Ten Rules-of-Thumb to Select Better Hydro Projects

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Abstract

Hydro projects are getting a bad reputation for downplaying the social and environmental impacts. While there are many lengthy textbooks and technical papers on how to select better hydroprojects, this brief summary seeks to condense them into a readable whole as only ten rules-of-thumb. These are: adopt best practice, perform regional planning, modernize existing hydro before contemplating new projects, dam tributaries before the mainstem, uphold human rights especially free, prior informed consent, avoid conflict zones and no-go areas, promote irrigation before electricity, manage climate change and mitigation, conserve biodiversity, manage reservoir size and reduce hydraulic head.

1. Adopt Best Practice

Follow “Best Practice” to the fullest extent possible. This includes utilizing best technology, as per Rule 10 below. All dam proponents and financiers need environmental and social policies, managed by separate environmental and social scientists. Much best practice for hydro selection, planning, construction, monitoring (starting with adequate pre-project surveys which are required if progress is to be measured), including panels of social and environmental experts, is well codified by the World Commission on Dams (2000), with a 10-year review by Moore et al. (2010). Follow best practice throughout the Environmental and Social Impact Assessment (ESIA) process -- beginning with adequate pre-project demographic, environmental, health, stakeholder, and socio-economic baseline surveys, then throughout construction, operations, and decommissioning. Teams who have worked in any one country should uphold or strengthen standards when working on dams in foreign countries; avoid double standards. One size does not fit all, so it is important to follow an adaptive management approach (WCD, 2000).[1]

2. Perform Regional Planning

Promote consideration of a wider range of options than sole focus on a single already selected dam. Reduce environmental impacts by cramming as many dams as feasible on the smallest number of rivers in a country or region. The first dam on a river normally has the biggest impact, compared with the impacts of subsequent dams on the same river. Often, the first dam imposes most of the impact of a cascade of dams. But scrutinize social risks beforehand. Interpolating one more dam into a cascade generally is lower impact. The highest impacts would be to site a single dam on each of the nation’s rivers. Interpolation of a dam between two existing dams or shortly upstream of an existing dam greatly reduces the impact of the new dam. Cumulative, Regional and Downstream ESIAs are essential. The goal is to leave a representative sample of a nation’s rivers in their original free-flowing state.

3. Modernize Existing Projects Before Building New Projects

Rehabilitate, refurbish, renovate or upgrade existing hydros before going ahead with new hydros. Adding new turbines or replacing old turbines with more efficient or bigger ones is almost always much lower impact than

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[1] Longer term environmental impacts (e.g., downstream erosion, decommissioning, decline of reservoir fisheries) are ignored or demoted by current conventional use of discount rates. Environmental flows in deferent seasons, fish passage facilities, proper assessment of Run-of-River projects (Annex 1), which are not necessarily environmentally friendly.

building new dams. Rehabs should normally be well in hand before a new dam is contemplated, just as energy conservation and demand management should be well in hand before new generation is permitted. For example, it has been calculated that 70,000 MW could be developed in the USA by rehab alone, with no new dams. Now that Venezuela's 8,900 MW Guri hydro complex, Nigeria's 760 MW Kainji and the 1,266 MW Zambia/Zimbabwe Kariba hydros, for example, are several decades old, they are being usefully upgraded with low impacts. Sweden's modernization of their 1957 Storuman hydro will add 8 GWh/year. New York State announced in 2012 that it has prioritized a $200 Million project to refurbish 125 ageing dams.

4. Dam Tributaries Before the Mainstem

Develop dams on tributaries before dams on the mainstem. For example, the 78 tributary dams proposed for the Mekong may have a bigger impact than a few mainstem dams. (There are four on the Lancang already).[2] Dams at different locations have different trade-offs between power generation and the loss in fish biodiversity and productivity. Dams with better trade-offs should be built first when the energy demand is relatively low. Cancel building those with the worst trade-offs. If the dam creates water pollution, then being further up a tributary may pollute more river than a dam lower down; that tradeoff must be assessed well in advance. If a mainstem dam is necessary based on comprehensive options assessment, it should be sited as far upstream as feasible. That will often impose less impact. Outstream diversions may be high impact.

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[2] . China's Yangtze case shows the importance of sequencing tributary dams before damming the mainstem. The world's biggest dam, Three Gorges, is the second on the Yangtze River's main stem. The first, 2715 MW Gezhouba, is 38 km downstream from Three Gorges and was completed in 1988. Construction of Three Gorges dam began in 1994; generation began in 2003; full output of 22,500 MW by 2012. Now c.300 tributary dams are planned or under construction. In 2011, the Government of China about-faced, admitting that the Three Gorges Hydroproject is causing massive social and environmental impacts, so fix-up money is flowing.

5. Uphold Human Rights, especially Free Prior Informed Consent

Seek free prior informed consent (FPIC) from stakeholders, as well as meaningful consultation. Reject any use of force, and reject any measure that would be involuntary. Choose sites with little or no need for resettlement. All resettlement must be strictly voluntary (UN DRIP)[3]. As soon as oustees consent to their move, it should proceed expeditiously. Oustees must promptly become better-off project beneficiaries as soon after their move as possible. If the dam is built and owned by Indigenous People or ethnic minorities (e.g., Canada's Minashtuk Hydro) other rules will apply.

6. Avoid Conflict Zones

Avoid conflict zones and militarized areas. Ensure effective grievance mechanisms and respect for human rights. All potentially impacted stakeholders (upstream, reservoir basin, downstream, and other (including those living along transmission lines and project roads) must be consulted and participate in decisions affecting them from the options assessment stage, to get away from a project-centered perspective, thru pre-feasibility and construction and afterwards. Free prior informed consent (FPIC) is the goal provided by UNDRIP partly in order that there will no need for involuntary displacement. The use by hydro proponents of mercenaries and armed forces should be banned. Avoid "No-Go Zones" for hydro projects,

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[3] Free prior informed consent (FPIC) is the goal as provided for by UNDRIP partly in order that there will no need for involuntary displacement. Involuntary anything implies the use of force as a tool in development. The United Nations Declaration on the Rights of Indigenous Peoples was adopted by the General Assembly in 2007 and has now been ratified by most nations. www.hreoc.gov. au/social_ justice/ declaration/ index.html. FPIC is the centerpiece.

such as Indigenous Peoples ancestral domains, World Heritage sites etc.

7. Promote Irrigation Before Electricity

Many dams are labeled “multipurpose” nowadays, suggesting that the purpose of the dam in question includes more than one purpose, such as generation of electricity, flood control, water supply, fisheries, navigation and irrigation. This can be misleading because in operating the dam, power generation is almost always the topmost priority, as compared to secondary uses such as irrigation. Electricity generation earns by far the most revenue. Some hydroelectricity revenue is best allocated to promoting other uses, such as irrigation. Both irrigation and hydro regularize steam flows, a major impact, so go together. It can be complicated if hydro is needed to provide the finance for irrigation. Energy ministries are often more modern and dynamic than irrigation and agriculture ministries. Most so-called “multipurpose” dams indeed have more than a single purpose, but the other purposes are subsidiary to power generation.

In many poor rural areas, water to grow domestic food is more important than electricity. Irrigation often depends on water storage during the wet season for release during the lean season. While it is possible for irrigation to be combined with hydro in multi-purpose schemes, there are often inherent incompatibilities between generation of electricity and provision of irrigation water when water is scarce but most needed during the dry season. When dam operators must choose one over the other, electricity generation almost always trumps irrigation. This is important in several ways, especially when in contrast to hydro electricity generation, there are few alternatives to water storage dams, and agricultural intensification for local food production[4] is much needed as world population may exceed 9 billion by 2050.

8. Manage Both Climate Mitigation and Climate Adaptation

All new dam designs nowadays need a thorough greenhouse gas (GHG) emissions assessment. Choose low emissions designs. The best proponents have a carbon-neutral corporate policy. Dams likely to emit as much GHG as a coal-fired equivalent should not be developed. Conversely, dams likely to emit less GHG than a gas-fired equivalent should be promoted. Reduce the amount of biomass in the reservoir before filling. More than 27 European nations and Australia, and many jurisdictions (e.g., Vancouver) now mandate a charge for GHG emissions. Hydro must internalize its GHG emissions in project design and cost/benefit analysis.

The best hydros will be designed to take climate change into account. Hydros are designed based on the best historic river discharge data obtainable. Now climate change has arrived, the best hydros will be designed using the most reliable predictions of climate change on the future of river flows. Extreme events (heavy rains, storms, droughts) may become more frequent. Appropriate adaptation strategies will include diversified and decentralized investments, to promote resilience and avoid putting all eggs into one basket in a time of increasing hydrological uncertainty.

Big storage reservoirs are unlikely to be the answer because climate changes are so unpredictable, long life-span big dams cannot be substantially modified, whereas short-lifespan infrastructure can be replaced

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[4] Irrigation dams for export commodities in the expectation that some of the profits of export companies will trickle down to enable the poor to buy imported food are lower priorities than water storage for domestic food production. If the goal is to reduce poverty, reduce it directly, not try some roundabout and leaky route of subsidizing big electricity consumers, in the hope that a fraction of the gains might eventually trickle down to the poor. Another tradeoff to be tackled is that Irrigation and multi-purpose dams often have bigger impacts from their extensive storage reservoirs than smaller reservoir hydro dams.

in the long term as the climate changes. Heavy reliance on hydropower creates significant vulnerability to climate change. High dams and extensive reservoirs are exceptionally capital intensive and are impossible to move if climate change renders the hydro useless or dangerous. Flexibility in the face of climate change by means of fully renewable energy systems, and by choosing hydro with low or no dams (See Rule 10 below), and small or no reservoirs is the lowest cost way to confront climate change.

More freshwater is available as green water (in fields and plants) than as blue water (in rivers and lakes). Water can be stored through techniques that maintain soil humidity, underground in aquifers, in local ponds, and in small reservoirs. Watershed management and reforestation will be key here. Most British freshwater has been obtained from off-stream storage for hundreds of years. There are better options for climate resilience beyond large dam storage. Groundwater storage can be achieved with many small decentralized recharging structures and rainwater harvesting. Another huge source of water storage is soil moisture. One of the best ways in which soil moisture retention can be increased is by switching over completely to organic farming and organic fertilizers. This has a double advantage - it avoids the use of chemical fertilizers, mostly derived from fossil sources thus reducing carbon emissions, and an enhanced soil moisture regime gives much better resilience to crops, especially in the face of increasing temperatures.

The World Water Forum's Ministerial Declaration stated on 13th. March 2012: "we need to build resilience to climate change and variability including through a more flexible and integrated land and water resources management system, by adopting strategies on both adaptation and mitigation, improving water use efficiency, regulation and storage, inland navigation, ecosystem services, wetland, forest and mountain ecosystems restoration and conservation as well as agricultural practices." [5]

9. Conserve Biodiversity

Choose sites with little or no valuable biodiversity habitat (such as tropical forest). Lower the dam height or move the dam to minimize forest loss. If some forest loss cannot be avoided, finance compensatory offsets that provide better benefits than the area inundated. Conservation units (e.g. National Parks, UN World Biosphere Reserves, UN World Heritage sites, protected forests and other No-Go Zones) should normally always be avoided.

10. Minimize Reservoir Size and Hydraulic Head

Reservoir area is the single best proxy for most social and environmental impacts; therefore dam proponents seeking to minimize impacts will minimize reservoir area. High dams with extensive reservoirs create the most severe impacts; hence will be abandoned by all who seek lowest impact. Select no-head, ultra-low head (c.3 m), and micro-hydro -- all before higher-head hydros (Abbasi, 2011). Hydros in which the reservoir fills the riverbed up to the annual wet season level are usually low impact. In the paramount tradeoff between reservoir area and impacts, reduce reservoir area by optimizing flow (by tube turbines), and reducing head, preferably to zero. Optimize the potential of hydrokinetic turbines or non-dam hydro. Select engineering (e.g., by kinetic turbines, which do not require any head of water as they are powered by the flow of water) to reduce the size of the reservoir area. The use of kinetic energy by means of axial tube turbines sitting in the riverbed, with little or no dams and

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[5] www.worldwaterforum6.org/en/news/single/article/the-ministerial-declaration-of-the-6th-world-water-forum.

reservoirs is the least impact way of the future.[6] Traditional tidal power schemes, such as the UK's proposed Severn Barrage, are controversial since they involve building barrages across estuaries that destroy upstream wetland ecosystems. Building dams perpendicular to the coast that do not enclose any waters, hence can impose very low impacts.

Caveat

Pithy "Rules-of-Thumb" suffer from simplification and these are no exception. Although these Rules-of-Thumb apply only to hydroelectricity dams, and not to irrigation dams, they would also all apply with minor revisions to most development projects (except Rule 10, which is entirely hydro-specific). These Rules-of-Thumb apply only to hydroelectricity dams which supply about 20% of world electricity, and for which there are many alternate sources of electricity, particularly renewables (e.g., solar, wind, wave). They apply mainly to big dams, rather than to microhydro, which impose lower impacts. The "Rules-of-Thumb" are offered mainly to hydro designers, hydro financiers and those seeking to reduce the impacts of big hydro. Renewable energy is fast becoming more feasible as climate change, democracy and biodiversity are accorded more importance.

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[6] Wave power is well explained by Previsic et al. (2012). Ocean wave energy offers a low air pollutant option for diversifying the U.S. electricity generation portfolio, and the "theoretical ocean wave energy resource potential exceeds 50% of the annual domestic energy demand of the United States". Here are a few worldwide examples. **(a)** Brazil's Santo Antonio hydro on the Rio Madeira sought to reduce flooded area mainly to prevent impacts upstream on Bolivia, by using 44 kinetic (tube) turbines of 71.6 MW each for a rated capacity of 3,510 MW. The tenth turbine entered commercial operation in January 2013. Most of the reservoir lies inside the existing river channel. The first turbine was installed in March 2012. **(b)** The US Federal Energy Regulatory Commission includes 240 hydrokinetic energy projects. **(c)** South Africa is building a 1MW hydrokinetic turbine in the Agulhas Current off Durban. Units of 8 MW each can subsequently be added, all 30 meters below sea level. **(d)** In October 2012, China and the Netherlands agreed to build a 15-GW hydrokinetic plant off the Chinese coast, by means of a 30-km by 60-km T-shaped dam.

Annex 1: Run-of-River (RoR) Hydropower Projects

Strictly speaking RoR means little or no storage; what water enters, flows out without being retained behind a dam, either through the turbines or the spillway or whatever. RoR *should* be used to mean: "a water supply taken directly from a river with no significant attempt to store water or regulate flow". No storage or no reservoir means low impact because no land is impounded for storage, no resettlement, no habitat loss, no impediment to fish, no decrease in the nature of river flows, and no GHG emissions. Because RoR has erroneously become associated with "Good Dams" it has become meaningless.

RoR has been misused at least since 1994 when RoR was applied to massive storage dams over 60 m high on the Mekong River (MRC 1994). More recently China labeled one of the world's biggest dams -- Zangmu -- as RoR. Sierra Leone's 400 MW Bumbuna dam -- 88 m in height -- is called RoR. RoR is now misused to imply that after the reservoir is full, what water enters will eventually flow out, with no additional storage, no out-stream diversion, and only brief (days or weeks rather than months or years) retention time.

RoR are more common in water courses which are not markedly seasonal. During a strong dry season ROR would not generate electricity. This implies that RoRs have a weir or small headpond in which water is spilled or released downstream all the time. During the wet season, RoRs can serve for peaking. But a disadvantage of RoR is that they cannot reduce flooding as big storage reservoirs can. The best RoRs hydros are those just below big storage dams which release constant flow whatever the season, therefore do not need storage or impoundment. Sometimes small water storage is called pondage: see below.

Pondage is a relatively small volume of water stored behind a low weir. Pondage refers to water storage for short periods of time -- hours or days -- sometimes weeks. Pondage explicitly excludes seasonal or annual storage. Pondage is the holding back or storage of relatively small volumes of water for later release for power development above a low weir of a hydroelectric plant either to equalize hourly, daily or weekly fluctuations of streamflow, or to permit irregular hourly use of water to manage fluctuations in load demand.

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About the author: Robert Goodland, served the World Bank Group as environmental adviser for 23 years, where he drafted and persuaded the Bank to adopt most of its current mandatory social and environmental "Safeguard" policies, including the policy on the social and environmental aspects of dams and reservoirs. He helped set up the World Commission on Dams in Cape Town. He was Technical Director of the independent Extractive Industry Review of the World Bank's oil, gas and mining portfolio (EIR.org).