphasised that maintaining sufficiently high water discharges from the reservoirs is crucial to preserve ecologically important wetlands and soil fertility, as well as to limit the decline of fish populations and habitat degradation of endangered bird species. To simultaneously avoid flooding of human settlements, optimum flow values on the studied tributaries were presented with a breakdown of the periods when water discharges should be higher. In this regard, it was also suggested that appropriate regulations be introduced in the Russian Federation, where the Zaya and Bureya rivers are located.
[73]	A reservoir with a very large capacity.	The occurrence of different flora species and differences in land cover in three areas–Alqueva Reservoir (Portugal) and upstream and downstream–were compared. Field surveys and analysis of historical photographs were carried out.	The number of endemic species was found to have declined in the study areas; however, they did not disappear completely–relict habitats remained. No excessive spread of invasive species was observed. The decrease in riparian woodland and the greatest loss of local species occurred in the immediate vicinity of the reservoir. Not all changes were induced by the establishment of the facility and, for example, the decrease in vegetation numbers upstream may be due to intensive water abstraction for agricultural purposes.
[74]	A reservoir with a very large capacity.	Environmental changes in the impact area of the Three Gorges Reservoir on the	Approximately 97% of the reservoir’s catchment area (56,500 square kilometres) was shown not to have been significantly altered after its creation. A trend towards expanding the area

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		Yangtze River (China) were studied. The change in land use before and after the construction of the facility, i.e. between 1999 and 2017, was compared.	covered by vegetation was shown, influenced by, among other things, the ecological restoration project and favourable changes in microclimate, i.e. average temperatures and precipitation. This was a result of the accumulation of significant amounts of water in the reservoir. Possible vegetation degradation has occurred in inhabited areas as a result of the expansion of the urbanisation process.
[75]	A reservoir with a very large capacity.	The effects of converting natural lakes and wetlands into the Chotiari Reservoir (Pakistan) were analysed. Aspects such as vegetation degradation and growth of the wetland and saline area were considered.	The results of studies based on the use of remote sensing and geospatial tools have shown that areas of a complex ecosystem have been flooded without rational justification. The extent of the wetland and saline area has increased significantly compared to the original state. This has resulted in the conversion of fertile agricultural land into unproductive and saline soil.
[76]	A reservoir with a small capacity.	Based on a phytosociological analysis and an ornithological inventory, the environmental impact of the Jagodno reservoir (Poland) was assessed after one year of use of the facility.	As conclusions of the study, it was pointed out that populations and bird species increased in the area after the reservoir was filled. The spontaneous appearance of previously unrecorded plant species in the region was also found, and the positive impact of the facility on landscape aesthetics was highlighted.
[77]	A reservoir with a large capacity.	The abundance of bird species occurring near the Goczalkowice reservoir (Poland) is presented. The influence of human activities on changes in the abundance of avifauna was considered.	A total of 101 aquatic and muddy bird species were found in the study area. Particularly high abundance was observed in the year accompanied by lower water levels and during the dam renovation. After the renovation was completed and the reservoir was filled, the number of species and their abundance decreased, but the reservoir still provides an important habitat for avifauna. An artificial sand and gravel island has been suggested as a solution for safe birds' broods.
[78]	A reservoir with a large capacity.	Changes in the abundance of fish populations found in the Feitsui Reservoir (Taiwan) were assessed. The study covered different periods over 14 years and was conducted using gillnet sampling.	Thirty-eight species were diagnosed, the dominant ones being those of the <i>Cyprinidae</i> and <i>Cichlidae</i> families. The long-term effects of the appearance of alien species on native species were determined. After four years of the study, a change in the dominant species was found, and in 2014 the emergence of the species <i>P. managuensis</i> was noted, which is correlated with a gradual decline in <i>Carassius cuvieri</i> .
[79]	A reservoir and dam system. No precise data on the size of the facilities.	Based on a case study involving reservoirs and dams in the Douro river catchment (Portugal), a model was tested to predict improvements in the morphological permeability of watercourses as a result of removing existing facilities.	The model was applied to the four constituent catchments of the Douro River Basin and took into account socio-economic, land-use and improved mobility of diadromous fish. It was shown that in only one of the four catchments could the removal of damming facilities measurably improve the permeability of the watercourse, but this is associated with the risk of expansion of invasive fish species.
[80]	A reservoir with a large capacity.	Field and numerical surveys were carried out to determine the best location for the	Based on studies of the maximum and minimum swimming speeds of eight native fish species, it was concluded that the optimum flow velocity at the inlet to the fish ladder

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		fish ladder, where flow velocities optimal for the species found in the Gujun Reservoir (China) would be maintained.	should be between 0.14 metres per second and 0.3 metres per second. A simulation exercise identified the best location for the fish ladder to provide unimpeded passage for fish.
[81]	A reservoir with a large capacity.	The correlation of fluctuations in the damming level of the Doumen urban reservoir (China) with groundwater levels in the study region was analysed. The impact on possible changes in groundwater quality was also investigated.	A high degree of correlation between the dynamics of water level changes in the reservoir and groundwater level fluctuations with a lag time of about 7 days was indicated. This influence is greater than that due to precipitation, and the groundwater level is steadily increasing. The impact of the reservoir on groundwater quality in the surrounding area was also found to be gradually increasing, covering a larger area over the years.
[82]	A reservoir with a large capacity.	Based on studies carried out in the karst area of the Mabie River reservoir (China), the environmental impact of the facility was analysed, particularly in terms of its impact on groundwater and the stability of mountain slopes.	Apart from minor exceptions, no major slope stability problems were identified in the reservoir area and the chance of leakage was described as low. A decrease in groundwater levels during the construction phase was also identified; however, these resources were quickly encapsulated without any negative impact on the surrounding vegetation. The chance of the rapid spread of possible contaminants in the groundwater was identified as a risk.
[83]	A reservoir with a large capacity.	A model-based study of the impact of the operation of a mountain retention reservoir on the Heihe River (China) on groundwater levels in the loess region was carried out. Groundwater levels before and after construction of the facility were compared.	Through field research, the correct calibration of the model was confirmed. Based on the latter, it was indicated that, in the study area downstream, the average groundwater level has decreased by approximately 6 m since the reservoir was constructed. It was concluded that the formation of such facilities in mountainous regions can have a particularly strong impact on groundwater levels and the exploitation of springs in the lower section of the watercourse.
C3.2 - Greenhouse gas emissions			
[84]	A review article based on a large dataset.	The publication estimates global GHG emissions from reservoirs and describes the methods in operation for assessing emissions.	Global greenhouse gas emissions from the surface of functioning reservoirs were found to be in the range of 0.5 to 1.2 Pg CO ₂ equivalent per year, mostly consisting of methane. It was also determined that the phenomenon of eutrophication significantly increases emissions.
[85]	A review article based on a large dataset.	This paper reviews publications in the field of greenhouse gas emissions from fresh surface waters, with a focus on the Indian area. Research gaps are identified, and further direction is suggested in this area..	Based on the review, it was concluded that India’s inland waters emit approx. 4% of global greenhouse gas emissions, most of which are CO ₂ (56%) and CH ₄ (19%). Surface waters are also sinks for CO ₂ , and emissions are intensified by pollution and eutrophication phenomena. It was emphasised that these are estimates and future research in this area of knowledge should address: (1) analyses of rivers from source to estuary, (2) intensification of estimates for emissions of greenhouse gases besides CO ₂ and CH ₄ , (3) inclusion of

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			seasonal variations in models, (4) intensified emissions at hydropower outflows, (5) gas sequestration as a mitigation strategy.
[86]	8 reservoirs, mostly with a large capacity.	Based on a study of a system of eight reservoirs on the Wujiang River (China), an empirical method for estimating CO ₂ emissions from reservoirs equipped with hydropower plants was proposed.	The results indicated that CO ₂ emissions are higher for a reservoir with a longer hydraulic retention time and a lower normal damming level. This was found to indicate the importance of these parameters in the phenomenon under study, and the use of this knowledge provides a basis for proper reservoir management to reduce CO ₂ emissions.
[87]	A reservoir with a very large capacity.	CO ₂ emissions caused by the hydroelectric operation of the Balbina reservoir (Brazil) located in the tropics were estimated.	Based on field research, model and statistical analyses, the annual CO ₂ emissions resulting from reservoir operation were found to be 2531 Gg, of which 81 Gg C were emissions below the dam cross-section, comprising 51% of the phase transformation at the outlet of the hydropower turbine.
C3.3 - Socio-economic aspects			
[88]	A reservoir with a small capacity.	The tourism potential of Gerokgak Reservoir (Indonesia, Bali) was analysed considering three aspects—economic and operational, biological and ecological, and social and cultural.	Based on the Rapid Impact Assessment Matrix (RIAM) method, economic and environmental aspects were found to have a particularly high impact on the investment potential. In the analysis, they received a grade of C+ indicating a “very positive impact”. For the social aspects, the impact was identified as A+, i.e. slightly positive. It is assumed that the operation of the reservoir without environmental conflicts will be important for the development not only of the local community but also of the whole island of Bali.
[89]	A reservoir with a large capacity.	To assess the impact of the construction of the Aposelemis reservoir (Greece) on its impact areas, a survey methodology of residents was carried out, asking in detail about feelings and observations related to the period before and after the construction of the facility.	Questions addressed environmental changes, fluctuations in river flows, availability, and quality of water resources, impacts on agriculture, and personal perceptions. The questionnaires showed that there was a perceived improvement in water supply to urban areas and improved flood safety among residents, as well as an increased desire to consume tap water. At the same time, there was also concern among people living near the dam and observations of various environmental changes, such as the appearance of more insects.
[90]	A reservoir with a large capacity.	This paper conducts a modelling study on the long-term potential impact of reservoir construction on a local farming community in Thailand.	The results indicate that as a result of the construction of the reservoir, the total income of farmers will increase over the next 30 years, mainly due to access to water and the possibility of exploiting dry land. However, the possibility of inequality in the compensation policy was noted and, without a change in the policy, some people would be compensated unequally in relation to their losses.
[91]	A reservoir with a large capacity.	This paper analyses two groups of people impacted by the construction of the Danjiangkou Reservoir (China)—those displaced close to their original place of	The results of the study indicated that the group of people who remain around of the reservoir were particularly affected in terms of financial, emotional and housing conditions. It was also indicated that those displaced a short distance experienced a rather positive impact of this circumstance on the aforementioned aspects. The results challenged

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		residence and those who remained despite the proximity of the facility.	the notion that only people displaced over long distances were the most unfairly treated group.
[92]	5 dry reservoirs, of which 4 have a small capacity and 1 has a large capacity.	This article is about a survey methodology conducted on three groups of people living in 3 different locations in Poland. The first was a village created for people displaced by the construction of the reservoir. The second was a municipality where the reservoir was built, and the third was two municipalities where a social movement prevented the construction of the reservoirs.	The surveys carried out confirmed the poor public awareness of the rights that people forced to relocate have. The issue of awareness of the public importance of the investment was shown to be important in terms of the potential impact on consent to resettlement, as was the issue of possible improvements in material status. Although the majority of resettlers spoke at least neutrally about the impact of relocation, there were also people indicating dissatisfaction and a deterioration of psychological well-being.
[93]	A reservoir with a large capacity.	The impact of the Nandoni Reservoir (RSA), established in 2005, on the life of the local community and on the potential development of the region and rural areas, as well as poverty alleviation, was analysed.	It has been shown that while the operation of the reservoir has indeed provided tourism development and new jobs, it has not significantly improved the quality of life of local communities. Furthermore, these communities were indirectly marginalised through the lack of financial opportunities for recreational use of the facility. Politicians and businessmen were identified as the main beneficiaries of the investment.
[94]	A reservoir with a very large capacity.	Based on social research, interviews with fishermen and informants, as well as conducting public discussions, stakeholders’ attitudes towards the legal regulation of fishing in Kaptai Reservoir (Bangladesh) were assessed.	The reservoir is suffering from a loss of biological diversity, and the studies carried out indicate that fishermen more or less consciously disregard regulations to maximise fishing and the profits that go with it. A very low level of surveillance and enforcement was found, as a result of which prohibited fishing practices and activities during theoretically prohibited periods, e.g. during the spawning season, are common practices.