Transport of persistent organic pollutants from land to sea

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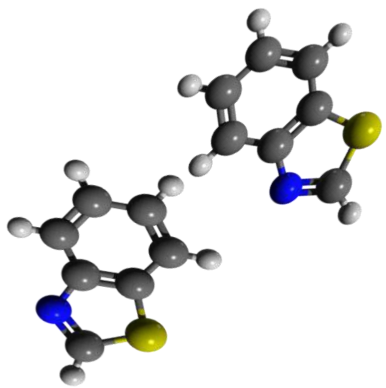
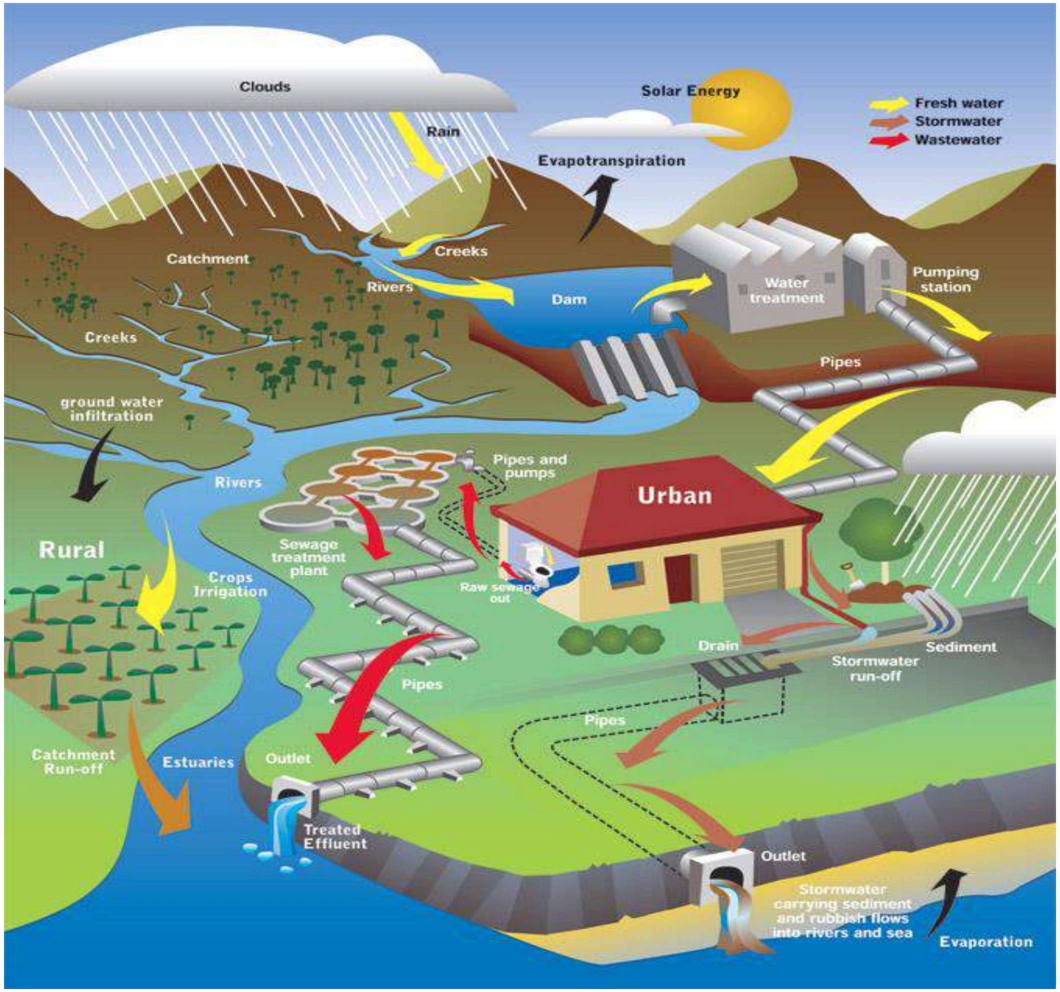
Chemicals in the environment - Why worry?



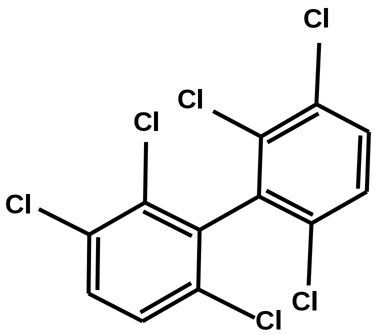


>13 000 high volume chemicals registered in EU

>In total 180 000 in use

Persistent Organic Pollutants (POPs)

- Semivolatile
- Long residence time, persistent
- Hydrophobic (lipophilic)



PCB

- Widely distributed geographically by air transport
- Accumulate in fatty tissues of organisms
- Associate with particles & organic carbon

- Intentional and unintentional formation
- Legacy and emerging POPs

PBT

Peristent
(long half life)

Bioacccumulate
(high concentrations in lipids)

Toxic

very Persistent

– Environmental half-lives:
> 60 d in water
> 180 d in sediment
> 180 d in soil

very Bioaccumulating

– Bioconcentration factor (BCF) > 5000

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Chemicals of concern

Flame retardants

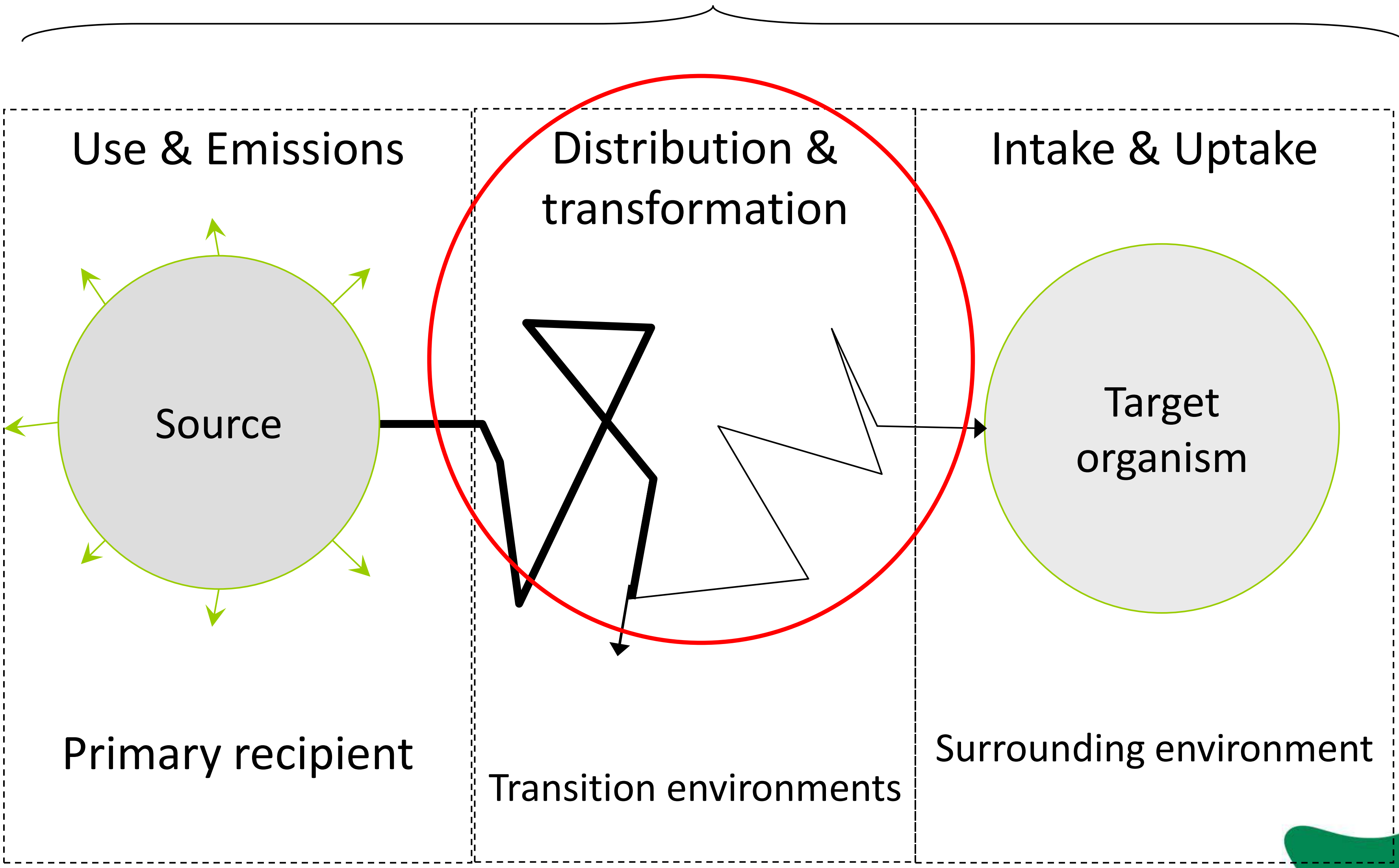
Perfluoroalkyl substances (PFASs)

Pharmaceuticals

Personal care products

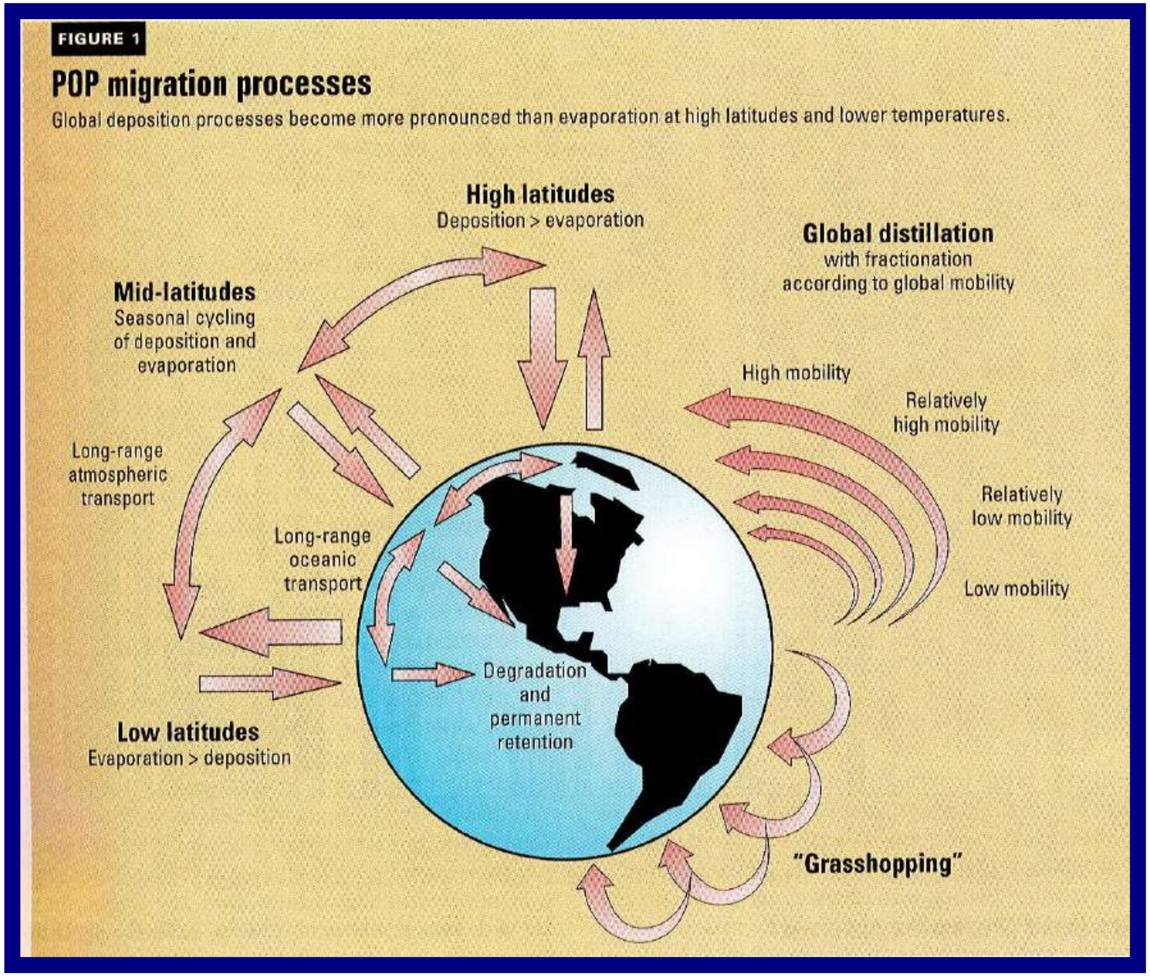
Pesticides

Exposure assessment



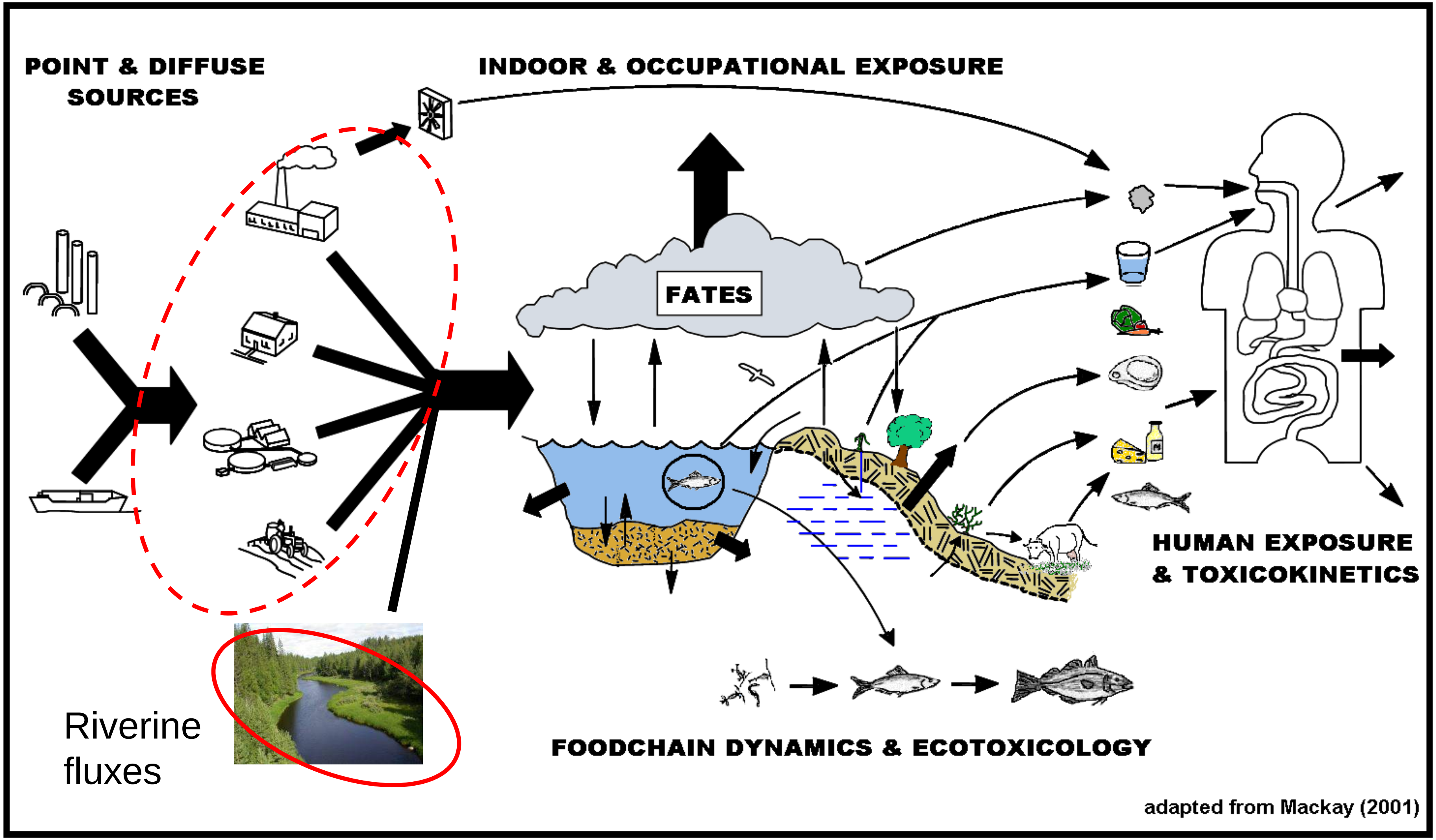
Where on earth will POPs go?

Global fate processes of POPs - diffuse pollution



Wania and Mackay, *ES&T* 1996.

Transport of POPs to the sea



adapted from Mackay (2001)

What do we know about POPs in surface water in Sweden?

- National monitoring of current use pesticides in four catchments & two rivers (in the south)
- No continuous monitoring of other organic pollutants in stream and river water (in contrast to metals)

- Screening campaigns
- Research and management projects
- Generally: Huge lack of data!

Monitoring of priority pollutants in streams/rivers

SWE: Organic pollutants: ”SÄMST i KLASSEN” = ”Worst in the class”

SWE

Available number of samples for countries within the 1999-2009 period

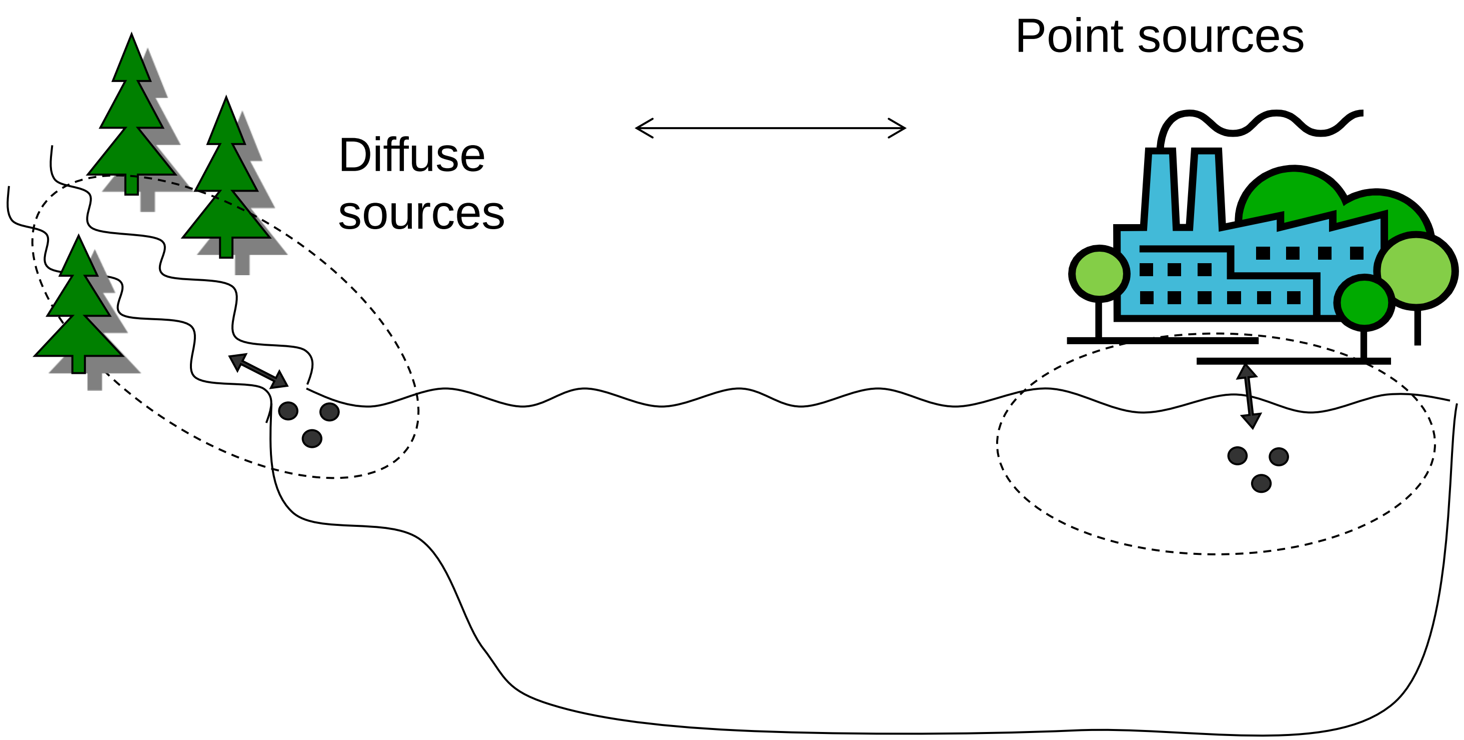
FI

Substance	AT	BA	BE	BG	CY	CZ	DE	EE	ES	FI	FR	GB	GR	HR	HU	CH	IE	IS	IT	LT	LU	LV	MK	NL	NO	PL	PT	RO	RS	SE	SI	SK
1,1,2,2-tetrachloroethene			341		57		8288		575		21904	816							6228	790				440		185					2	616
1,2-dichloroethane	537		1947		62	2586	7720		575		22330	1361					942		6213	790	18			439		409					67	793
4-nonylphenol			1392							161	9295	22					1751			15											12	764
Alachlor	11351	6	1956		78	2271			363	148	32152			258			1751		7604		18			540		230	74	6	146	124	306	794
Aldrin	197	3	1810	23	105	2226	2659		642	148	27332	3598	483	336			1751		4631	541		58		569		593	38	12	891		207	713
Anthracene	190	37	2323		105		3204		462	75	22709	1208		217			1751		1235	907		65		582		767	22	28			201	898
Atrazine	14892	97	2069		78	2268	8026		570	148	32183	2691	483	794	2461		1751		7706	548	36			540		172	80	36	891	135	301	799
Benzene	507	12	2126		62	2585	5994		622		22671	1266		223	554		985		5684	935	18	43		437		700	6				143	803
Benzo(a)pyrene	205	38	2381		25	2307	2546		473	74	23191	1569		217			672		2321	765	18	65		582		605	105	10	73		201	895
Benzo(b)fluoranthene	205	38	2376		25	2189	2515		458	75	23094	1574		217			672		2287	765	18	65		581		555	103	24	73		201	899
Benzo(g,h,i)perylene	205	23	2184		25	2306	2353		458	75	23781	1549		217			672		2300	765	18	65		581		535	55	19	73		201	897
Benzo(k)fluoranthene	205	38	2382		25	2306	2524			75	23918	1580		217			672		2241	764	18	65		581		483	55	19	73		201	838
Cadmium	14140	731	3445	1437	123	3379	18218	33	1365	5740	23250	14000	483	1628	11358	54	1134	20	16281	1820		1256	1717	1362	1595	1023	458	1579	254	7990	1102	891
DDD, p,p'		12	261		105	2464	2682			87	20885	177	483	945	265				758	522		58		563					891		182	769
DDE, p,p'		12	261		105	2466	2725			87	21040	759	209	946	308				22			48		563					147		4	421
DDT, o,p'			261		46					148	22838	735	274		98				143			58		181		447			744		12	349
DDT, p,p'	12	12	1628		105	2486	2894			148	22317	1305	209	1171	829				916	1306		58		569		383		40	892		191	802
Di (2-ethylhexyl) phthalate (DEHP)	362	17	163		105				15	205	17022	835					672		411	15	18			474							36	906
Dieldrin	197	3	1812	23	105	2186	2482			148	28985	3784	483	336	507		1751		4438	541		55		569		632	40		891		211	1127
Dichloromethane	441	6	1718		60		7491		416		22123	504		256			771		4135	932	18			403		405					231	742
Diuron	464	18	2047		21	730	6643		119	144	32384	1082		218			1751		2834	40	36			429		68	80		122	135	12	1238
Endosulfan			464						428			125		336					891	30				181		145						403
Endrin	185		1812	23	105	1350	2457			148	27774	3542	483	1103	506		1751		4247	541		67		528		587	38	8	891		203	1125
Fluoranthene	205	35	2350		105	2306	2495		462	75	22845	794					1751		2130	764	18	65		581		850	54	36	73		201	899
gamma-HCH (Lindane)	209	8	1944			2465	5829			87	32497	1489	204	946	1710				3886	1306	18	55		568	197		79	65	892	135	256	867
Hexachlorobenzene (HCB)	197	12	1813		105	2483	3892		591	87	26084	1459		263			1751		4364	505	18	55		569		309		12	891		242	819
Hexachlorobutadiene (HCBD)	185		1551		106	2492	4750		512	87	23633	1009		255			1809		5052	16	18			569		293					28	378
Chlorfenvinphos		17	677		78				265	148	28715	2006		258			1751		3185	40	36			512		62	3		142	135	266	186
Chlorpyrifos	364	17	1677		78	2073			363	148	27699	44	2						6495	40				512		37			146	135	40	1262
Indeno(1,2,3-cd)pyrene	205	24	2381		25	2306	2508			75	23328	866		217			672		1458	763	18	65		581		769	104	14	73		201	843
Isodrin	185		1812	23		2159	1133			145	25128	3007	2	305			1751		3408	40				569		437	38		147		8	1119
Isoproturon	464	6	2047		21	761	6576		123	144	30203	986		218			1751		2681	40	36			428		22			122	135	12	1206
Lead	13903	390	3449	1915	115	3279	11557	34	1394	5739	22858	12647	483	1630	10959	55	1107	12	16033	1515		1263	1654	1352	1595	1035	334	1849	257	7962	1045	867
Mercury	14105	571	2750	61	109	3031	17449		730	2444	22603	7084	483	118	10310	2	1093	20	14541	1290		374		1187	1379	1051	158	314	246	400	961	625
Naphthalene	190	18	1030		64		3201		564	75	22054	854					985		2476	168		65		181		490	24	48			35	469
Nickel	13902	679	3412	1481	125	3498	11525	10	1358	5771	22200	13377	483	1654	11109		1104		16052	1514		497	1647	1353	1600	1080	3	1818	253	7892	1207	488
Para-tert-octylphenol			1580							161	13729	452					672		164					454		20					12	726
Pentachlorobenzene	185		1687						283	148	24442	362		220			1751		1077	37	18			569		307		24			4	812
Pentachlorophenol	184	18	1808				2059		396		23345	2412		258	48		1751		2144	1452	18			460		335	3		96		292	540
Simazine	14892	12	2069		78	2268	7823		513	148	30903	2553	209	252			1751		7623	548	36			540		165			891	135	301	1289
Tributyltin cation			324				339				6048	19														10						384
Trifluralin	185		1886		78	2114	4491		371	148	29423	2587					1079		6764	40				537		152			147	135	266	836
Trichloromethane	549	12	2104		62		8771		575		21352	1737		277	187				5499	934		12		440		602					213	689

Metals - the only exception is current use pesticides (in the south)

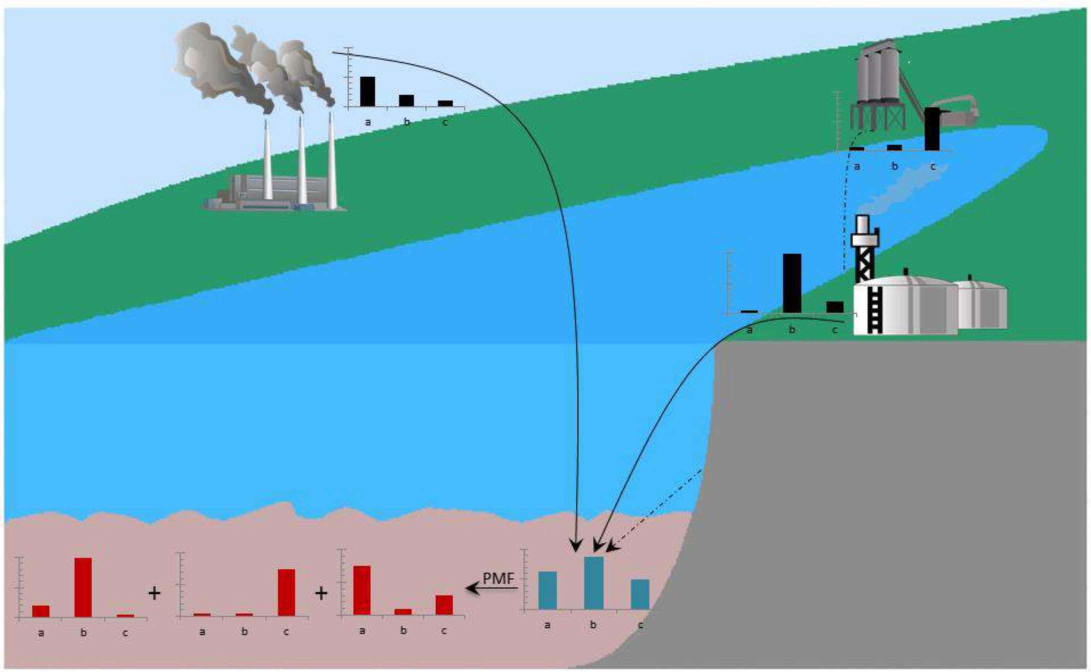
Source: Hazardous Substances in Water- report to the EEA Technical Report No. 8/2011

What do we need to know ?



- Which chemicals should be monitored? How?
- Do point sources impact the open sea?
- Is diffuse pollution (atmospheric deposition) retained by the terrestrial environment?

Source apportionment using "source-to-receptor" modeling

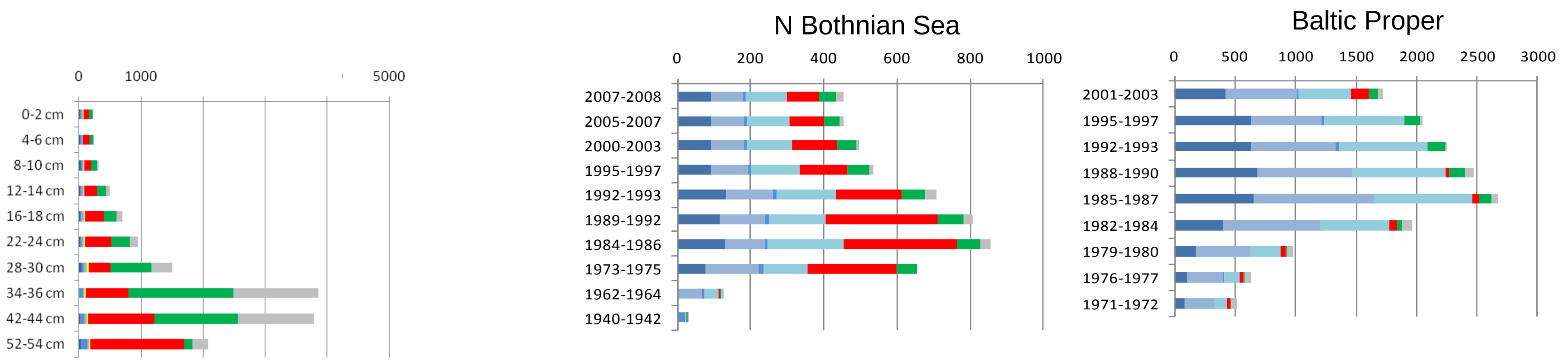


Percentage contribution from different sources – applied for dioxins

Do terrestrial point source emissions affect the open sea?

Dioxin levels (pg TEQ g^{-1} dw) in (dated) sediment cores

Coastal sediment core



Assefa et al, ES&T 2014a

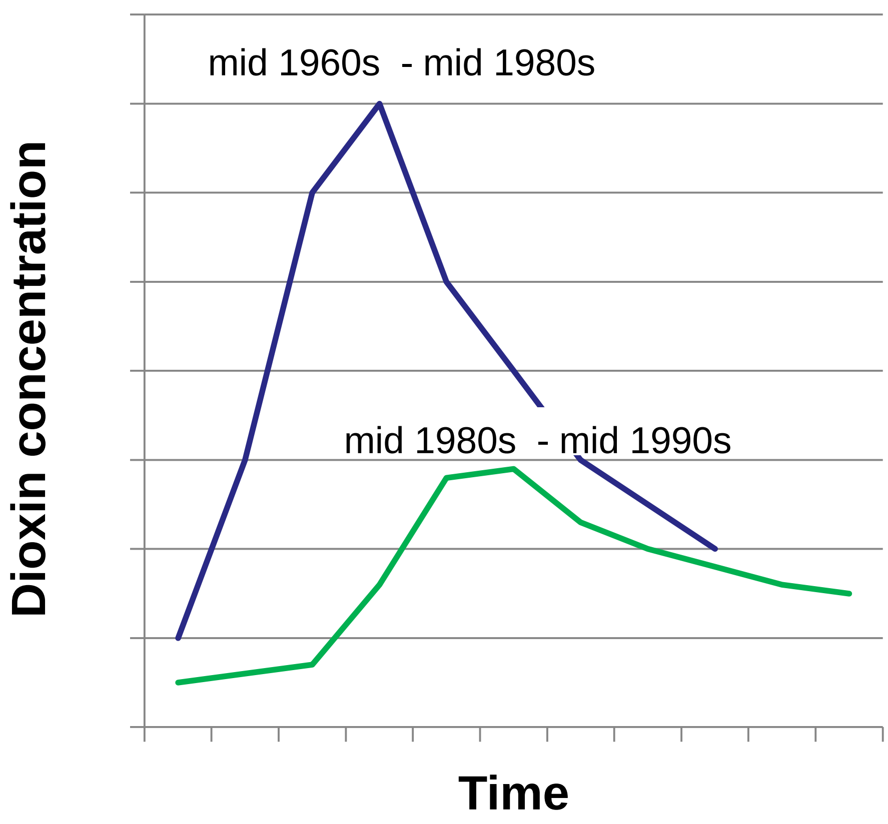
Terrestrial sources:

Red Chlorophenol

Green Kraft pulp

Blue Atmospheric deposition

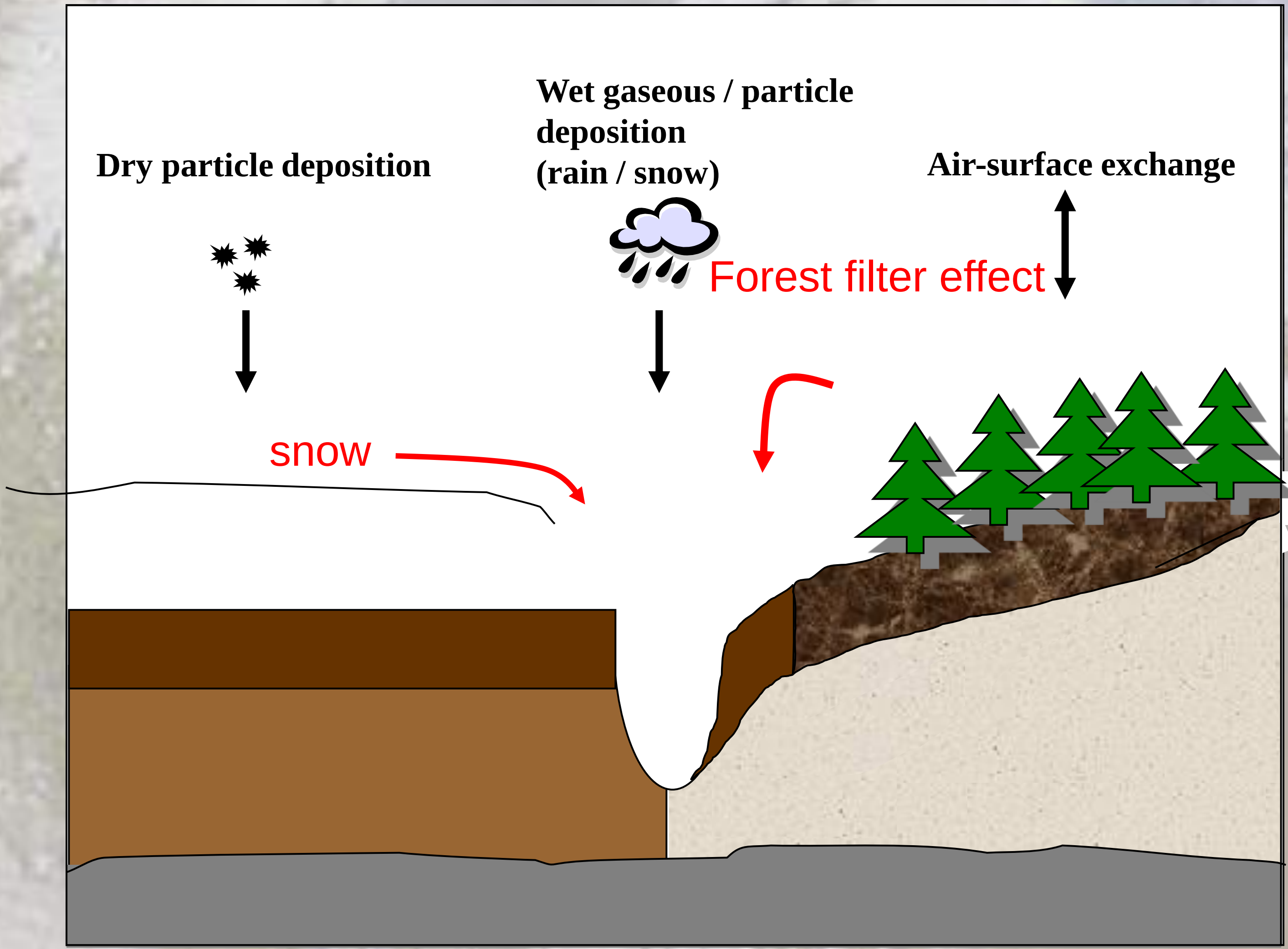
Point sources affecting the open sea?



Dioxin levels in Baltic Sea sediments – core analyses (historical records)

Assefa et al, ES&T, 2014b

Diffuse pollution: Atmospheric inputs of POPs



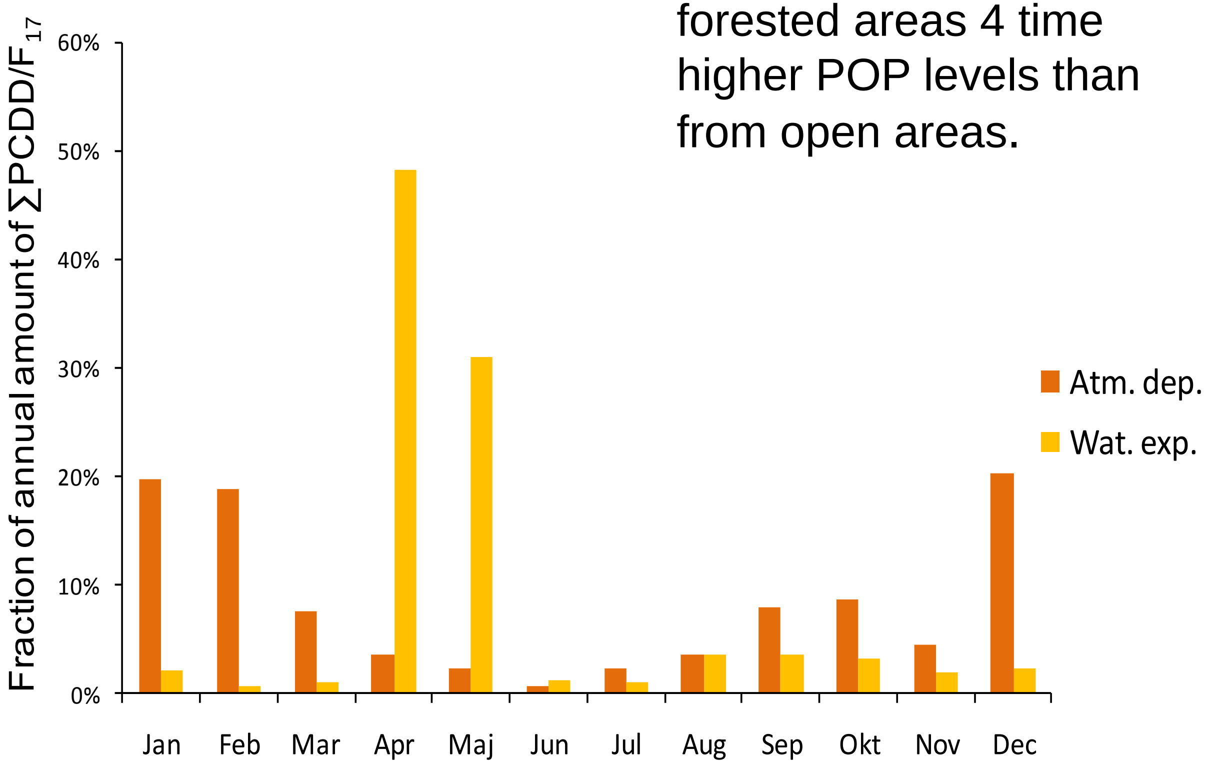
Regulators of fluxes of POPs from remote areas to the sea

- Retention by boreal soils and boreal vegetation. Landscape types
  - forests
  - wetlands

- Hydrological events


Snow-covered season
Snowmelt season
Snow-free season

Atmospheric deposition and water export of very hydrophobic POPs



Snowmelt water from forested areas 4 time higher POP levels than from open areas.

Terrestrial retention capacity is high

96-99% retained

Other studies:
Less hydrophobic POPs 40-80%

Bergknut M. et al.. *Environ. Pollut.*, 159(6):1592-1598, **2011.**

Projects

- **ForestPOPs** and **ForWater**. Better understanding of the fate and transport of POPs from Boreal forests to the sea
    - Impact of hydrological events and climate change?
- **SafeDrink** drinking water quality
- **RedMic –** waste water impact on surface and ground water
- New Interreg project: **NonHazCity**
    - Minimizing emissions of hazardous substances in the Baltic Sea Region
    - 10 municipalities: Stockholm, Västerås, Turku, Pärnu, Riga, Kaunas district, Silale, Gdansk, Lübeck, Hamburg)
    - demonstrate possibilities of municipalities and WWTPs to reduce emissions of hazardous substances from small scale emitters at urban areas

Summary

- TAKE HOME MESSAGE:
  - Huge lack of data and understanding!
  - Fluxes to the Baltic Sea? Which compounds?
  - The relation between diffuse and point source fluxes?

- Terrestrial point source emissions of POPs do affect the open sea - time lag.

- Hydrological events main regulator for transport of diffuse POP pollution from land to sea.


Thank you for your attention!

Why does reducing diffuse loads of nitrate and phosphorus from agricultural catchments prove so difficult?

Dr Magdalena Bieroza

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Department of Soil and Environment

&

Lancaster Environment Centre, Lancaster University, UK

2nd December 2015, Baltic Flows Workshop, Uppsala

Who am I?

BSc and MSc (University of Warsaw, PL)	Eutrophication and water exchange in a river-lake system,
BEng (Polish-Japanese Institute of Computer Technology, PL)	Database design and management,
PhD (University of Birmingham, UK)	Application of fluorescence spectroscopy to drinking water treatment,
Post-doc (Bristol University, UK)	Long-term nitrate concentrations in the River Thames basin,
Post-doc (Lancaster University, UK)	High-temporal resolution nutrient dynamics inferred from *in situ* monitoring,
Knowledge Exchange Fellow (NERC-Environment Agency, UK)	Nitrate from agriculture: moving from uncertain data to operational responses,
Marie Curie Research Fellow (SLU Uppsala, SE)	Improving targeting critical nutrient source areas in agricultural catchments.

Outline

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What is diffuse pollution?

Diffuse pollution controls

Tackling diffuse pollution

Take-home message

What is diffuse pollution?

Manure spreading
(http://www.clf.org/blog/tag/manure/)

Satellite image of a Nodularia bloom in the Baltic Sea (EOS MODIS 2005-07-11, NASA, processed by SMHIs oceanography unit)

What is diffuse pollution?

Source

Mobilisation

Delivery

Impact

Science of diffuse pollution

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P.M. Haygarth et al. / Science of the Total Environment 344 (2005) 5–14

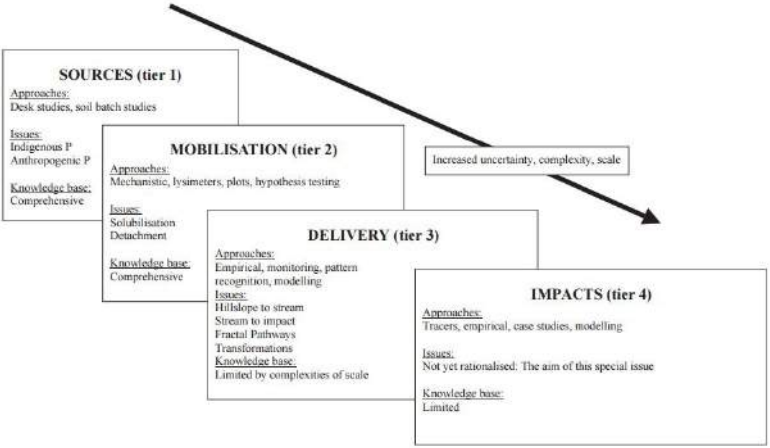
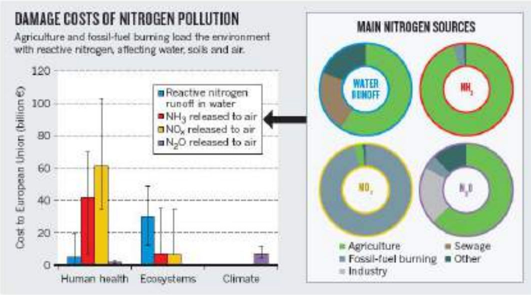


Fig. 1. The 'Phosphorus Transfer Continuum', a simple four-tiered model to describe the research approaches and needs for the continuum of phosphorus transfer from source to impact.

Diffuse pollution in numbers

- Agriculture contributes *ca* 50% of N and 25% of P losses to rivers (e.g. Salvide, 2015; HELCOM, 2013),
- 50% of N in fertilizers and manures is lost to the environment (Sutton, 2011),
- Livestock consume *ca* 85% of the 14 million tonnes of N in crops and only 15% is used for human consumption (Sutton, 2011),
- P alone accounts for 57% of failures to meet water standards set out in the WFD (Salvidge, 2015),
- N pollution costs the EU between €70 and €320 billion per year - double the value that N fertilizers are estimated to add to EU farm income (Sutton, 2011).



Sutton M. 2011 Nature 472 pp. 159-161

Economical, societal and environmental cost: eutrophication, loss of species and habitats, deterioration of water quality and increased cost of drinking water treatment, increased costs for farmers to comply with the European policy e.g. Nitrates Directive.

What is diffuse pollution?

A problem in space and time

Space

- Multiple sources include:
  - Surface and subsurface runoff from agriculture,
  - Soil erosion,
  - Direct (to streams) and indirect (to land) discharges from sewage treatment works and septic tanks,
  - Runoff from impervious surfaces like farmyards, roads etc. and
  - Other incidental sources such as sewer misconnections and storm overflows.
- Spatial heterogeneity of sources (and use, land management and practices), drivers (climate, hydrology) and pathways (topography, geology),
- Models of anywhere do not exist because everywhere is different,
- Scale issues e.g. national datasets, simple input-output models but the information is required at fine-scale e.g. farm-scale for the Nitrate Vulnerable Zones.

Time

- Sub-daily dynamics: in stream processing including uptake and release, hyporheic exchange, denitrification in the upper sediments,
- Seasonal dynamics: temperature and rainfall patterns affect crop uptake, growth and nutrient losses, varying hydrological regime from year to year,
- Long-term dynamics and time lags:
  - Internal P load from Baltic Sea sediments 23 kg P ha^{-1} yr^{-1} (Stigebrandt *et al.*, 2014) &
  - Average P load from agriculture: Sweden 0.4 (Bergstrom *et al.*, 2007) and Finnland 1.1 kg P ha^{-1} yr^{-1} (Heckrath *et al.*, 2008),
  - Penrith Sandstone unsaturated zone travel times 0-61 years (Wang *et al.*, 2013) - NO_3-N at the water table in 2014 was loaded into the USZ as early as in 1940s &
  - Peak NO_3-N loading from 1983 for Penrith Sandstone in several areas of the Eden catchment will arrive in the next three decades.

Diffuse pollution - space

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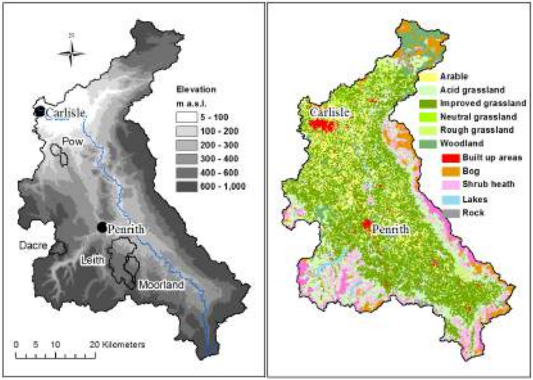
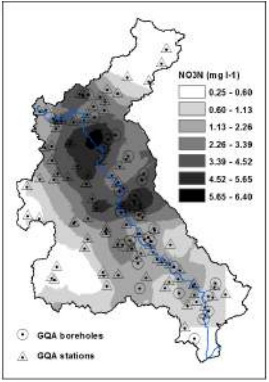
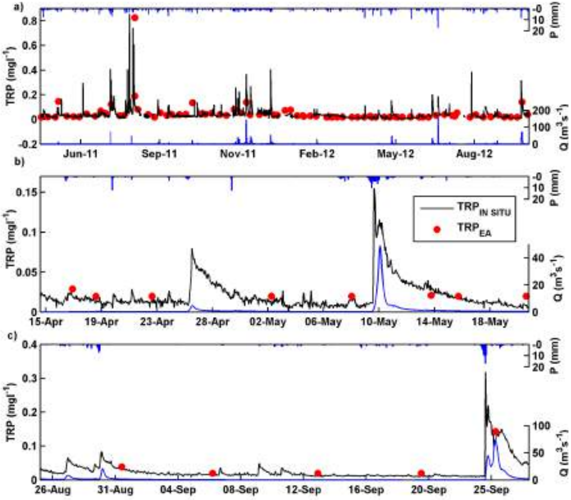


Spatial heterogeneity in topography, geology, climate, hydrology, land use and land management



Monitoring

Diffuse pollution - time



- Most of annual P load delivered during few largest storms (1% of time),
- Surface and subsurface delivery pathways,
- SW > GW,
- Storm dynamics - concentration effect,
- Chemical status can change from high (≤ 0.12 mgl^{-1}) to poor (≥ 1.0 mgl^{-1}),
- Coarse sampling underestimates true concentrations,
- "Clean" catchments without internal solute source or flashy surface-dominated catchments

Diffuse pollution - time

Phosphorus flow dynamics

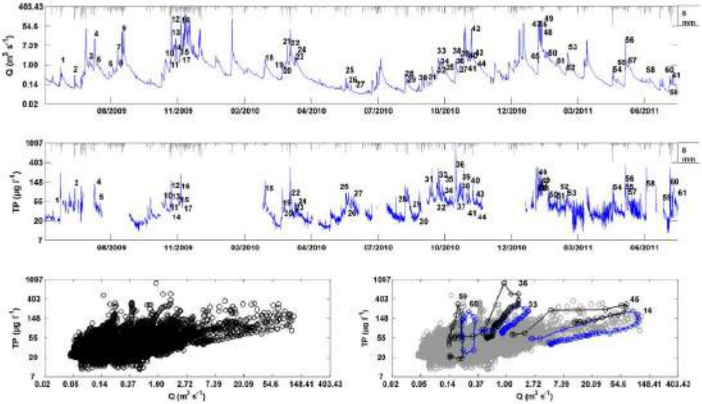


Fig. 2. Time series of flow discharge (top), TP concentration (middle) and Q–TP scatter plots with selected hysteresis loops highlighted. All data shown on logarithmic scale. The storms are numbered as in Supporting Table B. Observed gaps in TP concentration time series indicate periods when the in situ lab was not operational due to freezing or instruments malfunction.

Bieroza MZ & Heathwaite AL, 2015, Seasonal variation in phosphorus concentration-discharge hysteresis from high-frequency *in situ* monitoring. Journal of Hydrology, 524, 333-347.

Diffuse pollution - time

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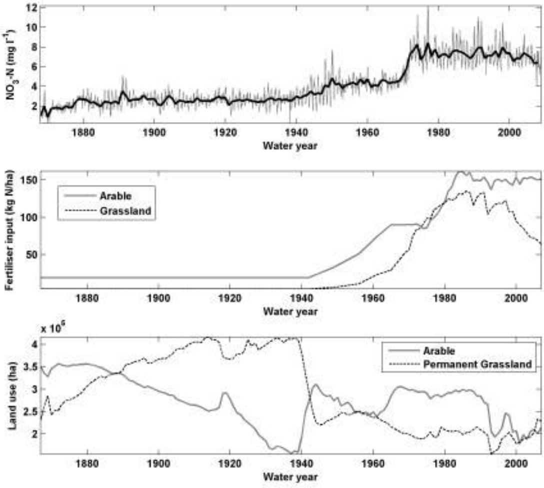
Nitrate from agriculture in the River Thames, England

- Two events of step concentration changes during WWII and in the early 1970s,
- Large-scale land changes, under-drainage, increase in fertiliser inputs, atmospheric deposition,
- The peak nitrate concentrations are attenuated in permeable catchments,
- Are increases irreversible?
- The value of long-term monitoring.

Howden, NJK *et al.*, 2010, Nitrate concentrations and fluxes in the River Thames over 140 years (1868-2008): are increases irreversible? Hydrological Processes.



Monitoring of diffuse pollution

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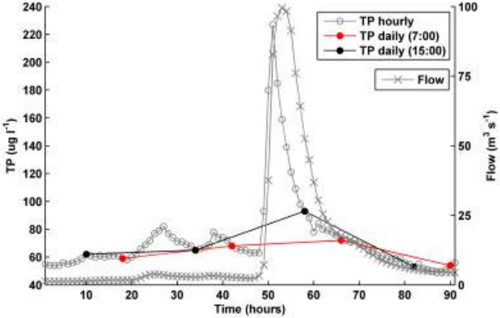
How much data are needed to accurately estimate loads?

Table 5 TRP and NO_3-N load estimation for the *in situ* and EA routine monitoring time series in Fig. 5 and 6 and artificially resampled *in situ* time series to coarser resolution

Dataset	Load estimate: TRP (kg P per year)	Load estimate: NO_3-N (kg per N per year)	Difference from hourly load estimate: TRP (%)	Difference from hourly load estimate: NO_3-N (%)
Resampled time series				
Hourly	3720	96 700	—	—
7 h	3470	95 700	−6.7	−1.0
Daily (9 am)	4240	93 900	14.0	−3.0
Daily (3 pm)	5530	101 000	49.0	4.4
Weekly	1330	97 400	−64.2	0.7
Fortnightly	1350	102 500	−63.8	6.0
Monthly (1st)	2040	92 200	−45.2	−4.7
Monthly (11th)	1170	94 700	−68.6	−2.1
Monthly (21st)	1630	93 100	−56.2	−3.7



Bieroza MZ *et al.*, 2014, Understanding nutrient biogeochemistry in agricultural catchments: the challenge of appropriate monitoring frequencies. Environ. Sci.: Processes Impacts, 16, 1676.

Mitigation measures

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P and N abatement

- Reduced fertilization,
- Reduction in cattle numbers,
- Reduction in poultry numbers,
- Reduction in pig numbers,
- Restoring wetlands,
- Improving wastewater treatment.

P abatement

- Constructed wetlands and ponds,
- Reducing P in detergents.

N abatement

- Catch crops e.g. under spring-sown cereals.

Ahlvik *et al.*, 2012; Hasler *et al.*, 2012

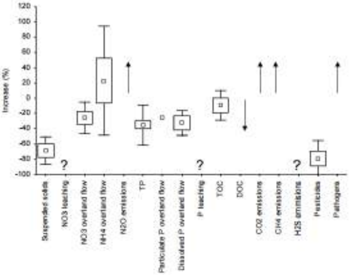

Figure 6. Percent reduction (-) or increase (+) from constructed wetlands when compared to control plots in: suspended solids, NO_3 leaching losses, NO_3 losses in overland flow, NH_4 losses in overland flow, N_2O emissions, total P losses on overland flow, dissolved P losses in overland flow, P leaching, total organic carbon losses in overland flow, dissolved organic carbon losses in overland flow, CO_2 emissions, CH_4 emissions, H_2S emissions, pathogens in overland flow and overland flow pesticide

Stevens and Quinton, 2009

"Pollution swapping" - P and N have different sources, mobilisation mechanisms, delivery pathways and biogeochemical transformations in aquatic systems.

Take-home message

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Why does reducing diffuse loads of nitrate and phosphorus from agricultural catchments prove so difficult?

- **Sources of diffuse pollution are distant in both space and time from the locations where their impact can be observed**,
- Tackling diffuse pollution is an important objective in the EU and Swedish legislation: Water Framework Directive 2000, Nitrates Directive 1991, the Helsinki Commissions Baltic Sea Action Plan 2007 and the Swedish Zero Eutrophication and Good-Quality Groundwater objectives 2001,
- Despite these significant scientific, management and financial efforts, improvement in chemical and ecological status of water bodies is not satisfactory,
- With a growing food demand, the negative agricultural impacts on environment are also likely to increase,
- Legacy nutrient stores (soils and sediments for P, aquifers for N) are likely to continue to control water quality in highly transformed catchments making mitigation measures unsuccessful,
- Need to improve scientific understanding of complex land-water interactions, including sources, pathways and impacts of the diffuse pollutants on water bodies and targeting of critical source areas of diffuse pollution in agricultural catchments,
- A collaboration between science, stakeholders and policy is crucial to address the challenge of diffuse nutrient losses.

SLU Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Capturing nutrient dynamics

Marie Curie Fellowship

- **Aim:** To evaluate the potential of the *in situ* optical sensors as a proxy for nutrient measurements at high spatial and temporal resolutions in agricultural catchments.
- **Study area:** Swedish Monitoring Programme for Agriculture catchments.
- **Methods:**
  - Lab analyses of the SMPA samples for TP, SRP, TN, NO_3N, TOC, SS and optical measurements.
  - Field deployments of the *in situ* TURB, CDOM, TLF and TEMP sensors.
  - Temporal (flow) and spatial (geography, land use) scale.
- **Impact:** Outreach activities, collaboration with Swedish Board for Agriculture and Swedish Environment Protection Agency.

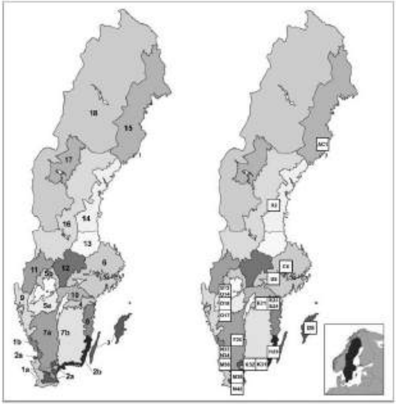

Fig. 1. Agricultural leaching regions and agricultural monitoring catchments (squares).

Kyllmar, K., et al., Small agricultural monitoring catchments in Sweden representing environmental impact. Agric. Ecosyst. Environ. (2014). http://dx.doi.org/10.1016/j.agee.2014.05.016

EU-funding

Baltic flows

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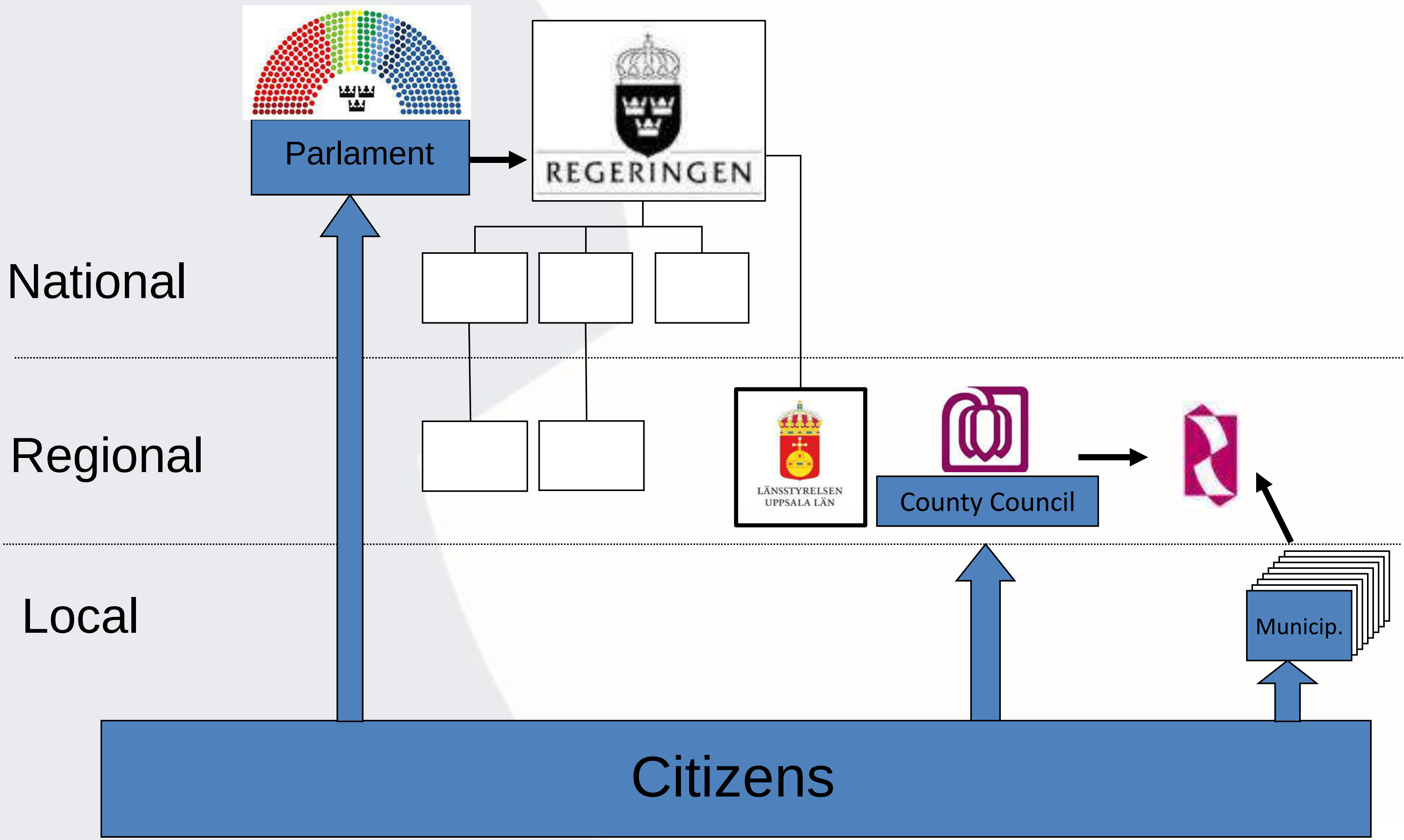
Uppsala Regional Council
Sweden

Uppsala Regional Council



Tasks of the Regional Council

Tasks given by the state
Strategies for Regional development and traffic/infrastructure

Political platform for dialogue and agreements
Continual dialogue and day-to-day issues

Tasks given by the members
Long and short-term commitments

- Infrastructure and public transport
- Labour market skill supply
- Trade and Industry
- Public health
- National and international affairs (EU)
- Energy issues
- Inclusive labour market
- Social services

Uppsala Regional Council
Sweden

How does EU aim to meet the environmental challenge?

1) Directives

2) Recommendations

3) Tools

Which focus?

Geographical	or	Sectoral
Structural and Investerings funds		Sectoral programs

Steering structure for EUs financial toolkit

Europa 2020 targets

75 – 3 – 20/20/20 – 10/40 – 20 million

↓

11 thematic priorities

↓

All European policies and tools

Uppsala Regional Council
Sweden

11 investment priorities

SMART

1. Strengthening research, technological development and **innovation**
2. Access to, use and quality of **information and communication technologies (ICT)**
3. Enhancing the **competitiveness** of small and medium-sized enterprises (SMEs)

SUSTAINABLE

4. Supporting the shift towards a **low-carbon economy** in all sectors
5. Promoting **climate change** adaptation, risk prevention and management
6. Preserving and protecting the **environment** and promoting resource efficiency
7. Promoting sustainable **transport** and removing bottlenecks in key network infrastructures

FOR ALL

8. Promoting sustainable and quality **employment** and supporting labour mobility
9. Promoting **social inclusion**, combating poverty and any discrimination
10. Investing in education, training and vocational training for skills and **lifelong learning**
11. Enhancing **institutional capacity** of public authorities and stakeholders and efficient public administration

COM(2011) 614 and Regulation (EU) 1303/2013

4) SUPPORTING THE SHIFT TO A LOW-CARBON ECONOMY IN ALL SECTORS

a) promoting the production and distribution of renewable energy sources

b) promoting energy efficiency and renewable energy use in SMEs

c) supporting energy efficiency and renewable energy use in public infrastructures and in the housing sector

d) developing smart distribution systems at low voltage levels

e) promoting low-carbon strategies for urban areas

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Sweden

5) PROMOTING CLIMATE CHANGE ADAPTATION, RISK PREVENTION AND MANAGEMENT

a) supporting dedicated investment for adaptation to climate change

b) promoting investment to address specific risks, ensuring disaster resilience and developing disaster management system

Uppsala Regional Council
Sweden

6) PROTECTING THE ENVIRONMENT AND PROMOTING RESOURCE EFFICIENCY

a) addressing the significant needs for investment in the waste sector to meet the requirements of the environmental acquis (a collective term which covers more than 300 EU Directives and Regulations)

b) addressing the significant needs for investment in the water sector to meet the requirements of the environmental acquis

c) protecting, promoting and developing cultural heritage

d) protecting biodiversity, soil protection and promoting ecosystem services including NATURA 2000 and green infrastructures

e) action to improve the urban environment, including regeneration of brownfield sites and reduction of air pollution

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Sweden

7) PROMOTING SUSTAINABLE TRANSPORT AND REMOVING BOTTLENECKS IN KEY NETWORK IN-FRASTRUCTURES

a) supporting a multimodal Single European Transport Area by investing in the Trans-European Transport Network (TEN-T) network

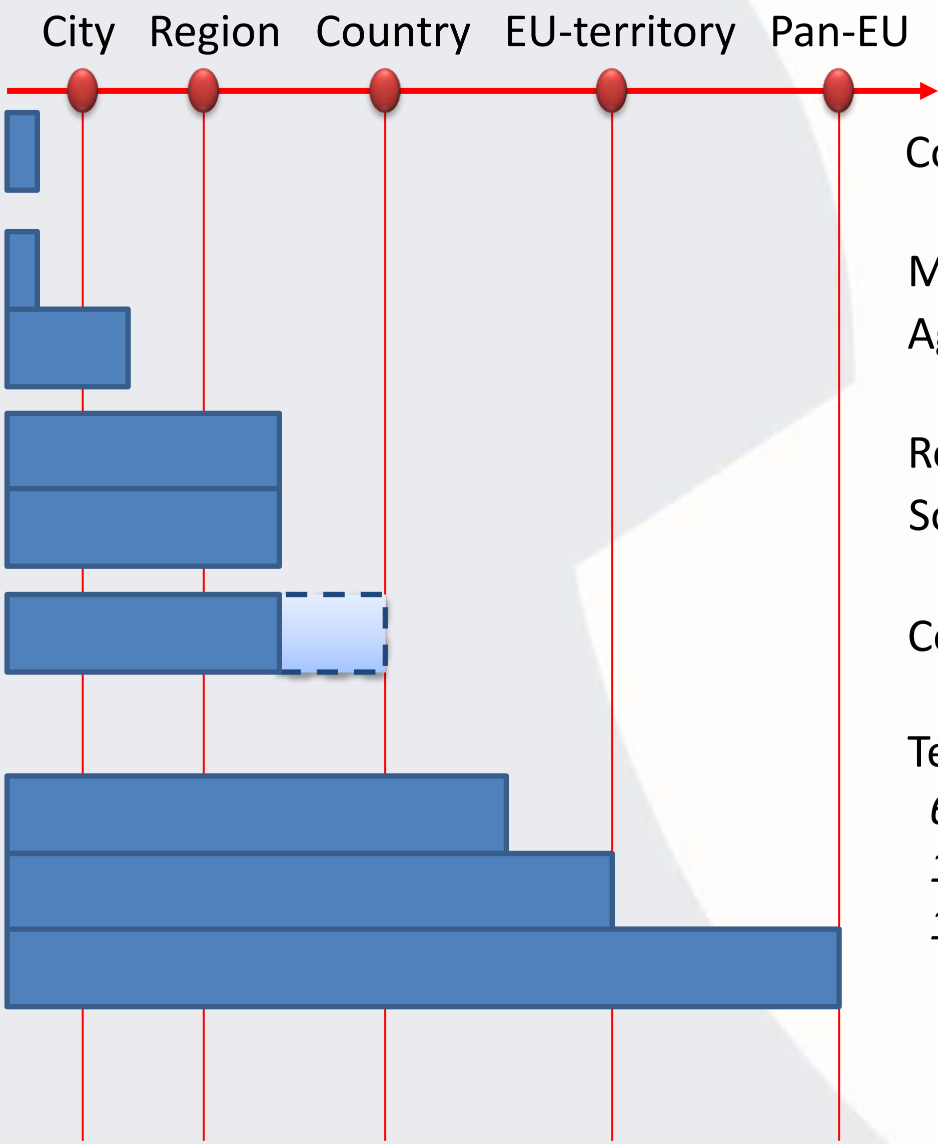
b) enhancing regional mobility through connecting secondary and tertiary nodes to TEN-T in-frastructure

c) developing environment-friendly and low-carbon transport systems and promoting sustainable urban mobility

d) developing comprehensive, high quality and interoperable railway system

How are funds allocated to specific investment priorities?

Structural and investment funds



Community Lead Local Development

Maritime and fisheries fund (EHFF)
Agricultural Fund for Rural Development (EARDF)

Regional Development Fund (ERDF)
Social Fund (ESF)

Cohesion/convergence Fund

Territorial Cooperation
60 Cross-border – Interreg V-A,
15 Transnational – Interreg V-B,
1 Pan European - Interreg Europa-C
3 networking programmes
(Urbact III, ESPON)

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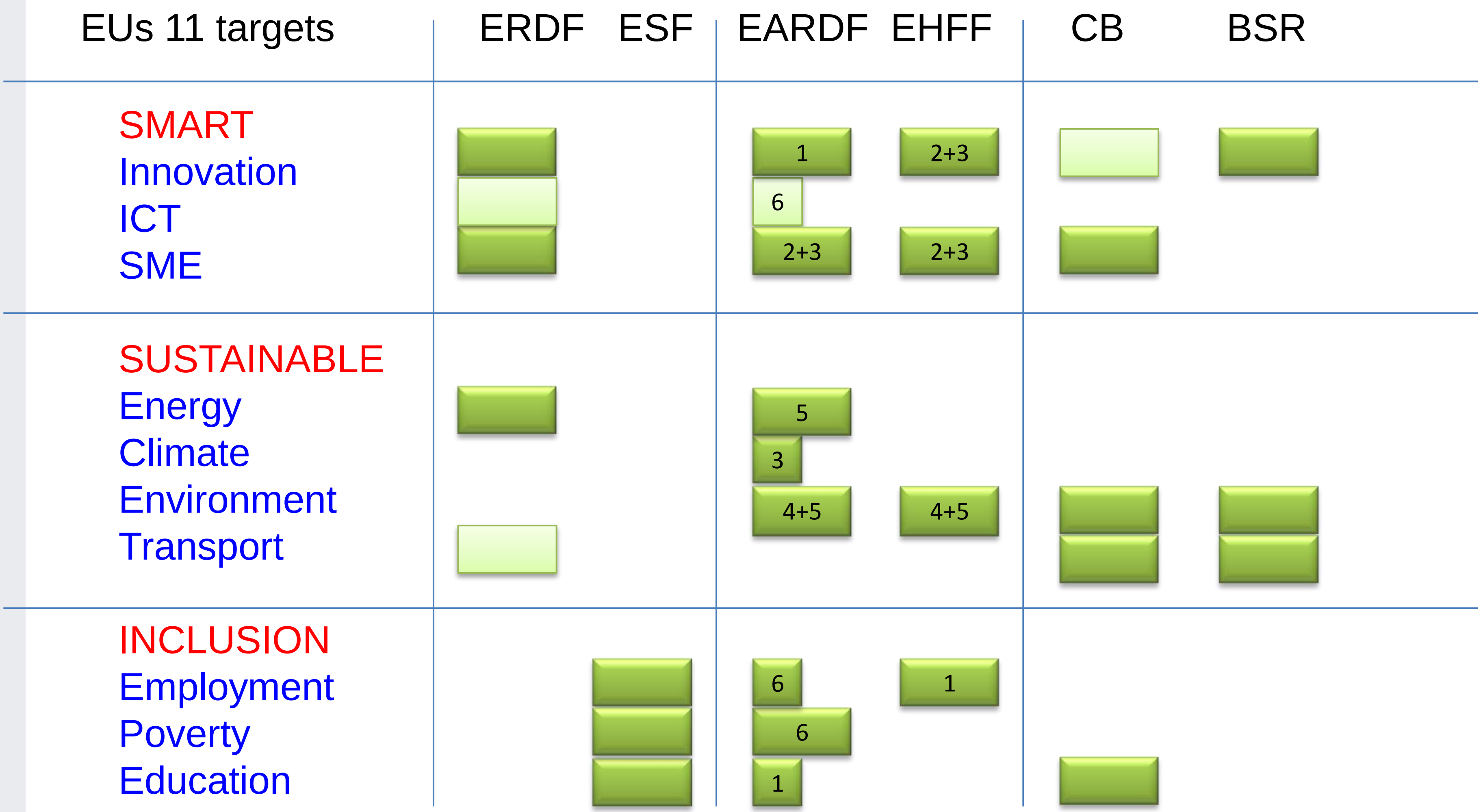
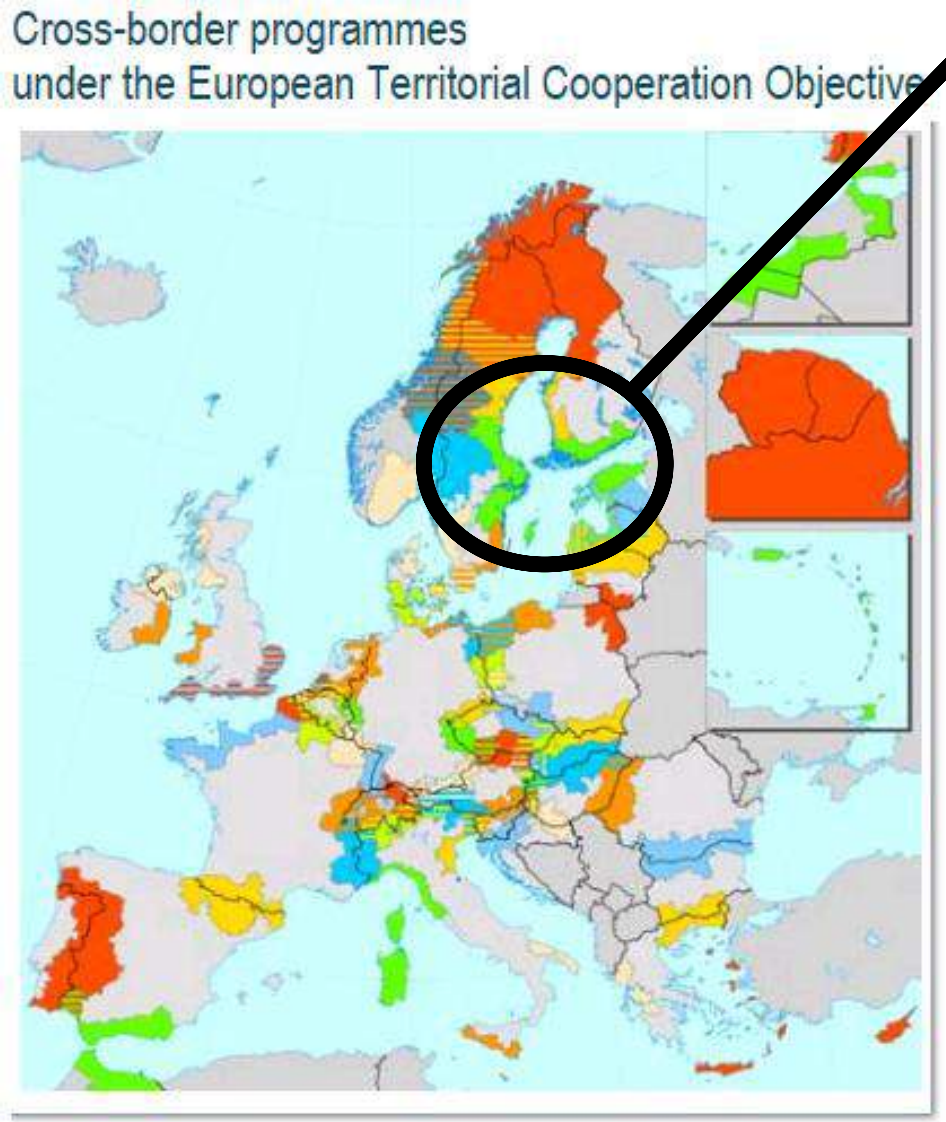
EU-targets and programs in Uppsala



Cross-border – Interreg V-A



Central Baltic www.central-baltic.eu

1) Competitive economy

2) **Sustainable use of common resources**

… improve the status of the Baltic Sea,
… reducing pollution from nutrients, hazardous substances and toxins' inflows via jointly developed and implemented new innovative methods and technologies,
… to protect and develop the regions' unique, joint natural and cultural heritage,
… promote sustainable use of marine ecosystems via maritime spatial planning and integrated coastal zone management
… to improve urban planning and management.

3) Well-connected region

4) Skilled and socially inclusive region

Next call: Jan 2017

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Sweden

Interreg Baltic Sea Region

Transnational – Interreg V-B
www.interreg-baltic.eu/home.html

Priority 1 'Capacity for innovation'

Priority 2 'Efficient management of natural resources'

- ***2.1 'Clear waters':*** *To increase efficiency of water management for reduced nutrient inflows and decreased discharges of hazardous substances to the Baltic Sea and the regional waters based on enhanced capacity of public and private actors dealing with water quality issues*
- ***2.2'Renewable energy':*** *To increase production of sustainable renewable energy based on enhanced capacity of public and private actors involved in energy planning and supply*
- ***2.3 'Energy Efficiency':*** *To increase energy efficiency based on enhanced capacity of public and private actors involved in energy planning*
- ***2.4 'Resource-efficient blue growth':*** *To advance sustainable and resource-efficient blue growth based on increased capacity of public authorities and practitioners within the blue economy sectors*

Priority 3 'Sustainable transport'

Priority 4 'Institutional capacity for macro-regional cooperation'

Next call: Earliest February 2016

Uppsala Regional Council
Sweden

Interreg Europe

European Union | European Regional Development Fund

Interreg Europa-C

www.interregeurope.eu/

Interreg Europe helps regional and local governments across Europe to develop and deliver better policy.

1) Research and innovation
2) SME competitiveness
3) Low-carbon economy
4) Environment and resource efficiency

Open call for tenders: Interreg Europe Policy Learning Platforms
Deadline for submission of offers: 11 January 2016

Uppsala Regional Council
Sweden

Connecting cities
Building successes

URBACT III

www.urbact.eu

URBACT helps cities to develop pragmatic solutions that are new and sustainable and that integrate economic, social and environmental urban topics.

Abandoned Spaces
City Planning
Disadvantaged Neighbourhoods
Financial Engineering
Low Carbon
Urban Mobility
Urban Sprawl

Capacity Building
Culture & Heritage
Energy Efficiency
Housing
Strategic Planning
Urban Renewal
Urban-rural

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Sectoral funds

Environment and climate action LIFE+

Horizon 2020

Civil Protection and Emergeny Response Centre

Copernicus (GMES)

Development Cooperation Instrument

Uppsala Regional Council
Sweden

LIFE+

ec.europa.eu/environment/life/index.htm

Call info

Environment:

Nature & Biodiversity

Environment & Resource Efficiency

Environmental Governance & Information

Climate Action:

Climate Change Mitigation

Climate Change Adaptation

Climate Governance and Information

By country

Project database

Uppsala Regional Council
Sweden

LIFE+

LIFE multiannual work programme for 2014-2017
The LIFE multiannual work programme for 2014-2017 sets the framework for the next four years for the management of the new LIFE Programme 2014-2020. It contains an *indicative budget*, explains the selection *methodology* for projects and for operating grants and establishes *outcome indicators* for the two LIFE sub-programmes – for Environment and for Climate Action. The total budget for funding projects during the period covered amounts to €1.1 billion under the sub-programme for Environment and €0.36 billion under the sub-programme for Climate Action.

26 action grants in first year of LIFE Climate Action projects - 25 November 2015
26 projects in 11 Member States. The projects represent a total investment of some €73.9 million. The EU will provide €36.75 million of this figure. The projects cover actions in the fields of climate change mitigation, climate change adaptation and climate governance and information.

Thank you for your time…

Good luck with your future projects!

Uppsala Regional Council
Sweden

ReSolve

Create "Stormwater (Dagvatten)" solution in Uppsala

INNOVATION COMPETITION

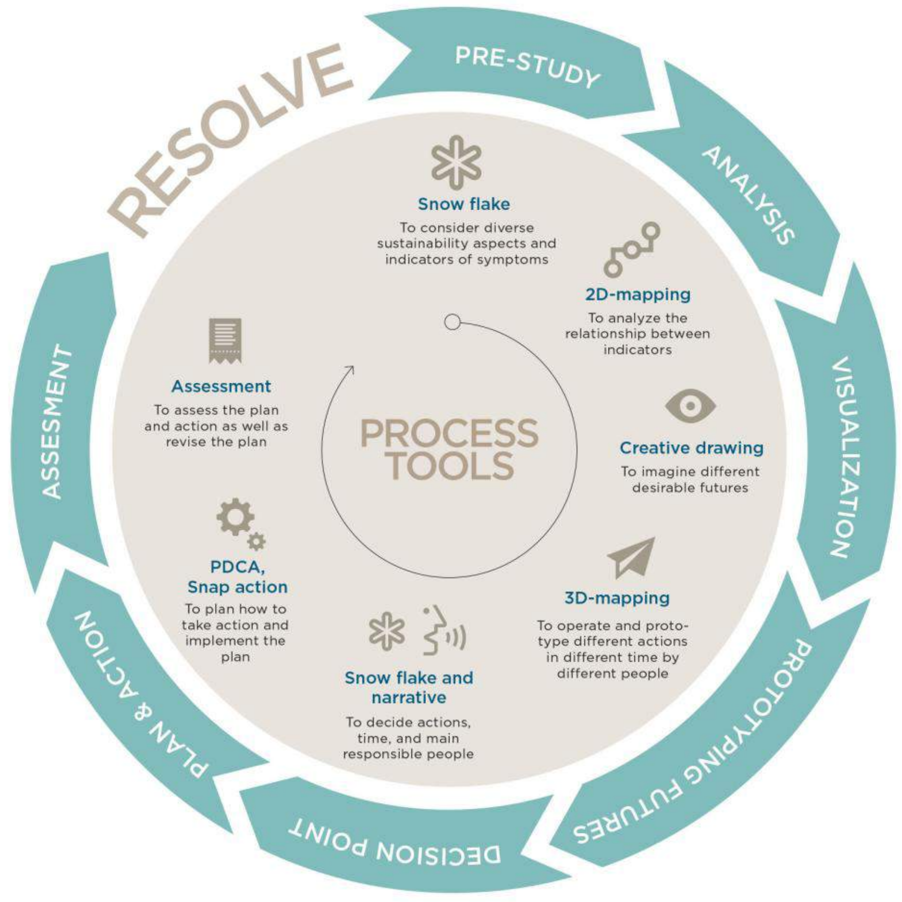
YOSHIKO ASANO, PH.D
PROJECT COORDINATER
CENTER FOR SUSTAINABLE DEVELOPMENT
UPPSALA UNIVERSITY

Uppsala KOMMUN · UPPSALA VATTEN · UPPSALA UNIVERSITET · CSD Uppsala. · SLU · VINNOVA

WHAT IS RESOLVE INNOVATION COMPETITION?

- The purpose of the ReSolve Innovation Competition(RIC) was to develop innovative sustainable solutions to address the storm-water issues faced by Uppsala Municipality.
- Another goal was to increase the awareness of how the competition can be used as mediate and catalyze viable innovations by collaboration between University, Municipality and local actors.

RESOLVE PROCESS



This process is called the Re-Solve Process consisting of seven steps, 1) pre-study, 2) analysis, 3) visualization, 4) prototyping futures, 5) decision point, 6) plan and action and 7) assessment.

HOW DID THE KEY QUESTION EMERGE?

- **The inception workshop was held at Uppsala Municipality with twenty participants. Uppsala Municipality is planning to develop the areas along *Tycho Hedéns väg (road)* and the surrounding land without increasing polluted water runoff into *Fyrisån (river)*.**
- **They sought an innovative solution from students:"*Find new methods for purifying the water from Tycho Hedéns väg in order to decrease the environmental impact on Fyrisån*. The student teams ideas were intended to support Uppsala Municipality in reconciling conflicts of interest between land use and storm water management.**

THE STRUCTURE ANALYSIS

- The project – a new Local Plan for the area – is based on the Structure Analysis *(made by SWECO for Uppsala municipality)*
- The purpose of the Structure Analysis was to suggest a new street section for Tycho Hedéns road, and how the surroundings can be transformed and shaped into a more urban part of the city.
- With focus on accesability for cyclists and pedestrians
- Principles for storm water management
- Pilot project for the road section

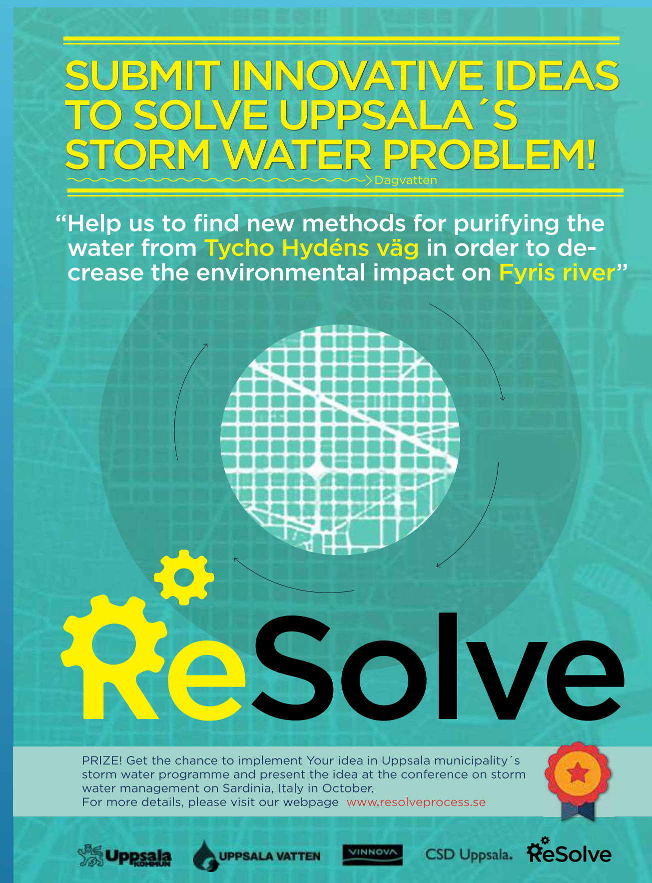
THE STRUCTURE ANALYSIS

Before…

… and after

THE STRUCTURE ANALYSIS

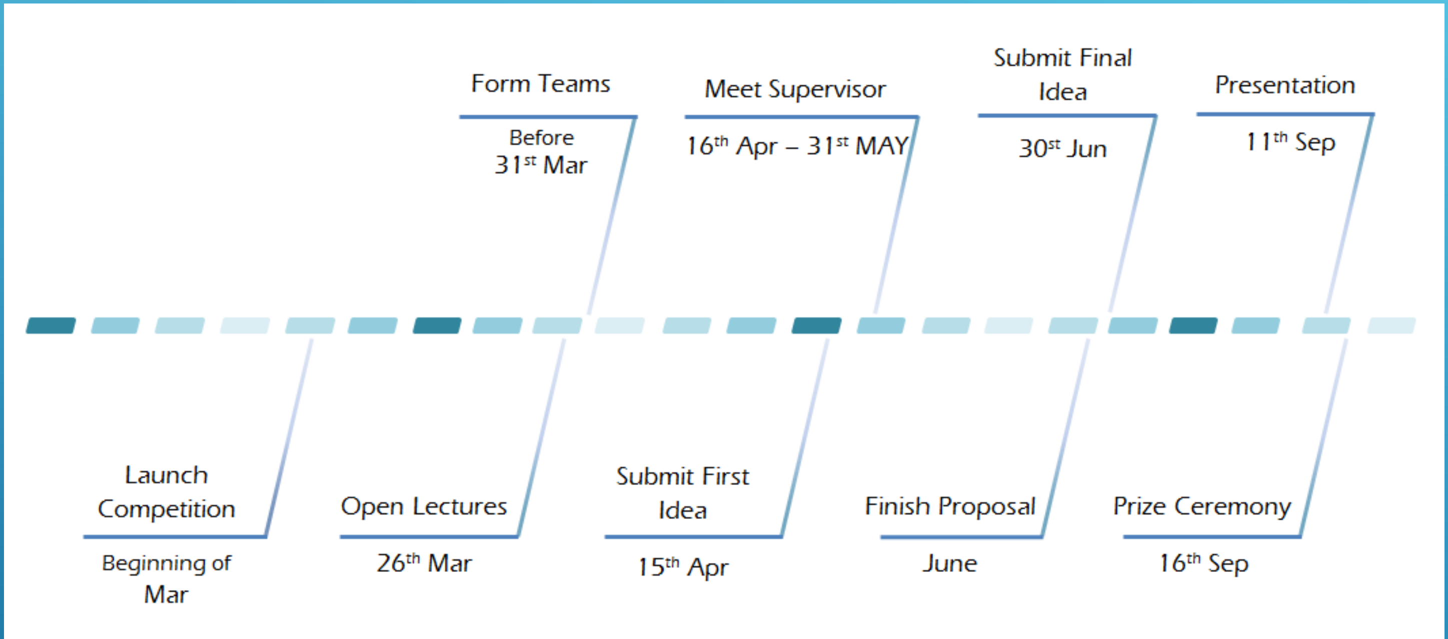
RESOLVE INNOVATION COMPETITION



PRIZE

☆***Get the chance to implement the idea in Uppsala municipality's storm water program!***

☆***Present the idea at the climate change conference on storm water management on Sardinia, Italy on 14-16th in October,2015!***


Form Teams
Before
31st Mar
Meet Supervisor
16th Apr – 31st MAY
Submit Final
Idea
30st Jun
Presentation
11th Sep
Launch
Competition
Beginning of
Mar
Open Lectures
26th Mar
Submit First
Idea
15th Apr
Finish Proposal
June
Prize Ceremony
16th Sep

SCHEDULE

STUDENT TEAM

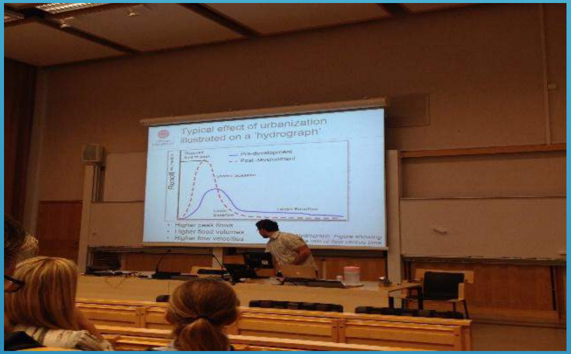
- **TAJB**-*Tilde Kamp, Agnes Forsberg, Johan Karlsson and Benjamin Selling* ***(Water programme and Environmental and Water Engineering)***
- **Inno-vew**-*Veronika Wang* ***(Water programme and Environmental and Water Engineering)*** *,Erik Österberg* ***(Computer Science) +Flexiclean***
- **SOLVED**-*Fran Pennynck* ***(Bio-Engineer),*** *Martha Mancheva and Filip Jennerholm* ***(CSD)*** *and Emelie Bergstroïm****(Landscape,SLU)***
- **Gröna Grannar**-*Robin Al-Salehi* ***(CSD)****,Josephine Haraldh* ***(Receptary program)***
- **LINNAEUS 4D**-*Felix Peniche* ***(CSD)****, Jonas Allerup* ***(Economics)****, Justin Makii* ***(CSD)****, Johan Payton* ***(Business)+ ICASSA***

HOW DID STUDENT TEAMS DEVELOP THEIR IDEAS?

- The One-Day lecture on Storm-water, 26th in March
- Team Consultation, May
- The Speed Dating Workshop, 14th in May

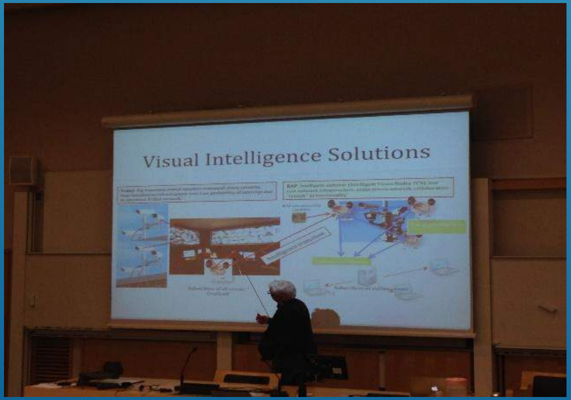
ONE DAY LECTURE OF STORMWATER

The aim was to create an exchange platform for students and stakeholders of the RIC.



Technik

Business

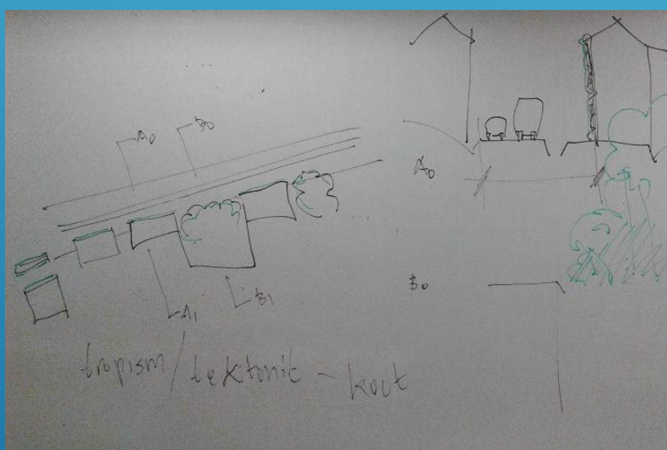


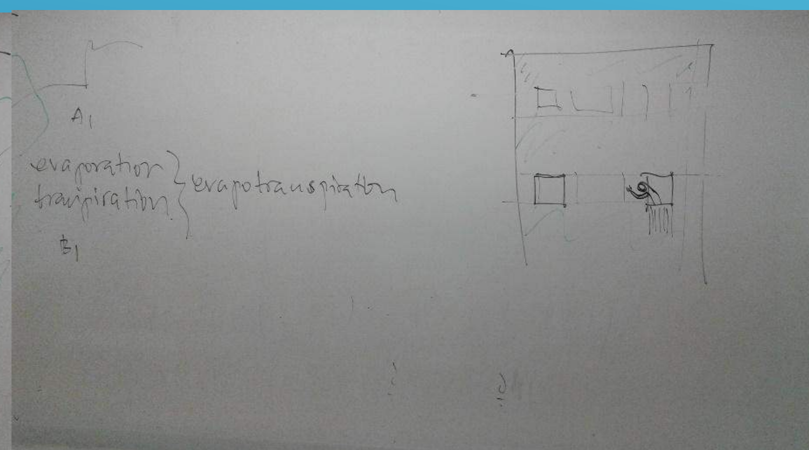
WSAP

FlexiClean

TEAM CONSULTATION

- The aim was to gain foster feedback on the initial team´s ideas from academics with backgrounds in *Technology, Sustainability, Landscape, Business, Governance and Presentation*.





Drawings by Per Hedfors, Landscape Architect (PhD)
Consultant of Landscape

SPEED DATING WORKSHOP

- The aim was for student teams to polish their ideas, perspectives and assumptions during a process where they responded to critique offered by RIC's stakeholders (Uppsala Municipality and Uppsala Water), local company representatives (IKEA), non-government organizations (NGO), a local high school representative and the general public.

Uppsala Kommun

Uppsala Vatten

Rosendahl School

Public person

JURIES

- Uppsala Municipality

Zahrah Lifvendahl *(Water strategist)*

- Uppsala Vatten och Avfall AB

Kristina Ekholm *(Investigation engineer)*

- CSD Uppsala, Department of Earth sciences, Department of Business, Uppsala University

Neil Powell *(CSD Uppsala)*

Lars Ryden *(CSD Uppsala)*

Ivo Zalander *(Department of Business)*

Giuliano Baldassarre*(Department of Earth sciences)*

FINAL PRESENTATION

TAJB

Inno-vew

SOLVED

Gröna-Granner

LINNEAUS 4D

WHAT WAS THE RESULT OF THE RESOLVE INNOVATION COMPETITION?

- Using the 10 evaluation criterias, the Juries assessed proposals from five teams. **Team SOLVED** won. The proposal acknowledged the needs and challenges of multiple stakeholders; it tackled a number of goals underpinning a sustainable Uppsala and addressed the problems of storm-water quality and quantity via an approach that fosters innovative, human centered technology and design.

<u>10 critereas</u>: Technical feasibility, Sustainability, Adaptability to the landscape, Imprementability, Inclusiveness (concern for stakeholders), Commercial potencial, Functionality(multi-functionality), Cost effectiveness, Novelity (creativity), Presentation (Oral and written)

THANK YOU FOR LISTENING!

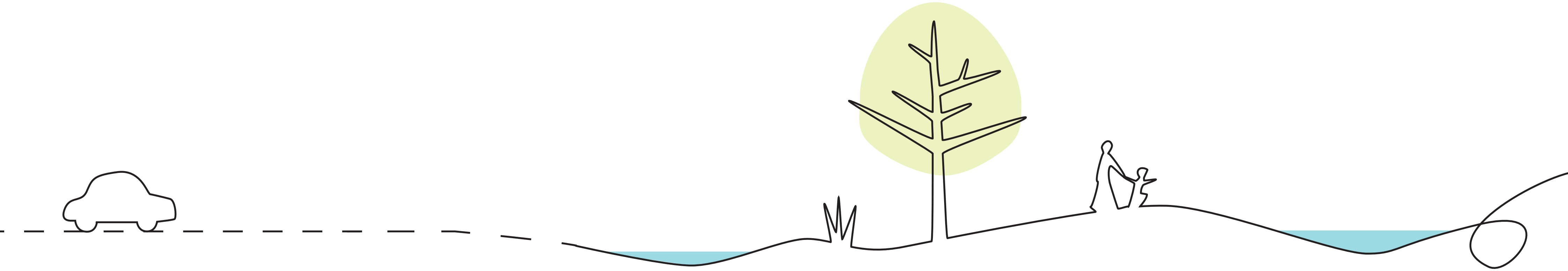
WWW.RESOLVEPROCESS.SE

***Winner Ceremony at UKK*, 17th in September, 2015**

***Climate change conference at Sardinia*, 16th in October, 2015**

TAKE HOME MESSAGE

- *What kinds of event or strategy does fit to solve the problem of stormwater in your region?*
- *What kind of difficulties do you have to involve stakeholders to the event or project?*
- *How do you think about involving youth idea to solve the problem in your region?*



From highway to greenway

Team SOLVED;
Fran Pennynck, Martha Mancheva,
Filip Jennerholm and Emelie Bergström

Resolve challenge

Handling stormwater in particular when the system is overburdened by heavy precipitation

Handling the runoff of polluted water from roads

On site analysis

Challanges

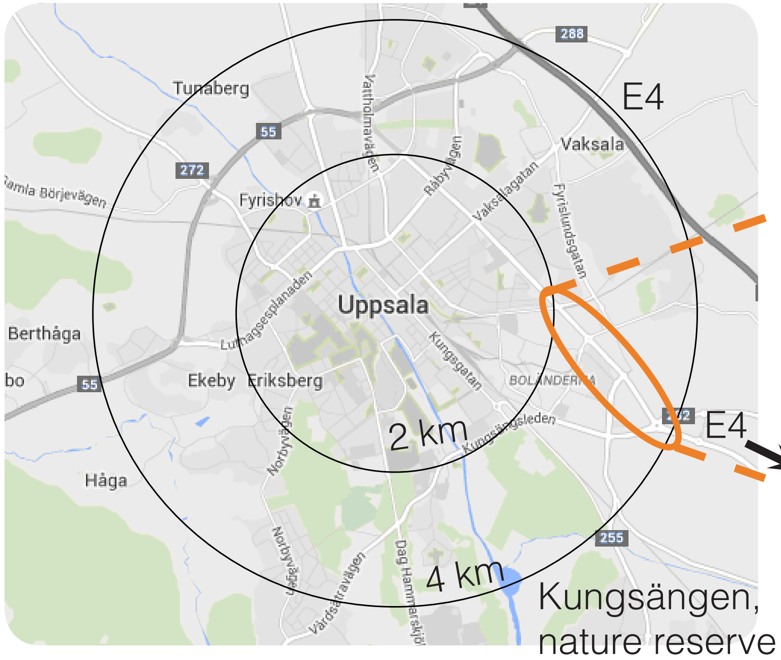
- The stormwater system is over-burdened
- Polluted runoff water from the road is not treated properly
- Unwelcoming industrial feel
- Automobile-centered area
- Fyris river
- Increased strain follows with heavier traffic loading
- Inaccessible to pedestrians and cyclists

Values

- Close to Natura 2000
- Close to the city core
- Entrance to Uppsala
- Green corridor
- Business centrum
- Disconnected from the sewer system
- Existing carpool parking

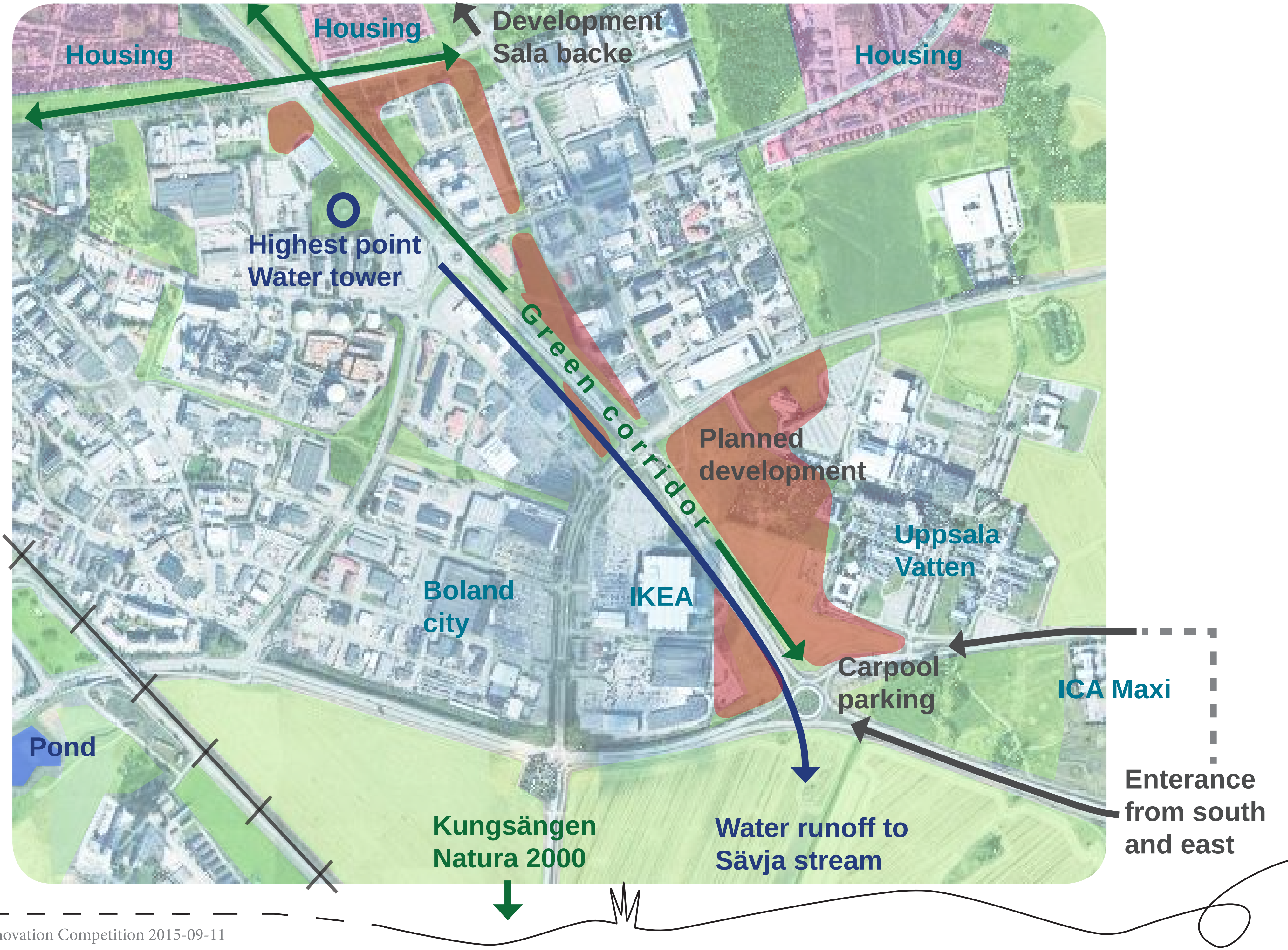
On site analysis

Uppsala

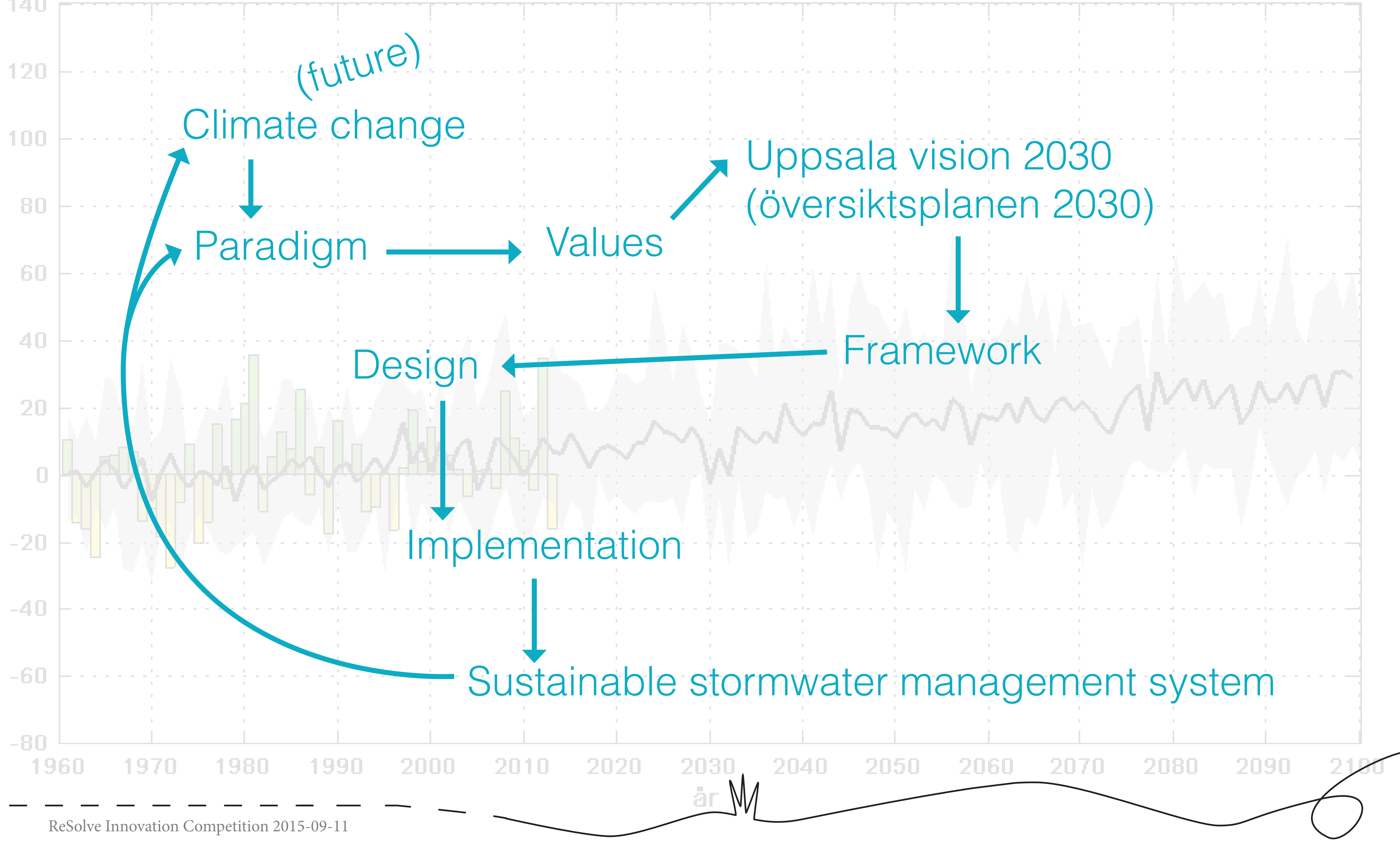


Boländerna, industrial and shopping area

Wildlife in the area


Housing
Housing
Development
Sala backe
Housing
Highest point
Water tower
Green corridor
Planned
development
Uppsala
Vatten
Boland
city
IKEA
Carpool
parking
ICA Maxi
Pond
Enterance
from south
and east
Kungsängen
Natura 2000
Water runoff to
Sävja stream

System analysis



Inspiration

Copenhagen Strategic Flood Masterplan, Atelier Dreiseitel

Swale

Rain garden

Interactive stormwater management

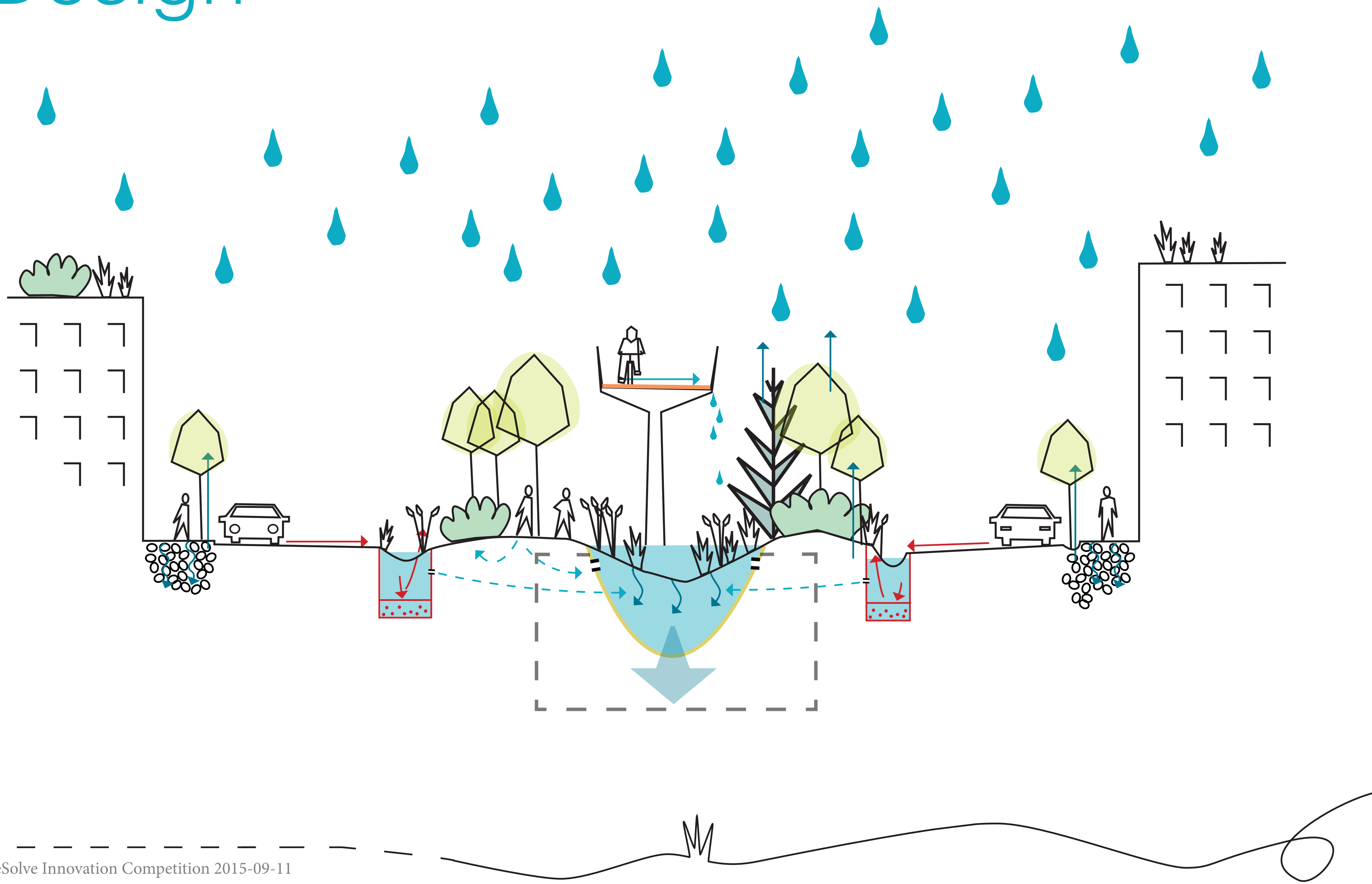
Transformation of the Cheonggyecheon River in Seoul, South Korea

Benthemplein, Rotterdam, the Netherlands

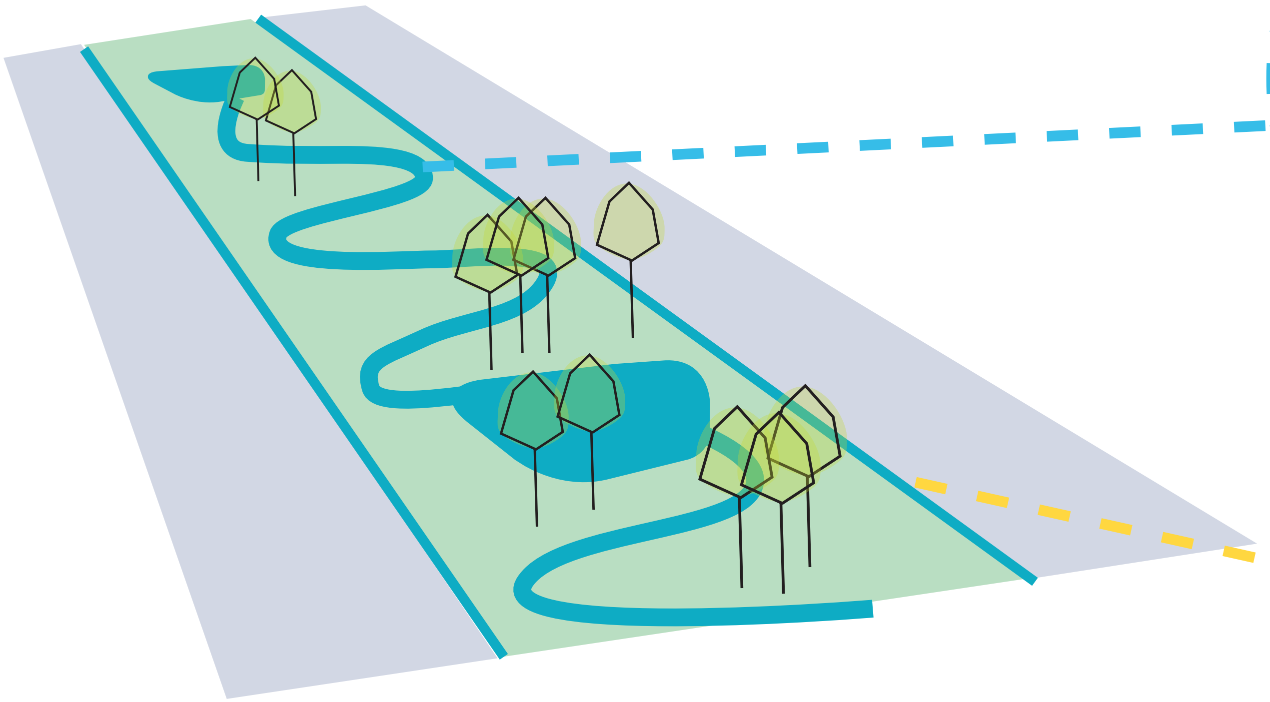
Design

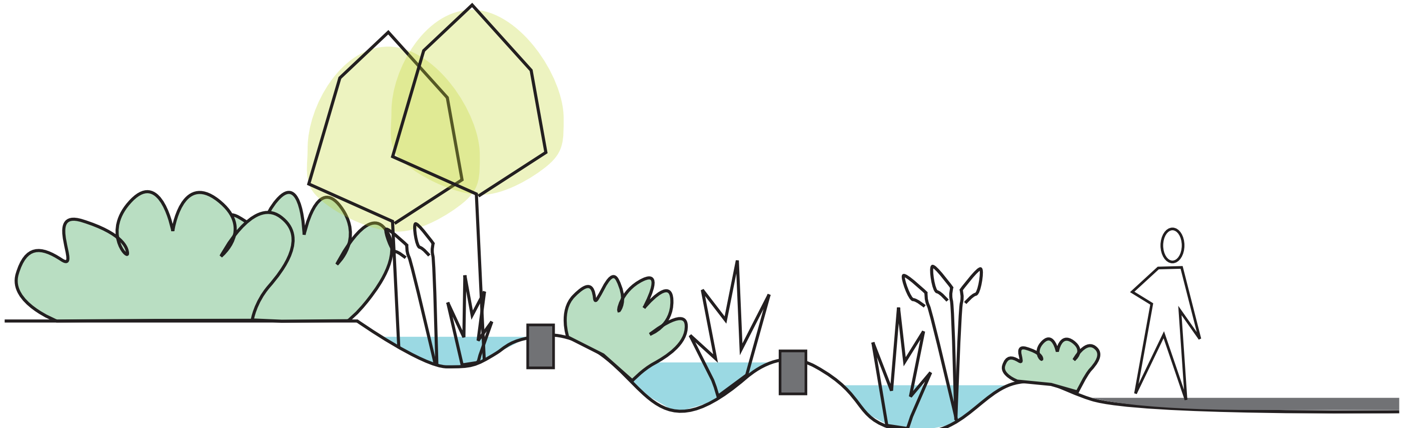
Design

Design



Examples of BMPs



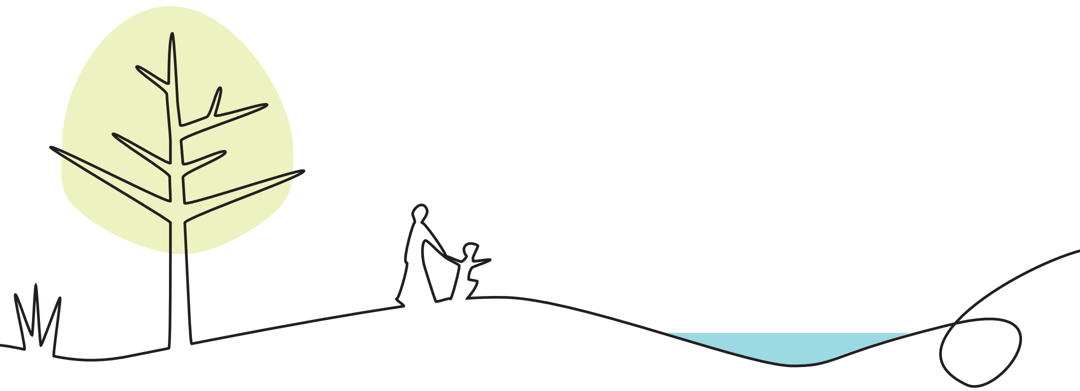


Benefits

- Green stormwater management
- Social interaction
- Sustainable transportation
- Long-term perspective
- Adaptability
- Resilience
- “Trademark” entrance to Uppsala
- Sustainable urban development

"the solution should be able to be revised or adapted over and over again if knowledge advances or circumstances change"

Resolve, 2015



Storm-water management:
”Approximately right or precisely wrong”?

Giuliano Di Baldassarre, Uppsala University
giuliano.dibaldassarre@geo.uu.se

Storm-water management
Urban flooding

(Jakarta flooding, 2013)

(Malmö flooding, 2014)

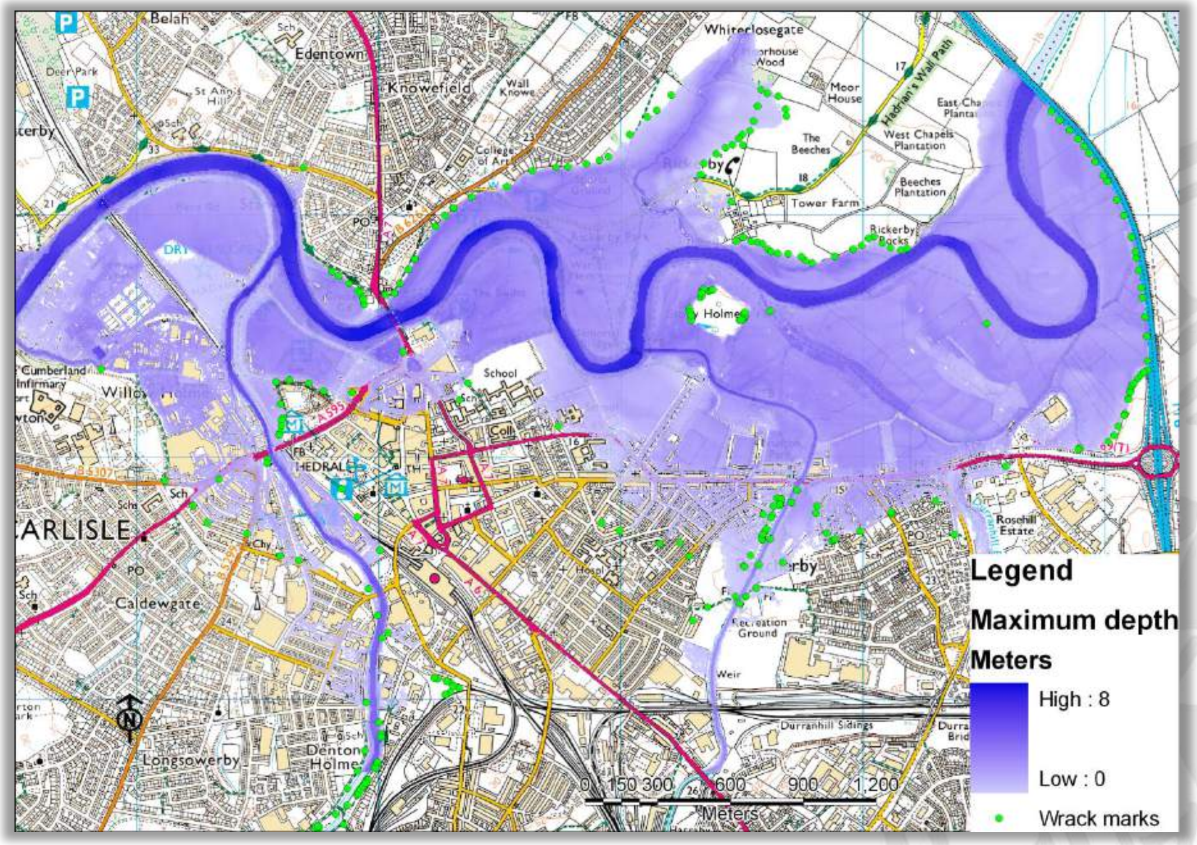
Storm Water Modeling

Modelling storm-water and urban flooding

Simulating urban drainage and flood inundation processes

+ Urban flood hazard mapping: identification of flood-prone areas

+ Reduce potential damage: urban planning, raising risk awareness, etc...

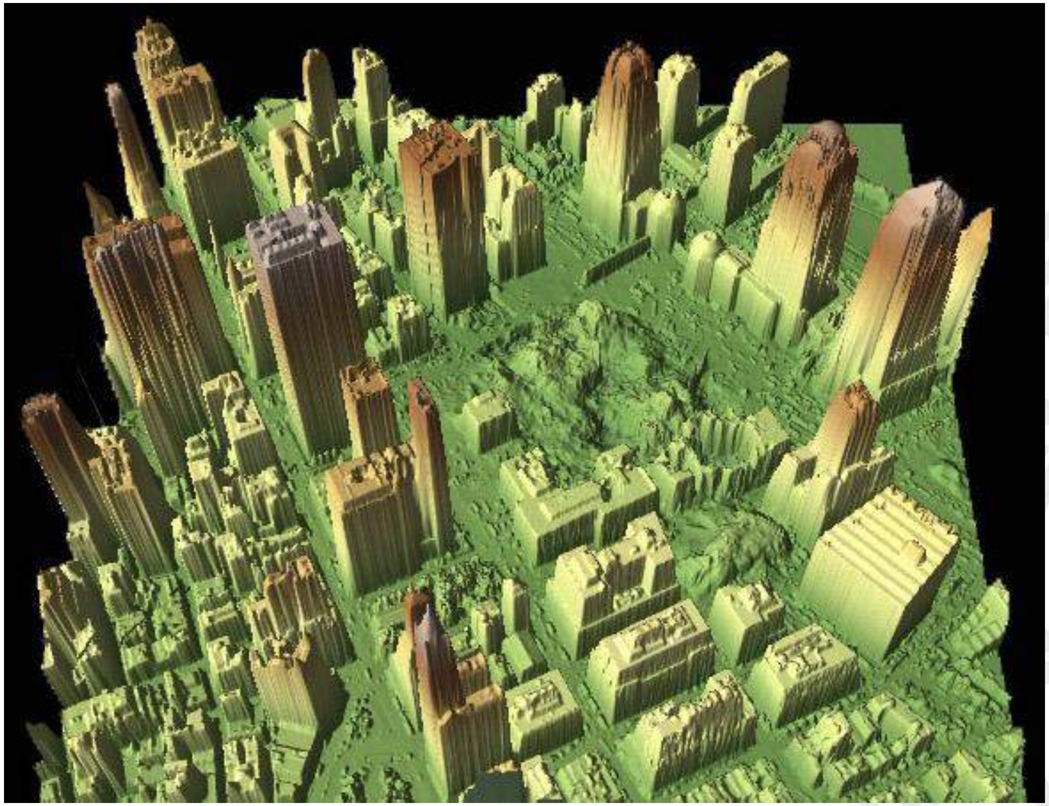


(Bates et al., 2012)

Remote sensing (topography)

Airborne laser altimetry: LiDAR

High resolution topography (e.g. 1m DTM; 10 cm accuracy) as input data



LiDAR topography of New York City Source: RST NASA

(Di Baldassarre and Uhlenbrook, Hydrological Processes, 2012)

Opportunities and Challenges

Small features (typical in urban areas) can now be included in the model…

...but what about cars?
Same dimension as 2m mesh, they can obstruct narrow streets, float, produce debris roundups

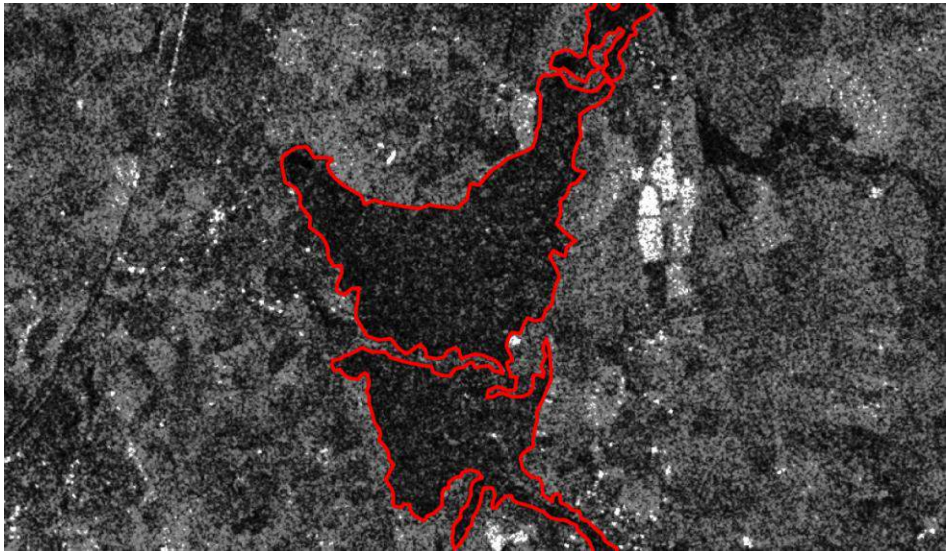
2011 Genova, Italy (sources: genova24.it; tg24.sky.it)

(Dottori et al., Water Resources Research, 2013)

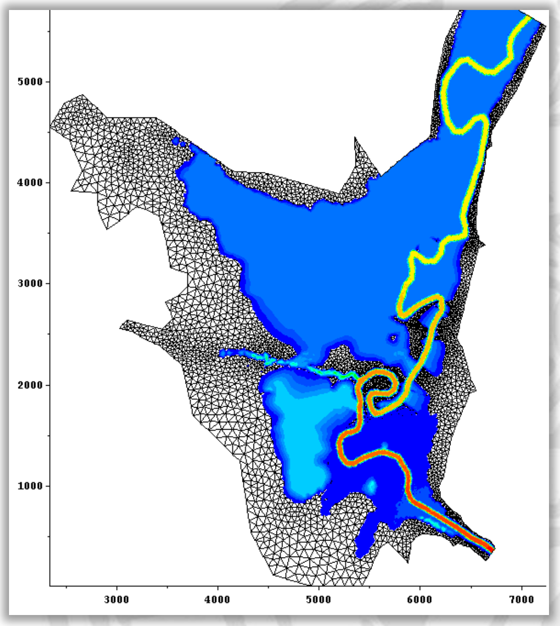
Remote sensing (flood extent)

Satellite or airborne images
Inundation maps as calibration data

ERS-2 SAR imagery (12.5m resolution)
Flood extent map (wet/dry)



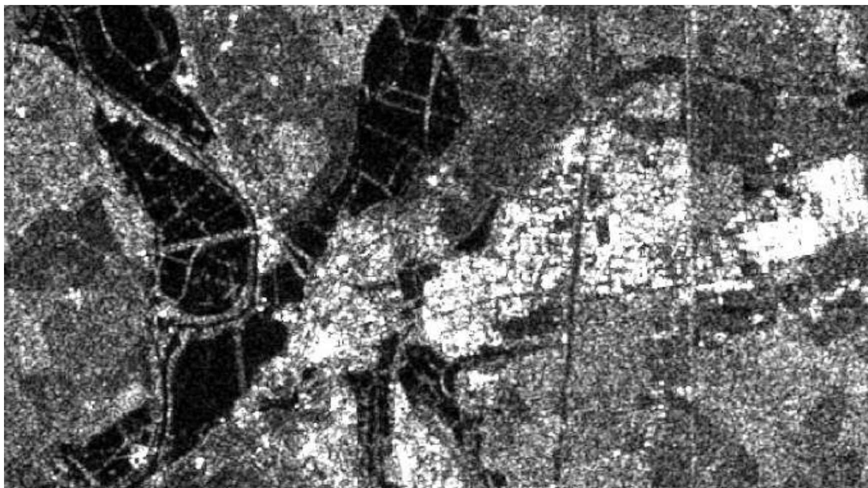
Flood model results
Water depth
(blue to yellow to red)

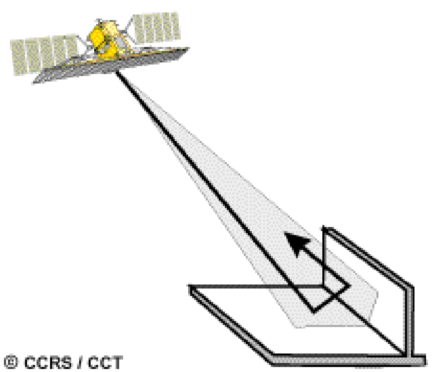


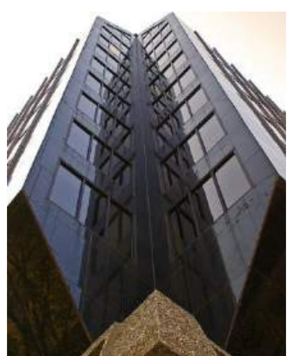
(Di Baldassarre et al., Journal of Hydrology, 2009)

Opportunities and Challenges

Sharp corners (typical in urban areas): signal bounces twice or more off the surface and returns signal back to instrument







(Di Baldassarre, Floods in a changing climate: inundation modelling, 2012; sources: Guy Schumann)

Uncertainty in storm-water modelling

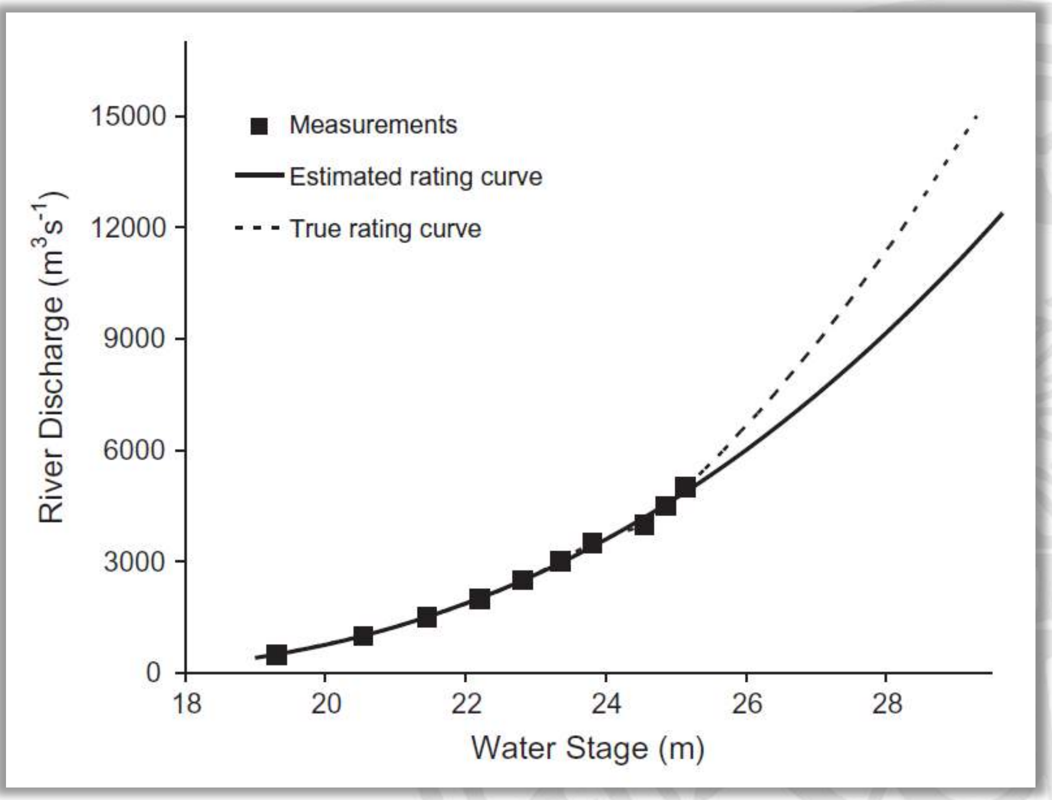
- Observation (input and calibration/validation data)
- Parameters
- Model structure

Uncertainty in input data

Typically, river discharge is not directly observed

Rating curves are used to convert water levels into river discharge

Errors in flood data may be high (up to ±40%)



Uncertainty in input data

Inflow conditions are often difficult to determine
(e.g. location of river bank overtopping, dyke breaching…)

Influence of sewer surcharging (in urban areas) and debris roundups

2012 Sestri Levante, Italy (source: classmeteo.it)

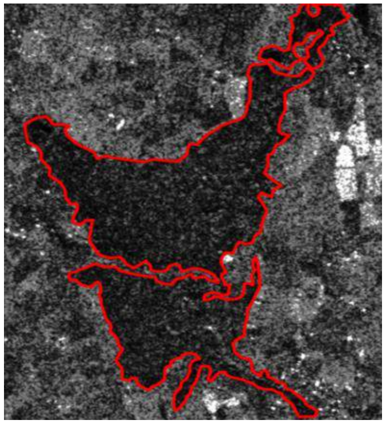
2011 Cinque Terre, Italy (source: skytg24.it)

Uncertainty in calibration data

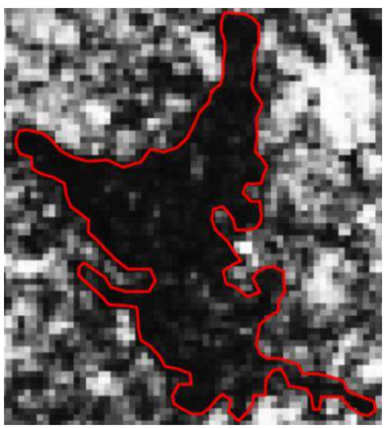
Deterministic binary (wet/dry) flood extent maps

River Dee (UK): 2 different images at the same time (2006 flooding)

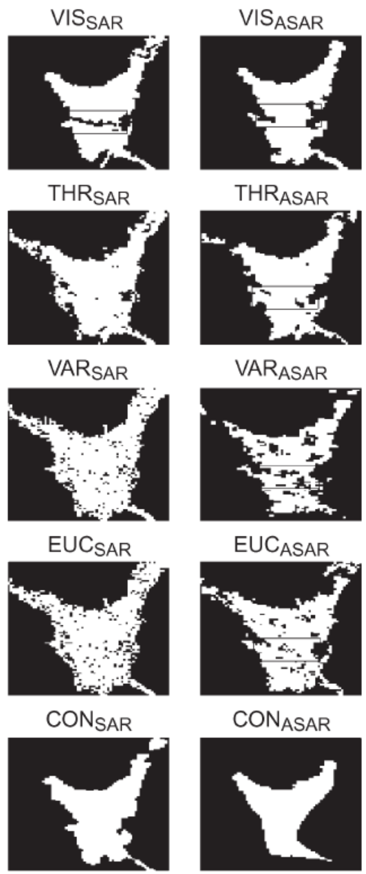
ERS-2 SAR (12.5m)



ASAR (Envisat WSM, 75m)

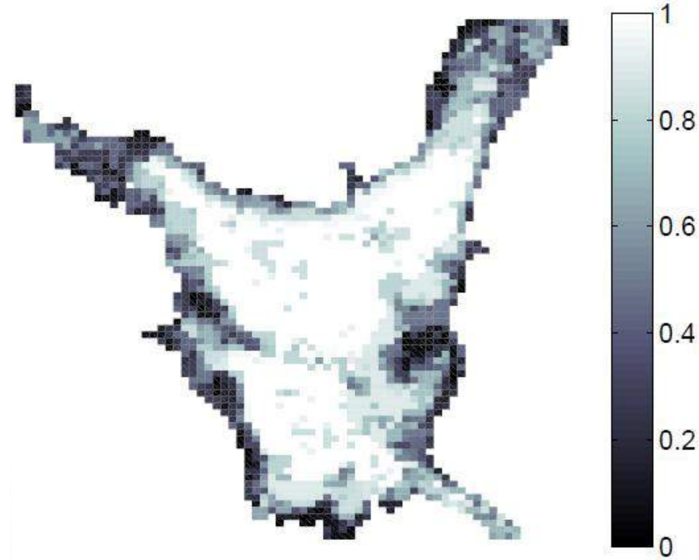


5 image processing techniques



Uncertainty analysis

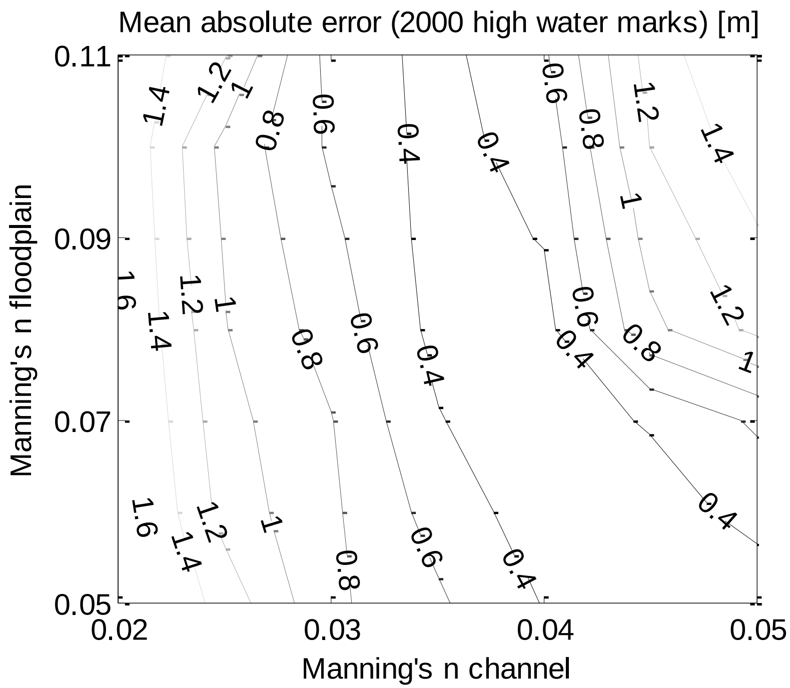
Probability of Inundation Map

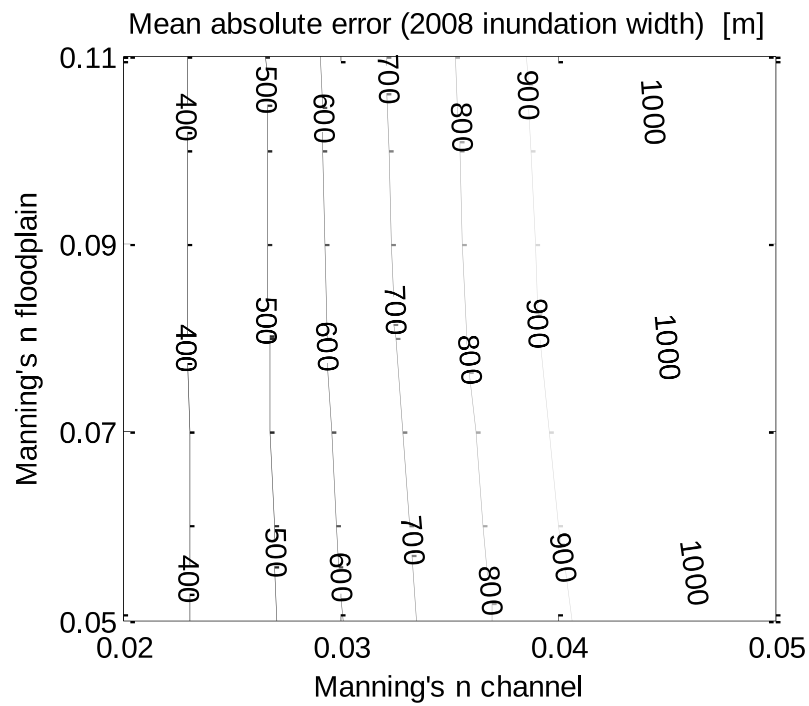


(Di Baldassarre et al., Journal of Hydrology, 2009)

Uncertainty in model parameters

Different optimal parameter sets
with changing magnitude of flood events





Example: Calibration and validation of a flood model

(Di Baldassarre et al., Hydrological Processes, 2009)

Uncertainty in model structure

How should we reproduce buildings in model grid?

They act as impervious obstacles, but they also are porous!

2011 Aulla, Italy (source: archivibeniculturali.it)

2011 Cinque Terre, Italy (source: ilsecoloXIX.it)

(Di Baldassarre, Floods in a Changing Climate: Inundation modelling, 2012)

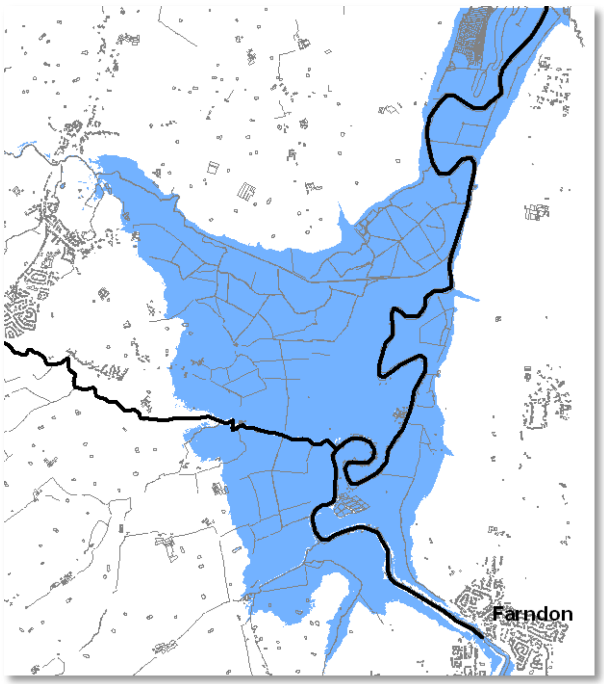
Uncertainty: State of the art

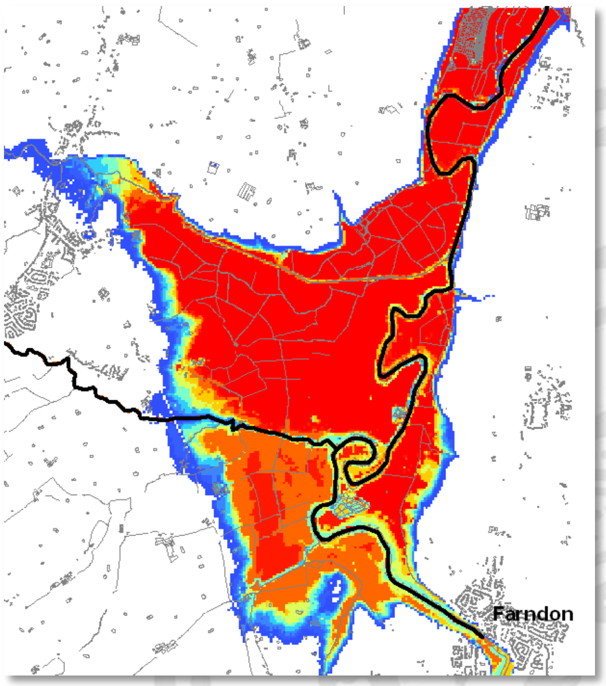
Deterministic (wet/dry) maps

Sophisticated models, single run

Probabilistic maps (red to blue)

Simple models, many runs



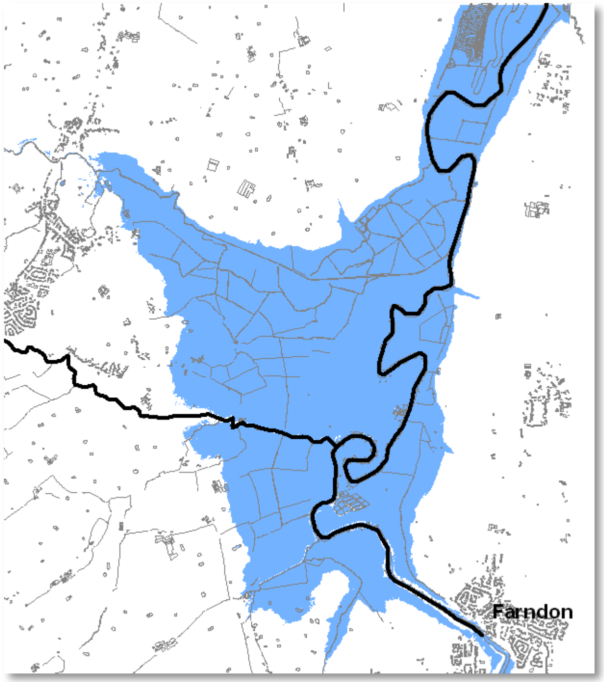


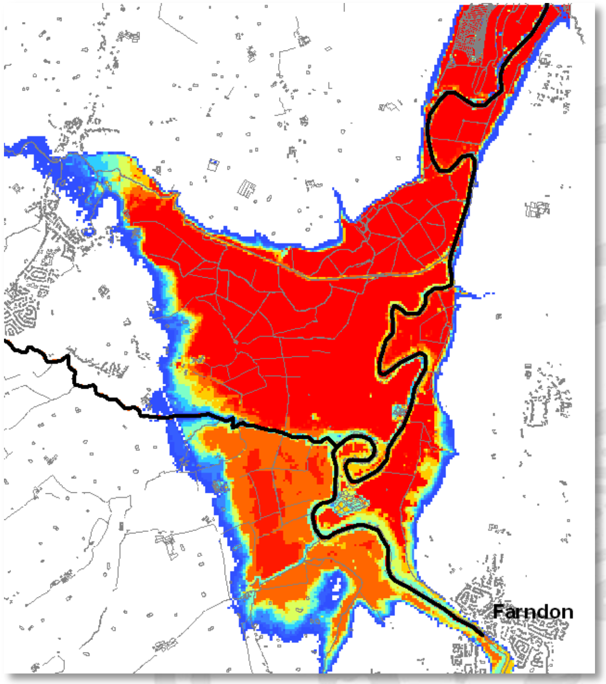
Communication of uncertainty, etc…

Storm-water modelling

Summary

Precisely wrong! *OR* *Approximately right!*





Storm Water Management

Current approach: Risk scenarios

climate
human impact

water system

Urban flooding
(probability)

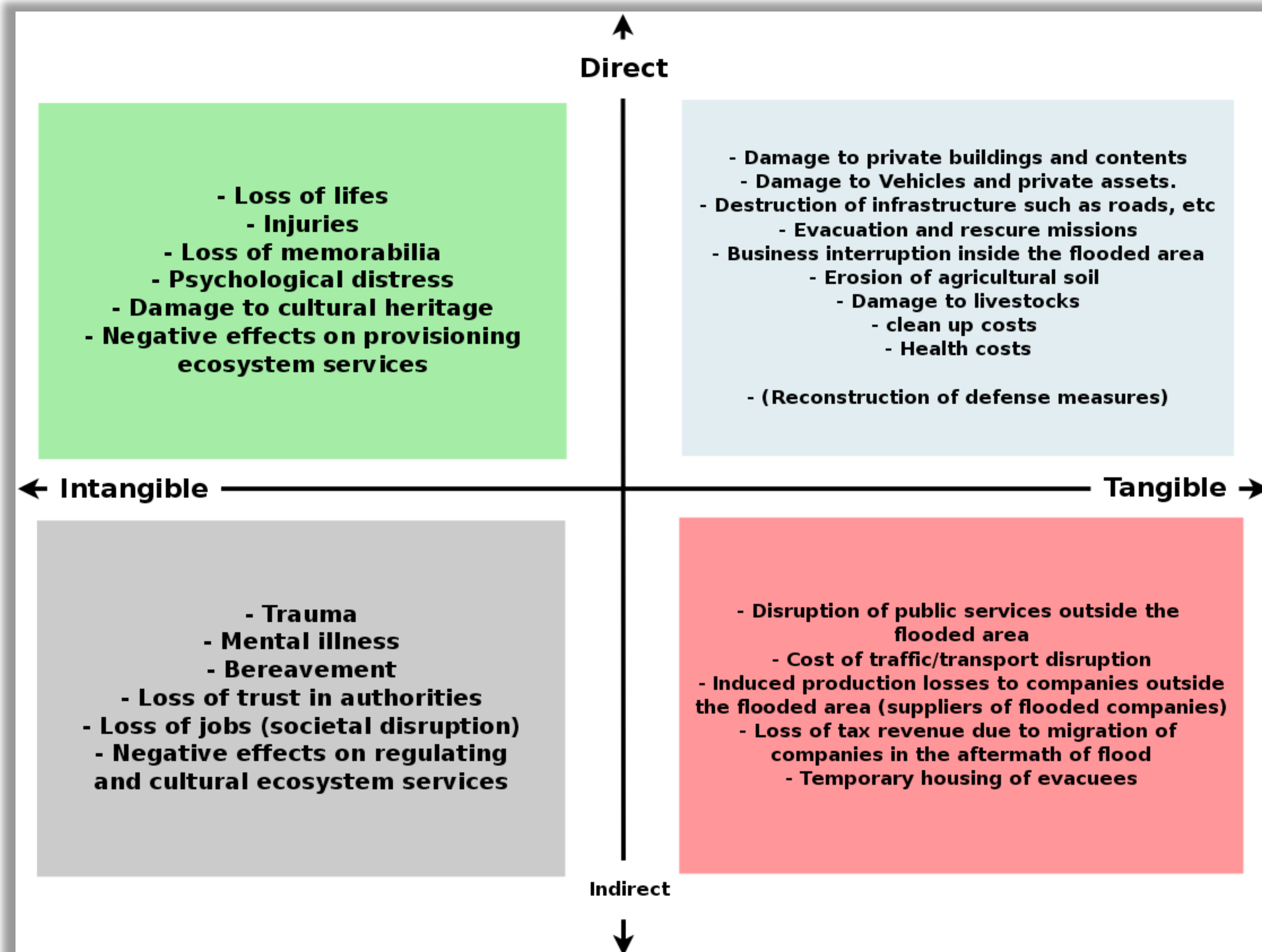
human system

Urban development
(losses)

demography
economy

Urban Flood Risk = f (Probability, Losses)

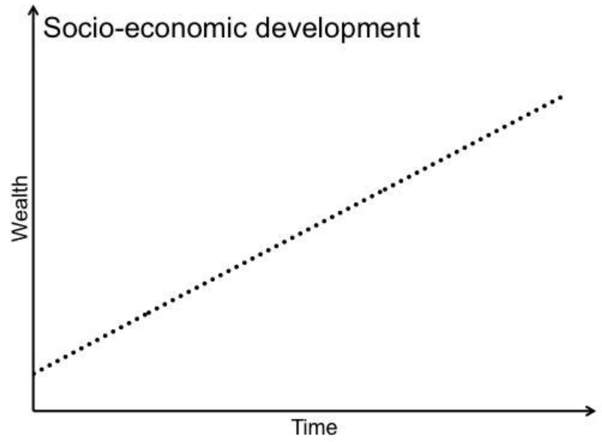
Losses
caused by urban flooding

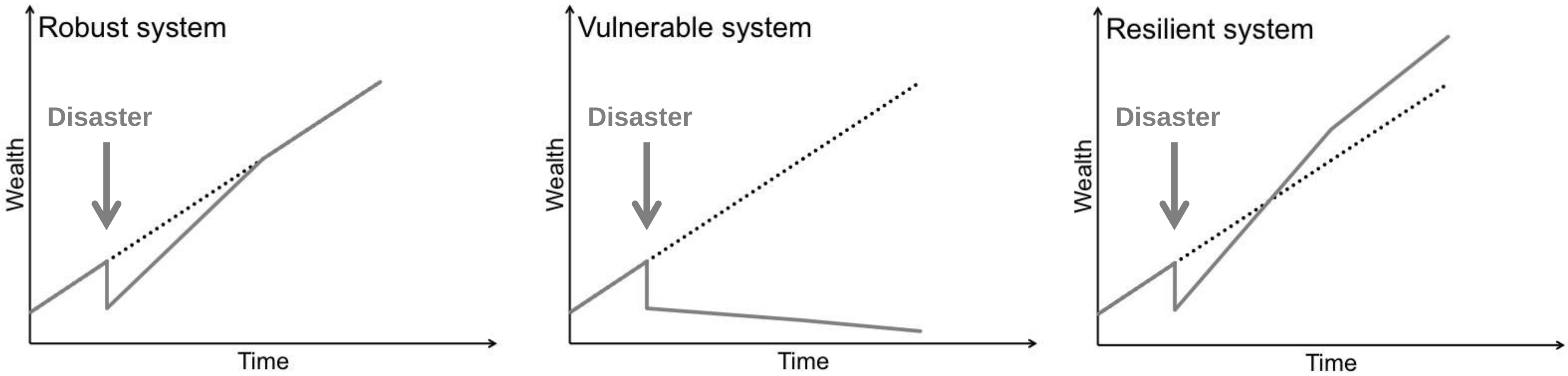


(Giupponi et al., KULTURisk, 2013)

Damages matter
But recovery is key!

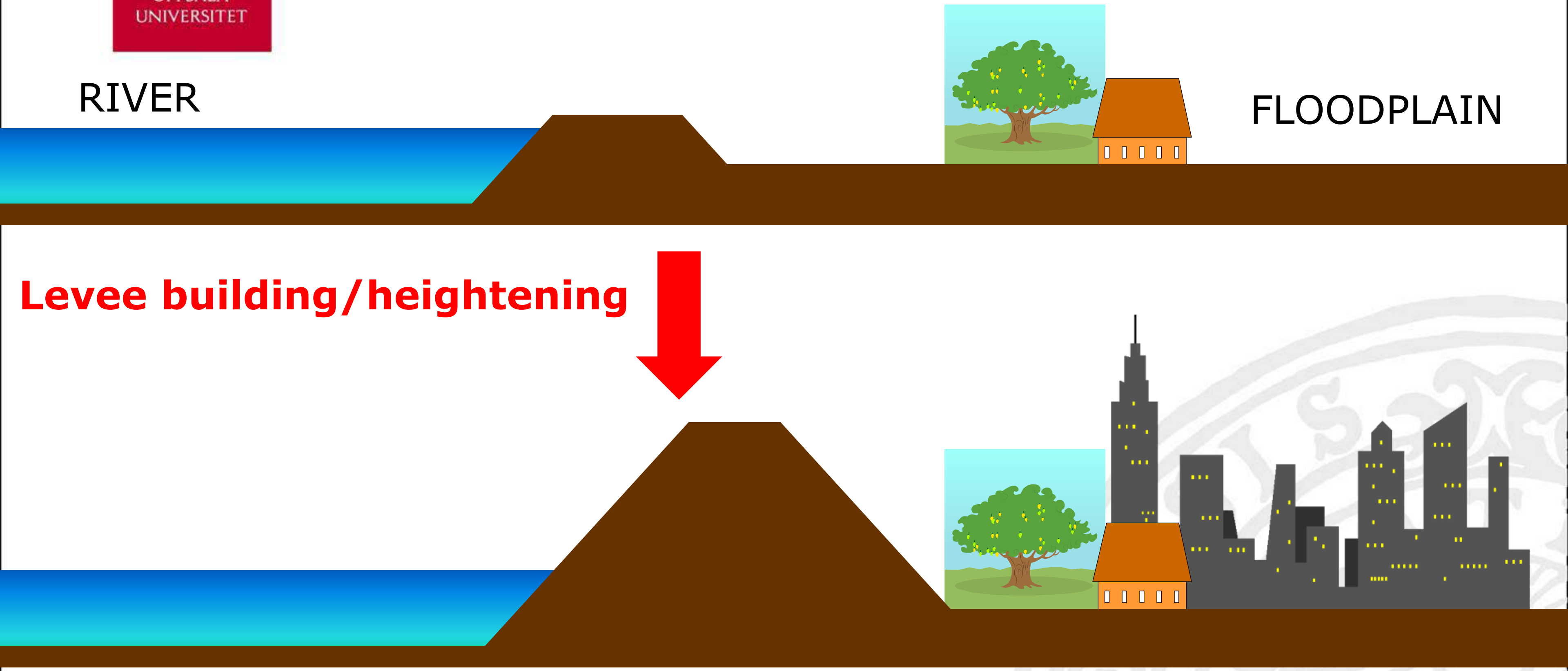
Current methods cannot capture **wealth** and **recovery trajectories**





(Green et al., CONHAZ, 2011; Di Baldassarre et al, Wires Water, 2014)

Risk dynamics: forgetting/levee effect



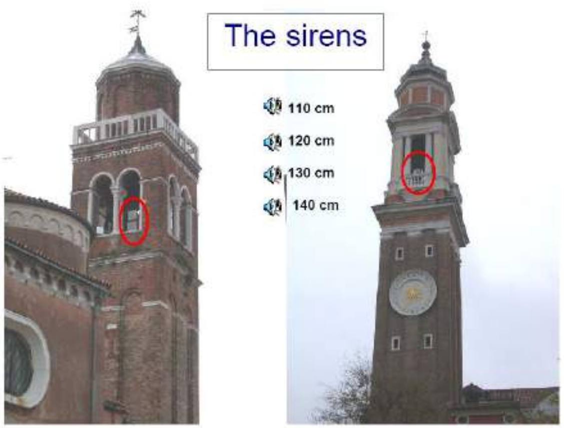
As flooding becomes less frequent, consequences increase

Shift from frequent flooding to rare-but-catastrophic flooding

(White, Human adjustments to floods, 1945)

Risk dynamics: learning/adaptation effect

Venice (Italy) flooded a number of times per year



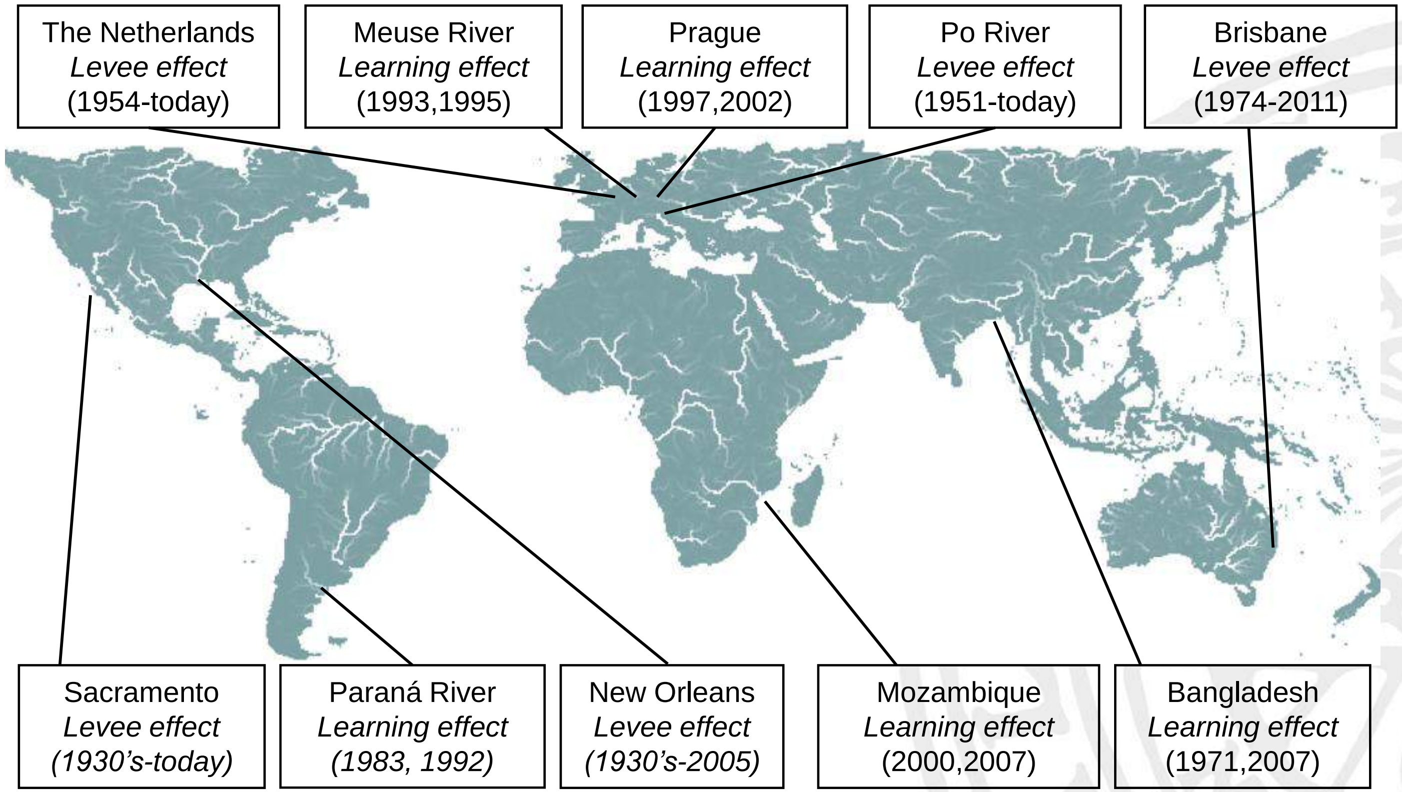
(Campostrini, KULTURisk workshop, 2011)

Dynamics around the world

(current approach cannot explain/capture)

Rare flooding - increasing potential consequences (forgetting/levee)

Frequent flooding - decreasing potential consequences (learning/adaptation)



(Kates et al., PNAS, 2006; Wind et al., WRR, 1999; de Moel et al., GEC, 2011; Bohensky et al., 2014; Penning-Rowsell, GR, 1996)

Dynamics around the world

(current approach cannot explain/capture)

Traditional approaches do not capture these dynamics!

This makes quantitative predictions of flood risk changes unrealistic

Less frequent flooding does not necessarily lead to higher risk
(because of forgetting/levee)

More frequent flooding does not necessarily lead to higher risk
(because of learning/adaptation)

Need to account for water-society feedbacks!

New approach: Feedbacks and emerging dynamics

Traditional Approach: Quantitative predictions, precisely wrong?

water system

Urban flooding
(Probability)

human system

Urban development
(Losses)

Novel Approach: Plausible scenarios, approximately right?

Urban environments as fully coupled human-water system

Urban flooding
(Probability)

human experience
(memory, learning)

Urban development
(Losses)

human interventions
(policies, structures)

Storm-water management:
”Approximately right or precisely wrong”?

Complex models to make a precise “prediction”?
Simple models to make a number of plausible simulations?

Quantitative risk assessment, neglecting dynamics?
Qualitative risk assessment, accounting for dynamics?

Shall we hide or recognize uncertainty?
Does it imply shifts of accountability?