Improved methods for identifying the cost-efficient N abatement set

Janne Helin

Luke (Bioeconomy and environment -unit)

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Janne Helin
Motivation
Data
Results
References

Acknowledgement

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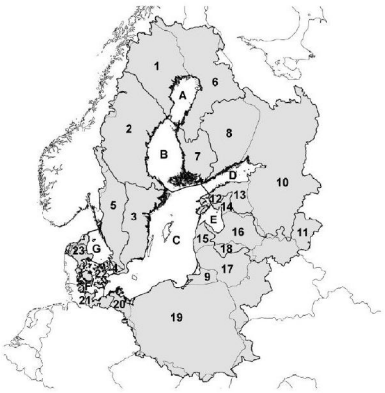
Motivation

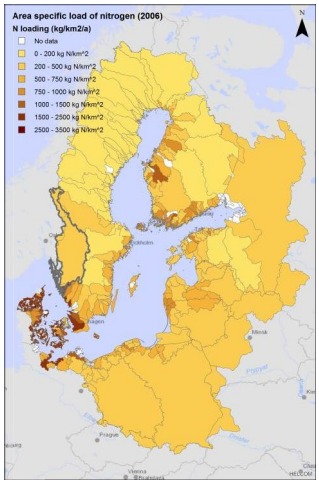
- Eutrophication
  Estimating the costs of meeting good ecological status (GES) of water framework directive (WFD)
  Using funds for environmental protection efficiently
  Identifying optimal abatement measures
  Academic interest in improving modelling tools
  Our understanding of what is possible with respect to nutrient loads and how much it costs is synthesised in models

Baltic context - scale



Sources: (Larsen, 2008; Gren, Savchuk, and Jansson, 2013; Hasler et al., 2014; Ahlvik et al., 2014)

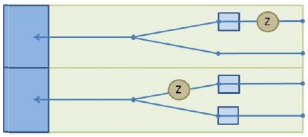
Model resolution matters?



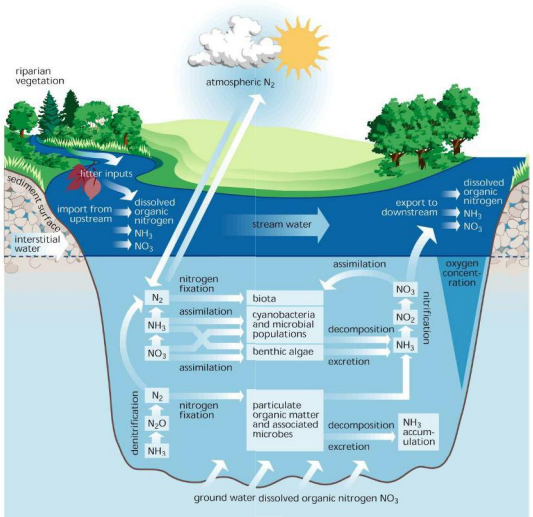
Hydrology - Catchment Area

- Littoral stretch, l
  Catchment area, i

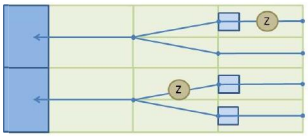
Spatial relations to sources



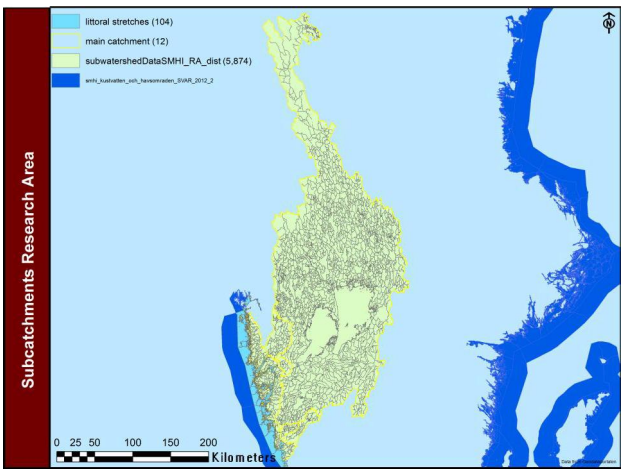
Retention



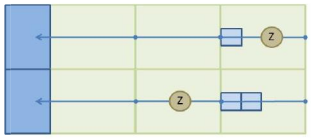
Sub-catchment - concept



Sub-catchment - data

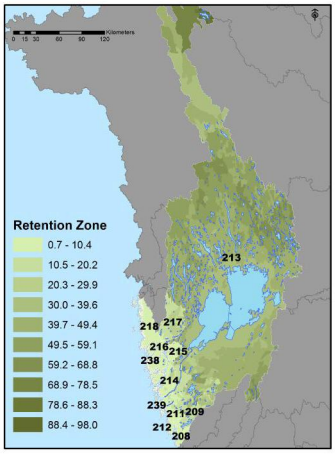


Sub-catchment - zoning

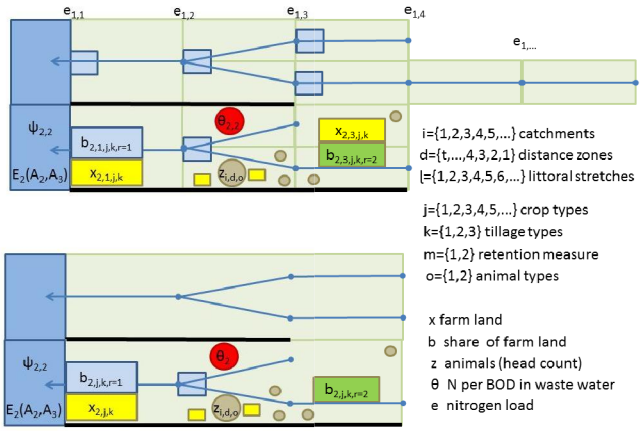


- distance zone d

Data with zoning



Model illustration

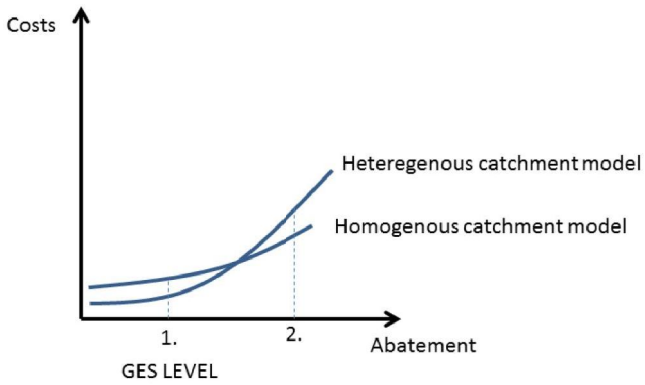


i={1,2,3,4,5,...} catchments
d={t,...,4,3,2,1} distance zones
l={1,2,3,4,5,6,...} littoral stretches

j={1,2,3,4,5,...} crop types
k={1,2,3} tillage types
m={1,2} retention measure
o={1,2} animal types

x farm land
b share of farm land
z animals (head count)
θ N per BOD in waste water
e nitrogen load

Expectations



Modeled measures

- Increasing WTTP capacity (following Hautakangas et al., 2013)
  - Reducing N application (following Brady, 2001)
    - Reducing chemical fertilisation
    - Reducing N from manure (by reducing animals)
    - Switching to crops with less N fertilisation
  - Increasing retention
    - Constructing wetlands
    - Establishing buffer zones (Helin, Laukkanen, and Koikkalainen, 2006)
    - Introducing crops with less N emission prowess (i.e. catch crops)
    - Relocating crops and fertilisation (both manure and chemical)

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Data sources

- Animal production site location: AFProduktionsplatser
  Animal production numbers (municipal data)
  Field locations and boundaries: LUJordbruksblock2014
  Type of field use (municipal data)
  Municipal boundaries: KommunSweref99TM
  Main & subbasin boundaries smhi huvudavrinningsomraden SVAR 2012, aro y 2012
  Subbasin brutto & netto nutrient load: Vattenveb (SHYPE)
  Subbasin net retention to sea: Vattenveb (SHYPE)
  Subbasin local retention: Vattenveb (SHYPE)
  Littoral stretch boundaries: smhi kustvatten och havsomraden SVAR 2012

Data sources

- Buffer zone maximum capacity: alla daro.xls (from a web site)
  Waste water treatment plants: WWTP2011 reningsverk
  WWT installations: miljoforvaltningsanlaggningar
  WWT cost parameters Hautakangas et al., 2013
  Current WWT abatement **NVV2010**
  Targets for GES: personal communication, länstyrelse
  Yield & nitrogen load function parameters: Brady, 2001
  Standard output of animals SE SO SGM coefficients
  Manure nitrogen content: Baltcost input data
  Animal care labour (hours per year): various sources in Sweden and Finland
  Daily grass requirement: Finnish recommendations
  Livestock unit definition: Eurostat
  Crop prices: Jordbruksverket -statistikdatabasen
  Price of nitrogen fertilisation: Rekommendationer för gödsling och kalkning 2016, Jordbruksinformation 19 – 2015 (pdf)
  Costs of other farm inputs: Brady, 2001, price index from Jordbruksverket -statistikdatabasen
  Agricultural subsidies (for grassland)

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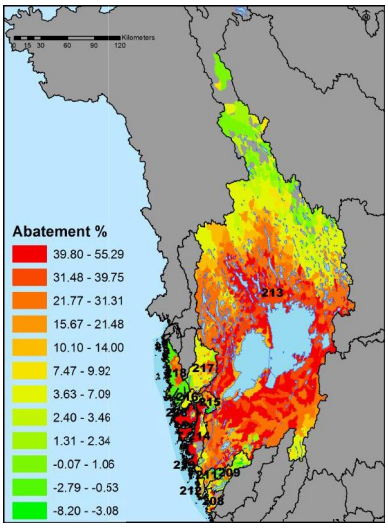
Some spatially explicit results on optimal measures that reach waterbody specific GES targets...

Abatement -distance classes



Optimal wetland allocation

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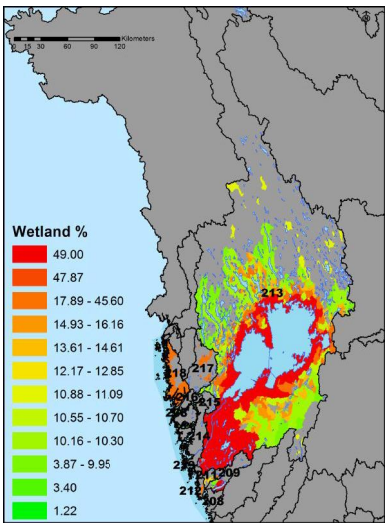
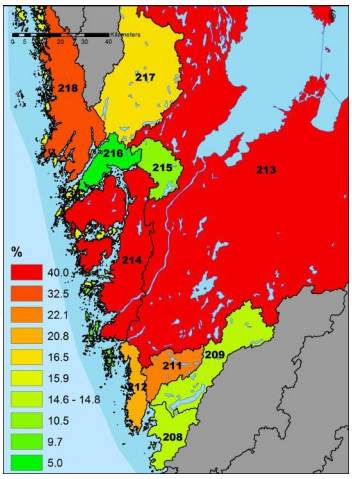
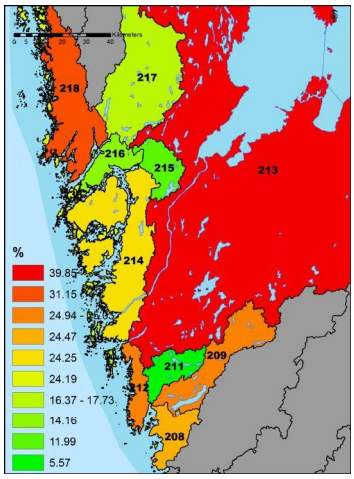


Abatement -catchment level comparison





Optimal management

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Table: Summary of key results for the whole research area

	BL_{HO}	BL_{HE}	GES_{HO}	GES_{HE}
Retention %	35.68	35.91	35.32	36.33
Abatement %	0.00	0.00	36.31	37.27
Wetland Effect	0.00	0.00	3909.21	2195.92
Wetland %	0.00	0.00	2.07	8.45
Buffer %	0.62	0.62	0.16	0.34
Buffer max %	5.65	5.65	1.45	3.08
Fallow %	5.12	5.41	46.73	53.84
% AU	100.00	99.97	100.00	81.61
% N input	100.00	100.00	91.24	66.42
Grass %	38.56	38.56	82.46	69.10
Delayed Tillage %	0.01	0.00	0.00	0.81
Catch Crop %	0.00	0.00	0.00	12.20
WWTP Count	0.00	0.00	1.00	32.00
WWT %	73.79	73.79	74.16	92.75

Abatement costs for GES

- Homogeneous 12.2 EUR/kg N
  Heterogeneous 44.6 EUR/kg N

Conclusions

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- The resolution of spatial data influences the distribution of optimal nitrogen abatement measures.
  The optimal share of abatement between the catchments is subject to the spatial scale of the model
  The results show an overall cost increase due to improved understanding of interactions and limitations of the abatement measures.
  Given the Swedish data, reaching water policy targets in countries around the Baltic Sea is more costly than what has been previously communicated to policy-makers

Literature

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- Helin, Janne, Marita Laukkanen, and Kauko Koikkalainen (2006). "Abatement costs for agricultural nitrogen and phosphorus loads: a case study of crop farming in south-western Finland".
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