

Assessment of small versus large hydro-power developments

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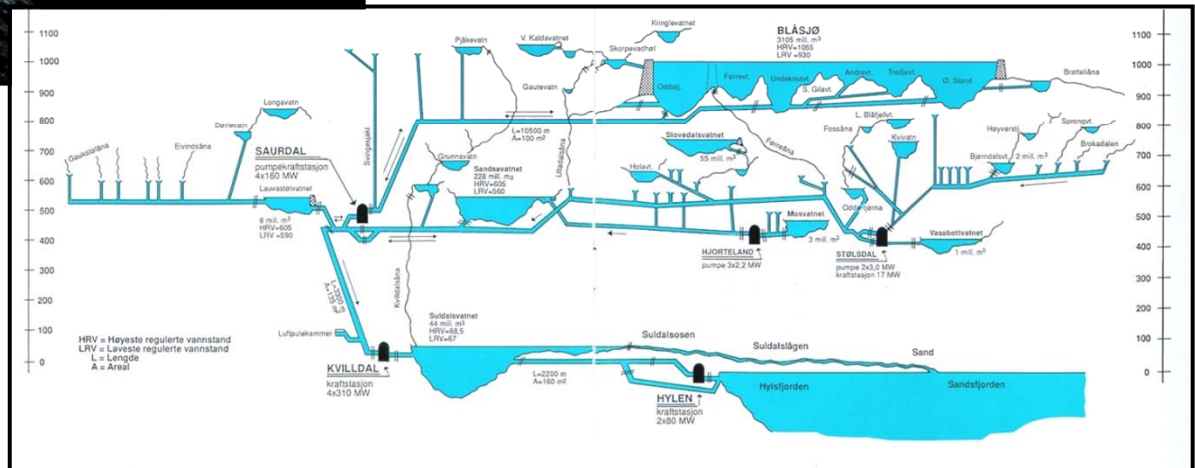
Large plants – large impacts?



Long history of conflicts

Resistance formed the environmental movement

Source: Statkraft



Development of Alta-Kautokeino river basin, Norway



Three Gorges project, China

China's dam busters protest controversial resettlement project

It is the world's largest building site, a showcase for the 'new' China. But rising around the Three Gorges Dam project

By Calum MacLeod and Lijia MacLeod

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WATER WORLD

Farmers protest over Three Gorges Dam relocation: residents

by Staff Writers

Beijing (AFP) March 4, 2009

Farmers relocated to make way for the Three Gorges Dam, the world's biggest [hydroelectric power](#) project, clashed with police in a protest over alleged corruption, locals said Wednesday.

Between 1,000 and 2,000 people protested in Jiangnan township in central China's Chongqing municipality on Monday and Tuesday, leading to clashes with police, they said.





Small plants – small impacts?

Accumulated effects?

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Accumulated effects?





Small plants – small impacts?

Accumulated effects?









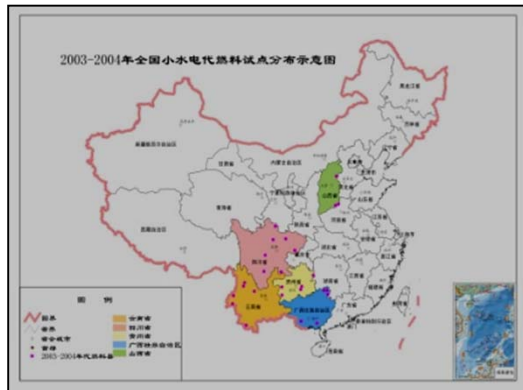




An extreme example from China

Small hydropower (< 50 MW):

- More than **1000** plants built
- Producing **2.5 TWh/a**



Large (enormous) Three Gorges:

- **1** huge plant
- Producing **96 TWh/a**



In order to produce the same energy output from Three Gorges project, approximately **40 000 small** hydropower plants (< 50 MW) must be constructed.

What are the accumulated environmental (and social) impacts?

Climate change asks for development of renewable energy

How to realise the EU Renewable Energy Sources (RES) Directive?

Large hydropower?



Many small-scale?



Wind power farms?



Approach for comparison

Similar volumes of energy production



**Environmental impacts from one large
plant compared to accumulated impacts
from many small**

Approaches for comparison

Comparison of environmental impacts across types of energy (electricity) production technologies:

- Few studies published
- Lack of mature and well-proven methodological frameworks
- IPCC SRREN-report (2011) suffers from lack of studies

The quality of the energy production should also be considered:

- Regulated versus non-regulated
- Security/reliability of supply / hydrological risk
- Access to grid with sufficient capacity

Comparison of environmental impacts (1)

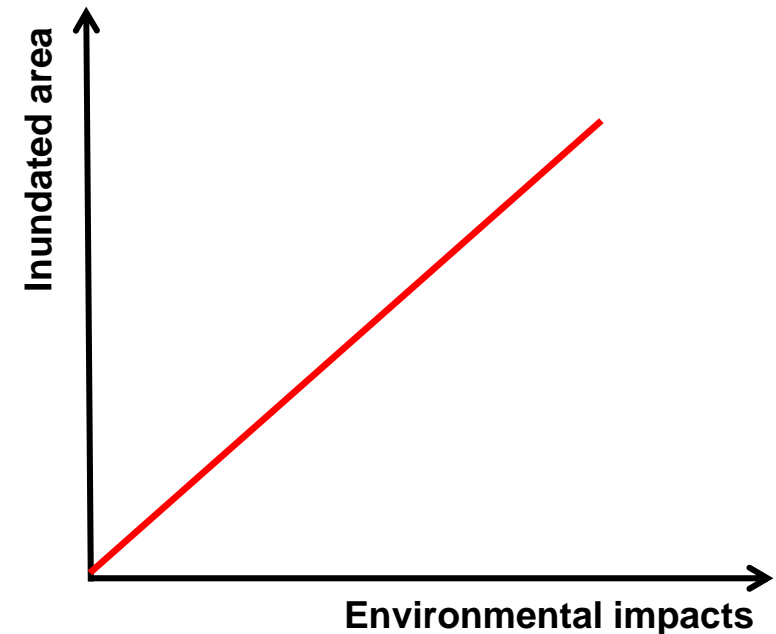
Rule of thumb; environmental impacts are roughly proportional to area inundated, (e.g. Egge & Milewski (2002))

Outcome:

Small-scale plants without reservoirs come out better than large reservoir plants

Developed for reservoir plants?

What about large run-of-the-river plants?



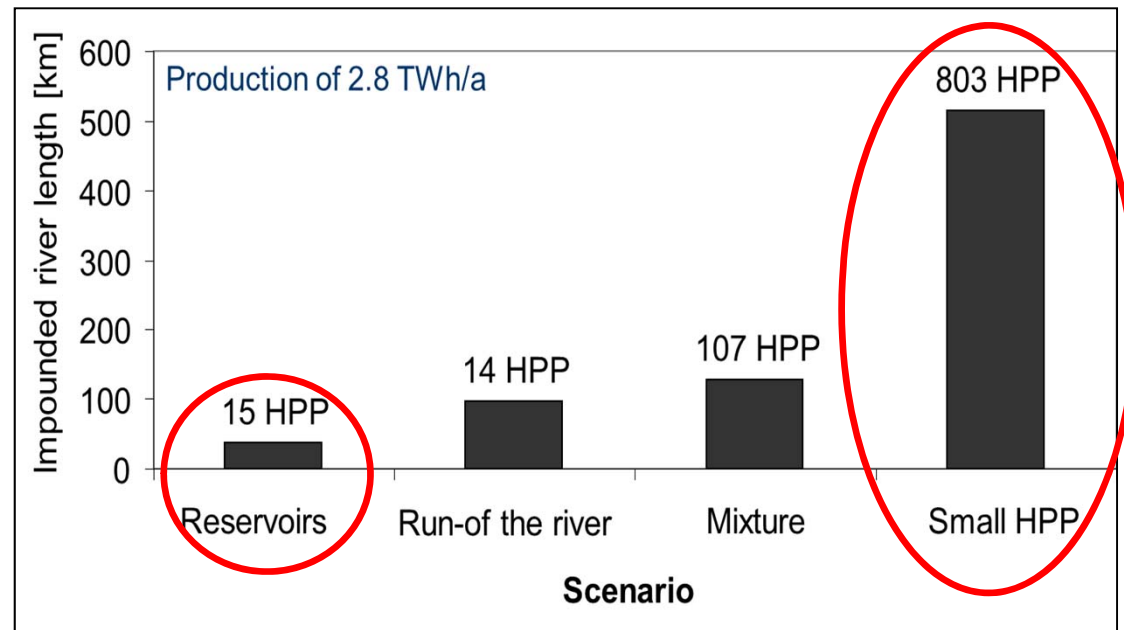
Comparison of environmental impacts (2)

Comparison of impounded river lengths, given the need to produce 2.8 TWh/a (Schmutz et al. 2010):

Outcome:

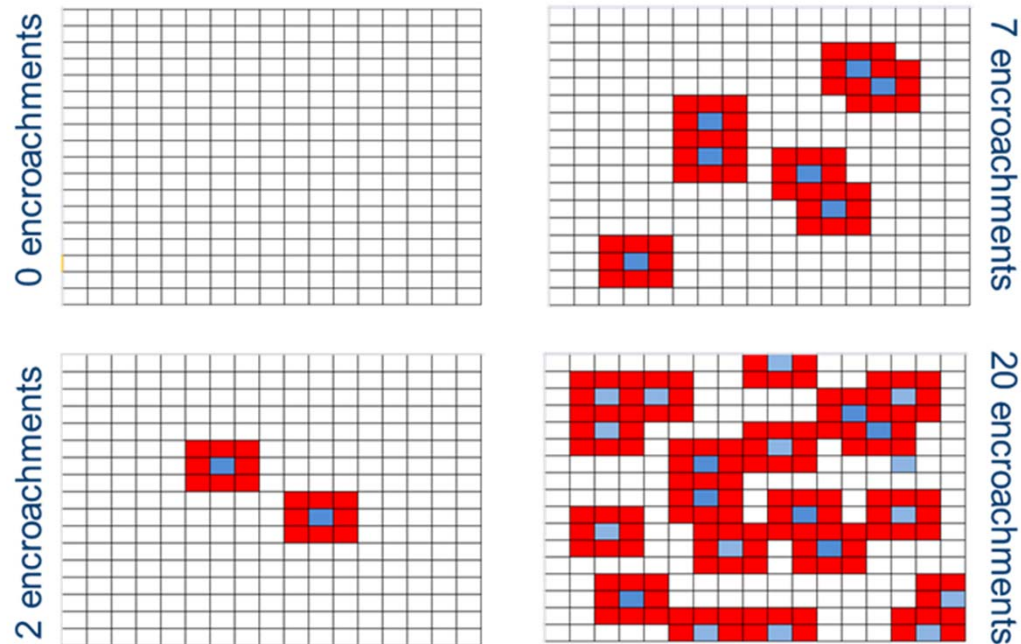
Reservoir plants better than all other strategies

Simplified to include only impounded rivers as the impact



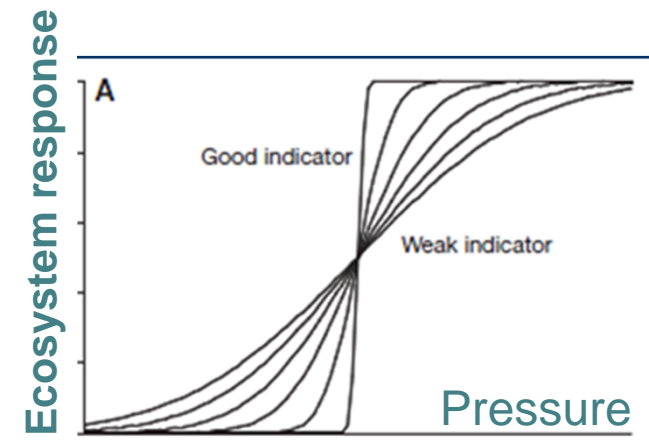
Comparison of environmental impacts (3)

Reduction in areas with no prior or major encroachments (INON-areas);
(Directorate for Nature Management (DN))



Outcome:

- Better to develop new energy resources in already exploited areas?
- Selective exploitation of nature types (Erikstad et al., 2009).



Source: from Carstensen & Heiskanen, 2007

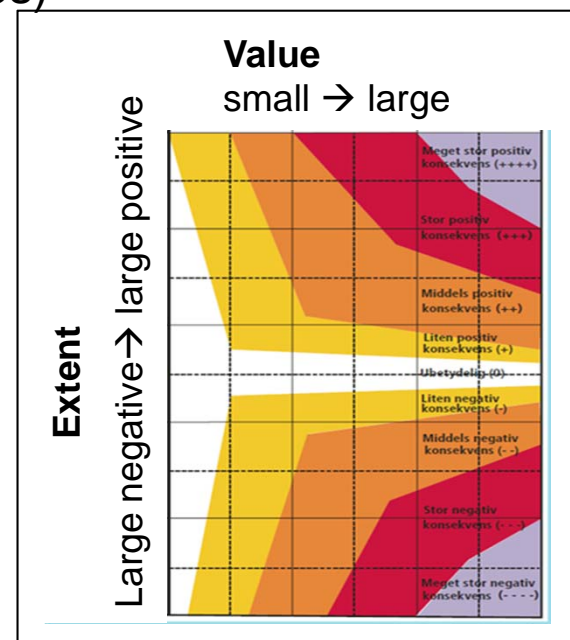
Comparison of environmental impacts (EIAs)

Use of standardised Environmental Impact Assessments (EIA) for comparison (Bakken et al. 2012):

EIAs in Norway and internationally: A standardised and complete set of environmental topics to investigated (given by guidelines)

- Landscape
- Biodiversity
- Fish
- Water quality etc.

A standardised way to classify impact level (Statens Vegvesen, 2006)



Data 27 on small-scale HPPs

- Accumulation of impacts
- Interpretation of qualitative data
- Expert judgments

Identified impact / Small-scale hydropower project	Areas with no prior & major encroachments (INON)	Area protected due to landscape values	Anadromous fish present	Fish fauna affected	Withdrawn water anadromous river stretch	Changed water quality	Cultural heritage affected	Changed water temp.
Bjåstad	Yes	No	No	Yes	No		Yes	
Duvedalen	Yes	No	No	No	No	No	No	
Eitreselvi	Yes	No	Yes	Yes	No		No	
Eitreneselvi	Yes	No	No	No	No		No	
Engeseteelva	Yes	No	Yes	Yes	No	No	Yes	
Hatlestad	Yes	No	No	No	No		Yes	
Holsen	Yes	No	No	Yes	No		Yes	Yes
Hopland	No	No	No	No	No	No	Yes	
Jordal	No	No	Yes	Yes	No		Yes	
Kjørstad	No	No	Yes	Yes	Yes	Yes ^c	No	Yes
Kvamselva	No	No	Yes	Yes	Yes	No		
Kvernhuselva	Yes	No	Yes	Yes	No		Yes	
Lidal	Yes	No	Yes	Yes	No		Yes	
Mjølselvi	Yes	No	Yes	Yes	No			
Romeyri	Yes	No	No	No	No		Yes	
Røneid	No	No	Yes	Yes	Yes	No	No	
Sandalselva	No	No	No	No	No		No	
Selselva	Yes	Yes	Yes	Yes	No	Yes ^d	No	
Senneset	No	No	Yes	Yes	No	No	No	
Storelvakraft	Yes	No	No	Yes	No		No	
Storelva	No	No	Yes	Yes	No		No	
Strupen	Yes	Yes		Yes	No		Yes	
Sætedalen	Yes	No	No	Yes	No		Yes	
Timbra	Yes	No	No	Yes	No		No	
Torvikelva	No	No	Yes	Yes	No		Yes	
Ygleelvi	Yes	No	Yes	Yes	No		No	
Øyni	Yes	No	Yes	Yes	Yes	Yes	No	

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Sum inst. capacity: 112 MW

Sum production: 390 GWh/a

Data on large HPP

'Average HP plant'

EIA

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Vestsideelvane

EIA

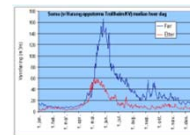
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Vigdøla

'EIA'

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
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SUMMED (*)	2	2	1

Trollheim



Scientific reports

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SUMMED (*)	2	2	1

Average plant:

Installed cap.: 54 MW

Production: 350 GWh

Comparison of impacts

Large

54 MW
350 GWh



Average large HPP

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
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SUMMED (*)	2	2	1

Many small

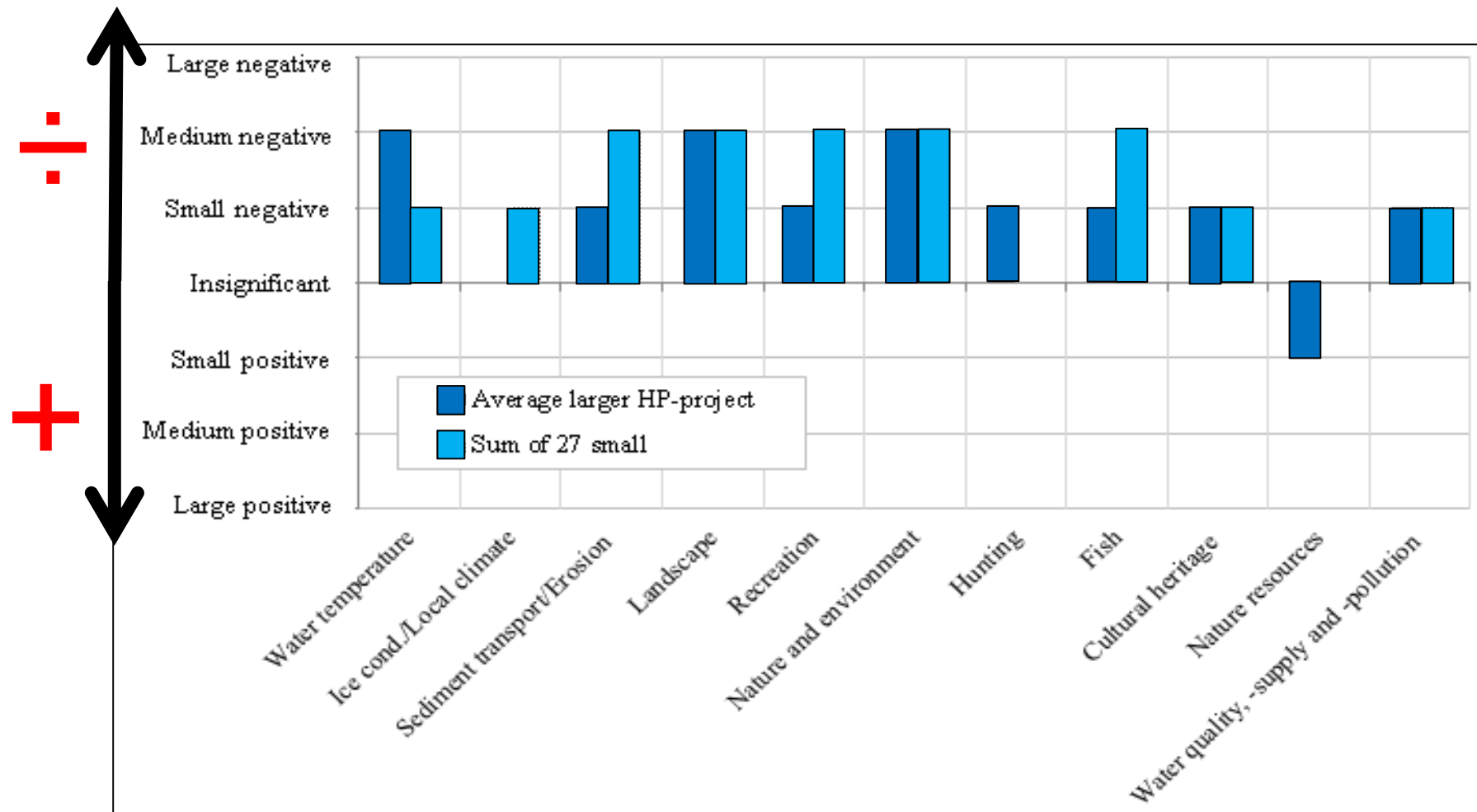
112 MW
390 GWh



Accumulated impacts
from 27 small HPPs

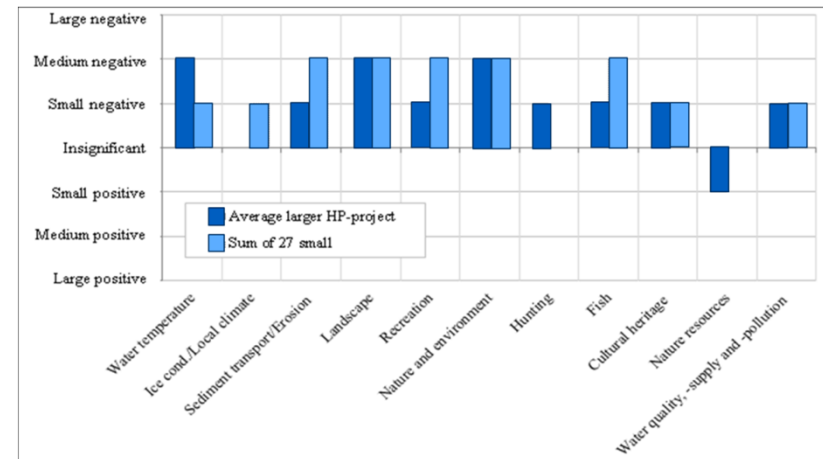
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Results: Comparison of impacts



Comments to the results

- Small-scale HP scores 'worse' (more negative/less positive) on the following topics:
 - Ice conditions/local climate
 - Recreation
 - Fish
 - Nature resources



- ▶ Large HP scores 'worse' (more negative) in the category water temperature
- ▶ The scores differ with only one impact level

Points of discussion from our study

- Quality of available information; completeness, precision.
- Accumulation of impacts from many small projects
- How to compare 'non-comparable environmental qualities'?
- Other aspects affecting the environmental performance; professionalism/competence in developer's organization, monitoring/control, corporate responsibility (CR)
- Qualities of the energy production

Conclusions from our study

- The results show a slight tendency that large hydropower has a lower degree of impacts than many small-scale projects.
- The results are, however, marginal in the favour of large hydropower.
- Lack of precision in the data and weak methodological foundation introduce uncertainty in the results.
- Taking into account other benefits such as the provision of regulated power, it is reasonable to assume that a few large hydropower projects will produce electricity to a lower environmental cost compared to many small projects.
- The study raises a more fundamental question on valuation of environmental qualities.

Is salmon more important than moss?



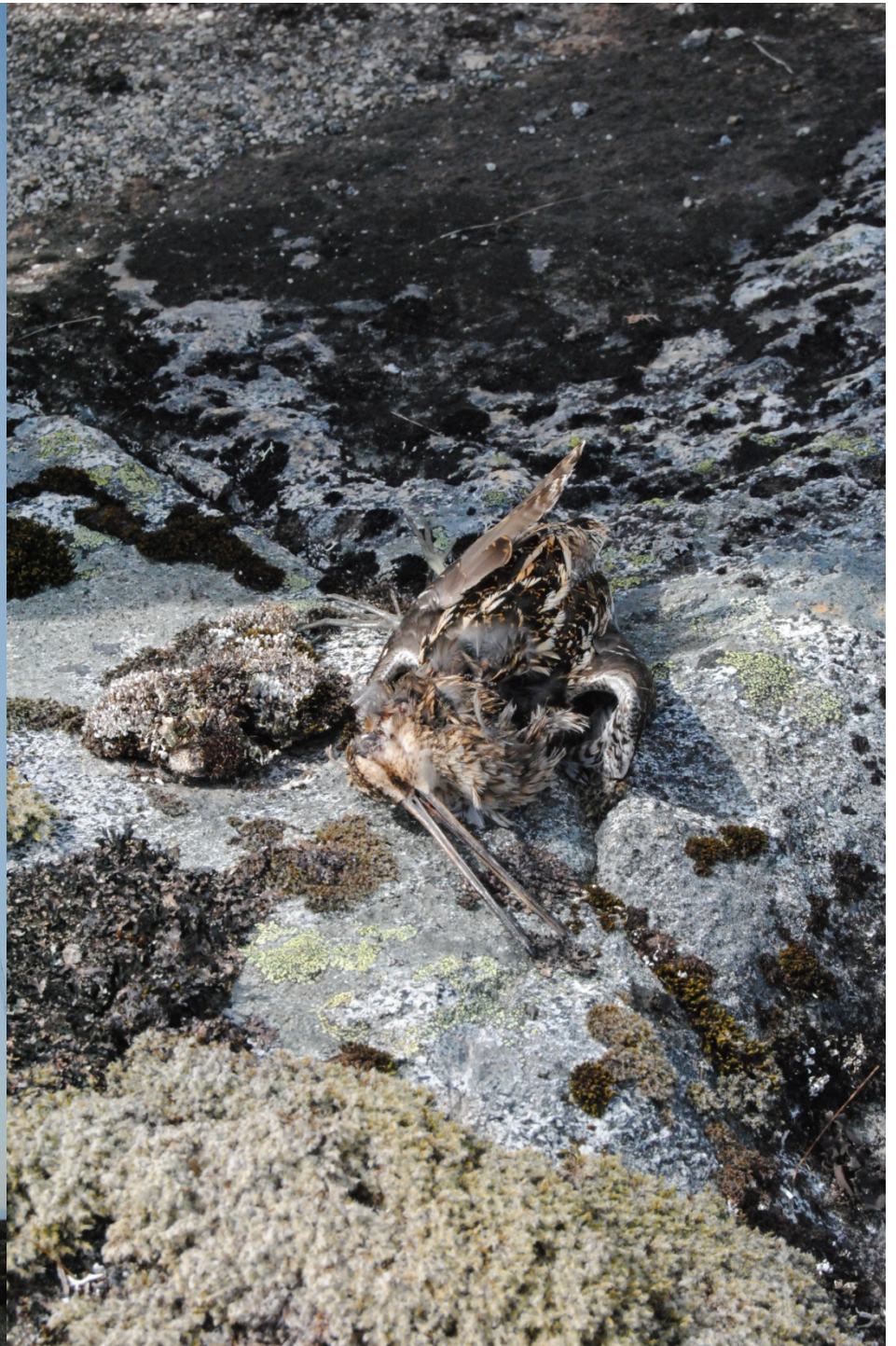
Who to assign values/priorities to the environment?

- Researchers?
- Management authorities?
- The majority?
- Other stakeholders?

Follow-up study recently started







Improvements of methodology

- MSc-study started up this Fall, finalized Summer 2013
 - Includes also wind power
 - Uses a standardized set of parameters relevant for all production technologies:
 - areas directly affected by the projects
 - reduction in untouched nature (INON)
 - visibility
 - impacts on red-listed species
 - main problem of concern
- Habitat, biodiversity
Landscape
Biodiversity ('Party-stopper')
Conflict

Improvements of methodology

- Based on GIS-data and tools
- Preliminary testing promising

