

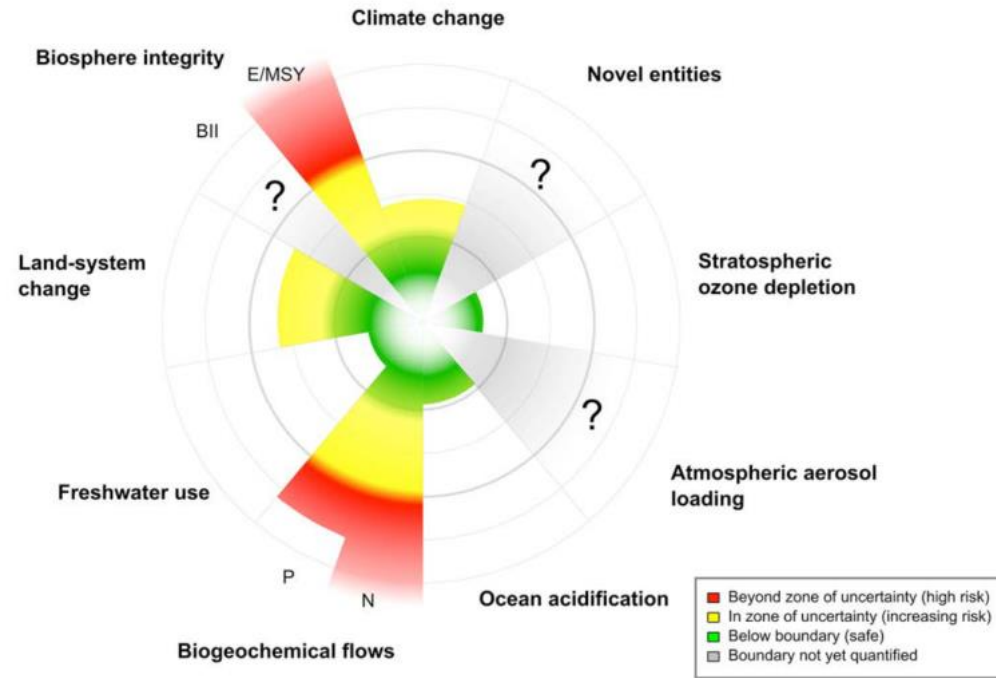
# SOURCE SEPARATION– *How READY IN THE SWEDISH WASTEWATER SECTOR FOR TECHNOLOGY TRANSITION?*

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- Planetary boundaries are being crossed
- Paradigm shift “resource recovery”
- **Source separation** of wastewater improves treatment capacity & nutrient recovery



Source: *Steffen et al. 2015*

## But... seldom applied in urban settings

## AIM

- Assess status of source separating systems in Sweden
- Identify opportunities for scaling-up

# METHODOLOGY

- System boundary: wastewater treatment in Sweden
- Multi-level perspective (MLP)
  - **Niche:** source separation systems
    - Critical functions from Technical Innovation Systems (TIS) methodology (*Bergek et al., 2008; Hekkert et al., 2007*)
    - Case studies in 8 Swedish municipalities
  - **Regime:** mixed sewerage from WC
    - Institutional analysis e.g. (*Fuenfschilling and Truffer, 2014*)
    - Data from national statistics, policy documents, literature and expert interviews
  - **Landscape:** STEEPLD analysis

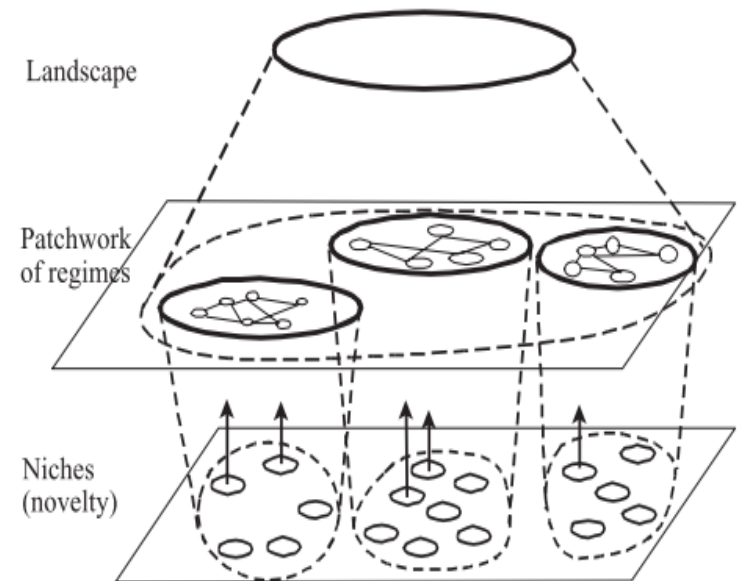
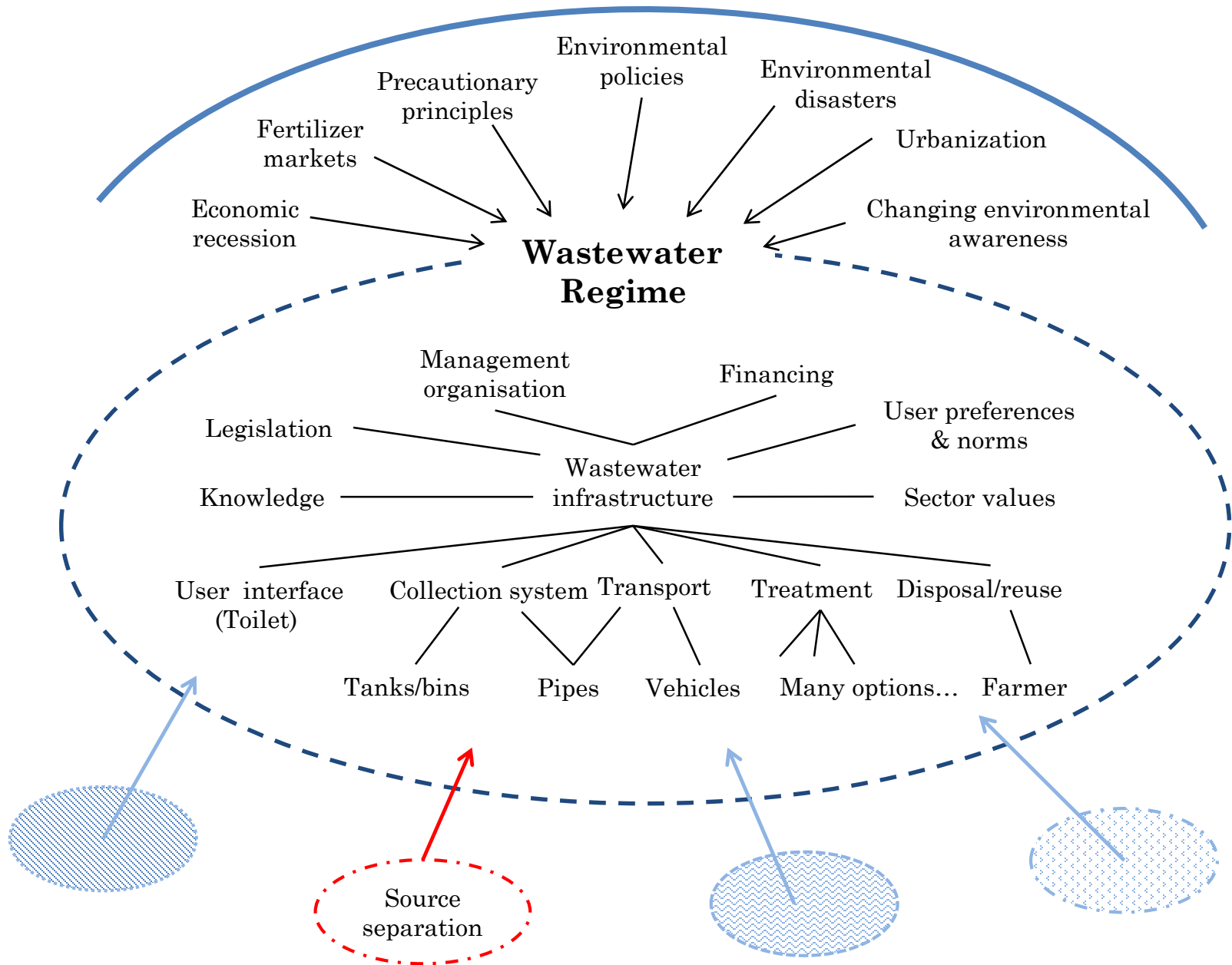


Figure from *Geels, 2002*

# Landscape Factors

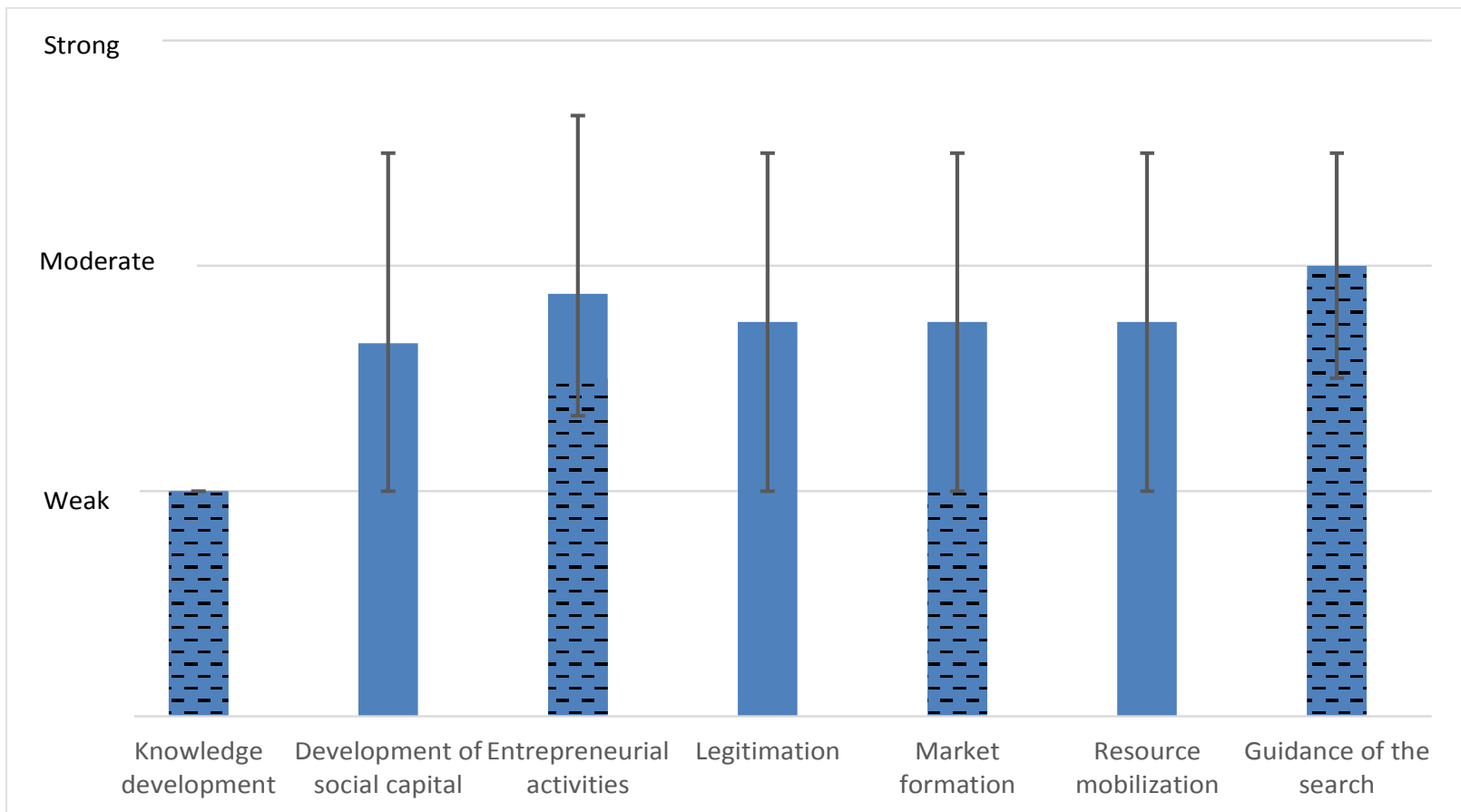


# RESULTS: NICHE TIS ANALYSIS

Function	Definition	Indicators
Knowledge development	Process with which knowledge related to the system is gained and spread.	Bibliometrics analysis of publications Analysis of national knowledge exchange forums
Development of social capital	Process through which social relationships are built and maintained	Existence of communication mechanisms between actors Quality of relationship between stakeholders
Entrepreneurial activities	Iterative and social learning through which uncertainty in the system is reduced	Diversity and accountability of actors involved # companies involved Clarity of division of roles & responsibilities
Legitimation	Process through which social acceptance is created – both technically & socially	Assessment of advocacy activities Level of user satisfaction & acceptance
Market formation	Process through which the market emerges for system services	% of residents connected Growth rate (%)
Resource mobilization	Process through which stakeholders develop a resource base	Financial resources mobilized (% of costs) Human resources required
Guidance of the search	Processes which shapes stakeholder decisions about how they will use their resources	Local political support Alignment with national policy & legislation

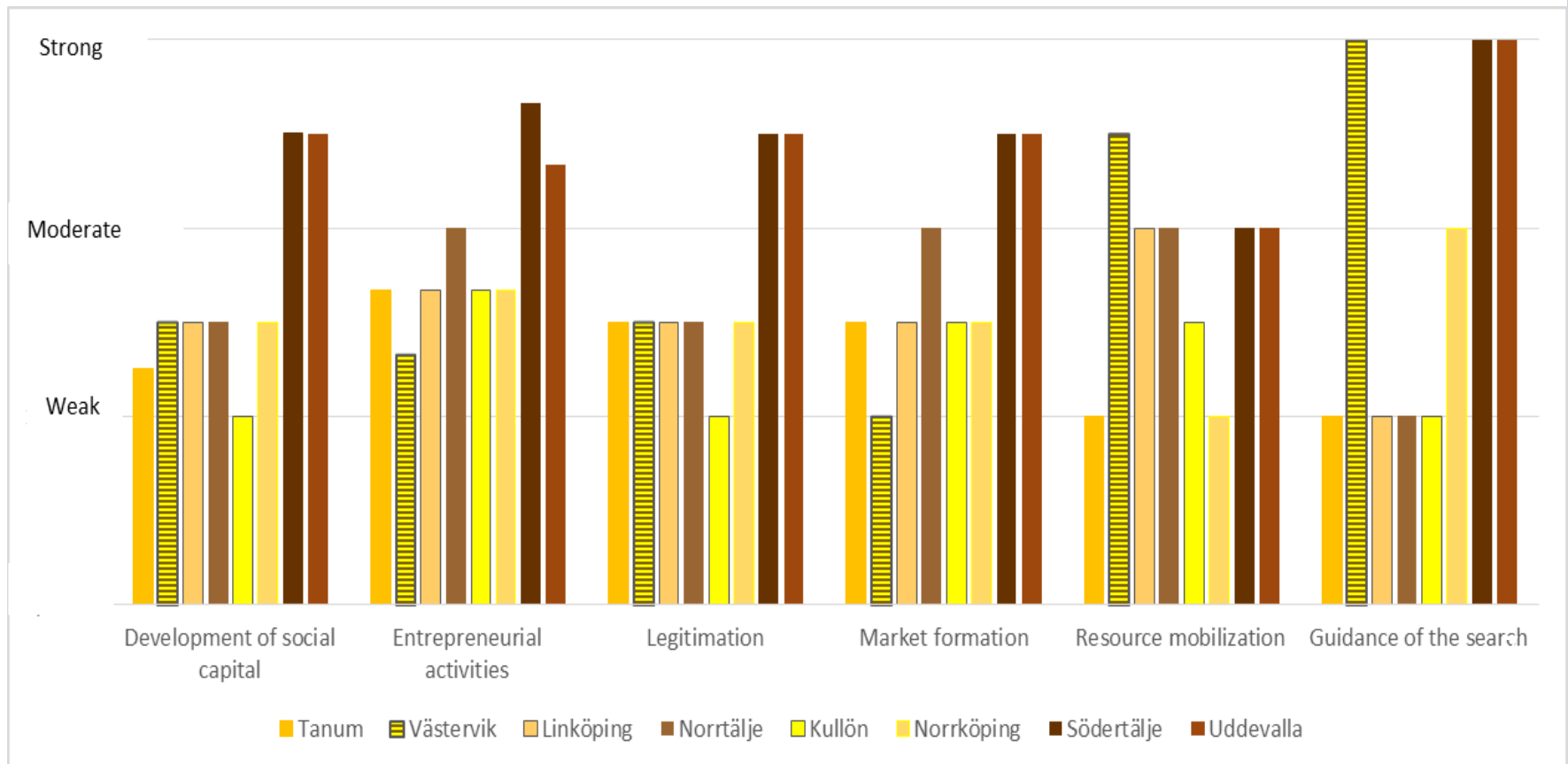
# RESULTS: NICHE

- Works moderately-well within the on-site niche
- Knowledge development is weak
  - Need entrepreneurial activities to iron out bugs
  - Need to clarify organisational models



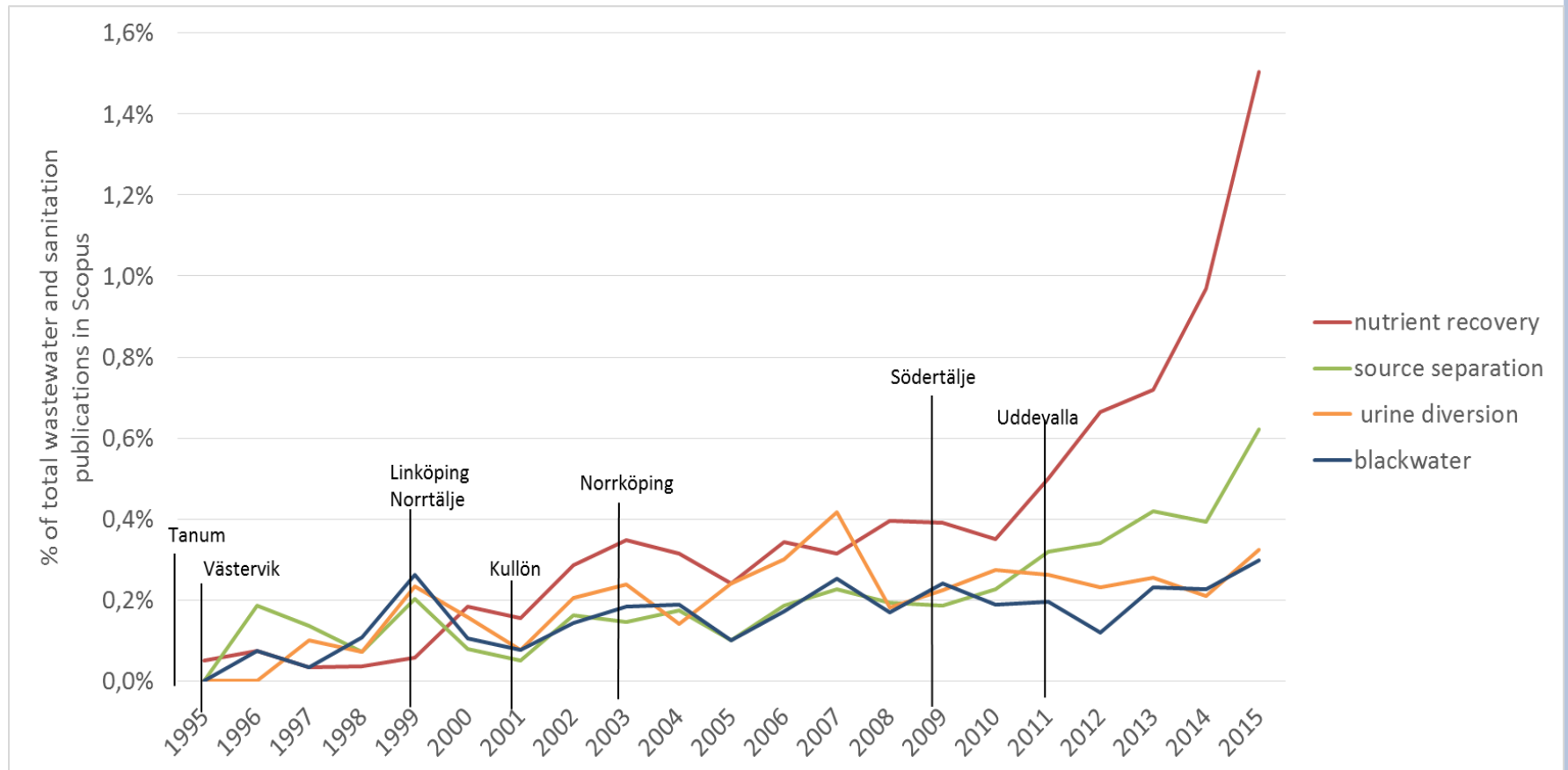
# RESULTS: NICHE

- Blackwater systems perform better than urine diversion
- Time-dependency in many functions → more recent initiatives perform better



# KNOWLEDGE RELATED TO NICHE

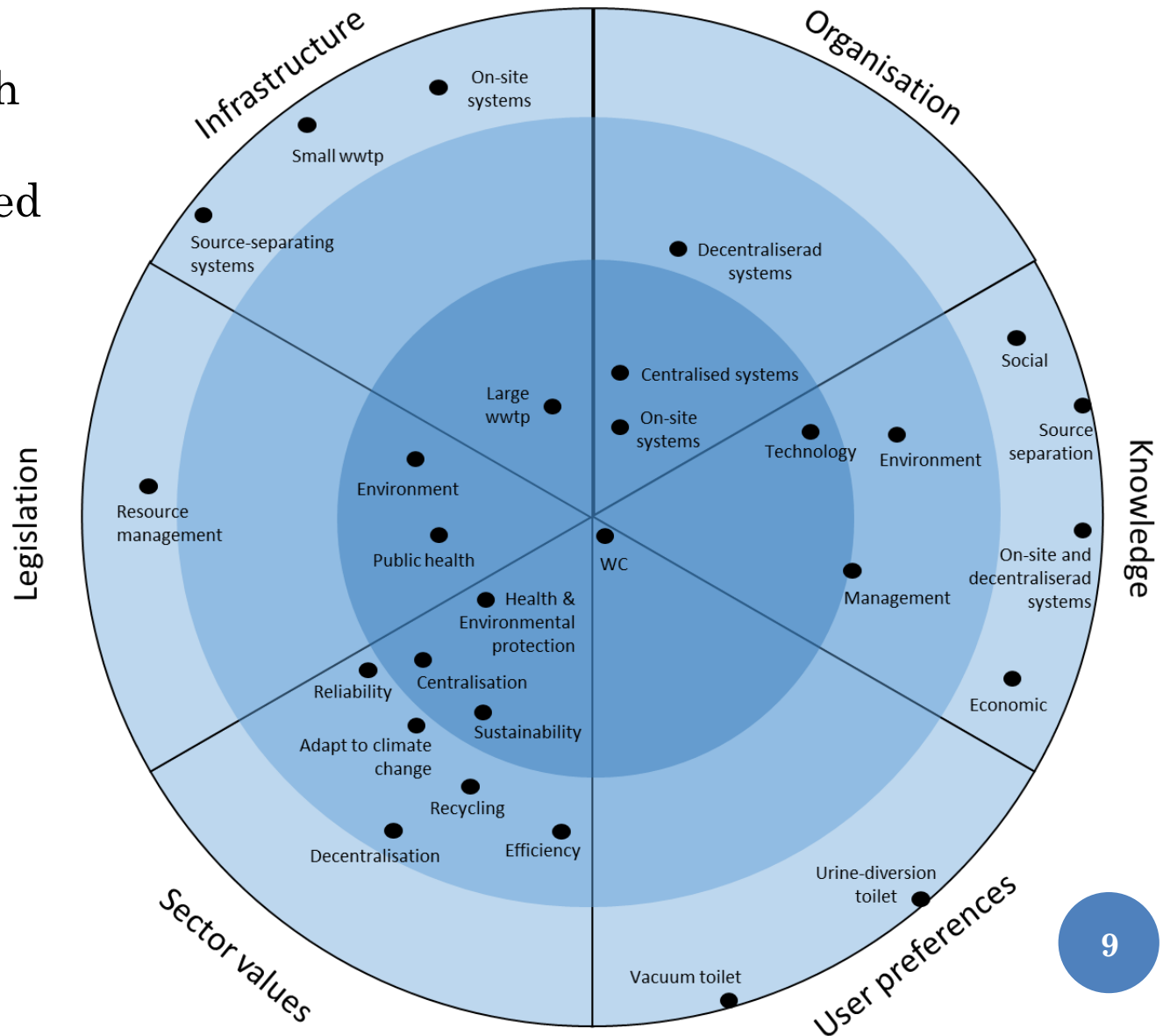
- Nutrient recovery & source separation still a fraction of total wastewater publications
- Significant increase in knowledge – new trend?





# RESULTS: REGIME

- Looking for elements which are weakly institutionalized
- Closer to the center the stronger the regime



# REGIME RESULTS - INFRASTRUCTURE

- Approx. 91% of the Swedish population is connected to a municipal wastewater treatment plant (*SCB Statistics Sweden, 2014*)
  - ~85% to large WWTPs serving > 2000 *pe*
  - ~6% to small WWTPs serving 25-2000 *pe*
  - >60% of WWTPs have bio-chemical treatment + nitrogen removal
- Remainder connected to on-site systems
  - ~5% septic tanks and infiltration
  - ~2% source separation systems (UD or blackwater) (*Ek et al. 2011*)

Ek, M., Junestedt, C., Larsson, C., Olshammar, M., Ericsson, M., 2011. Teknikenkät - enskilda avlopp 2009. Sveriges Meteorologiska och Hydrologiska Institut, Norrköping, Sweden

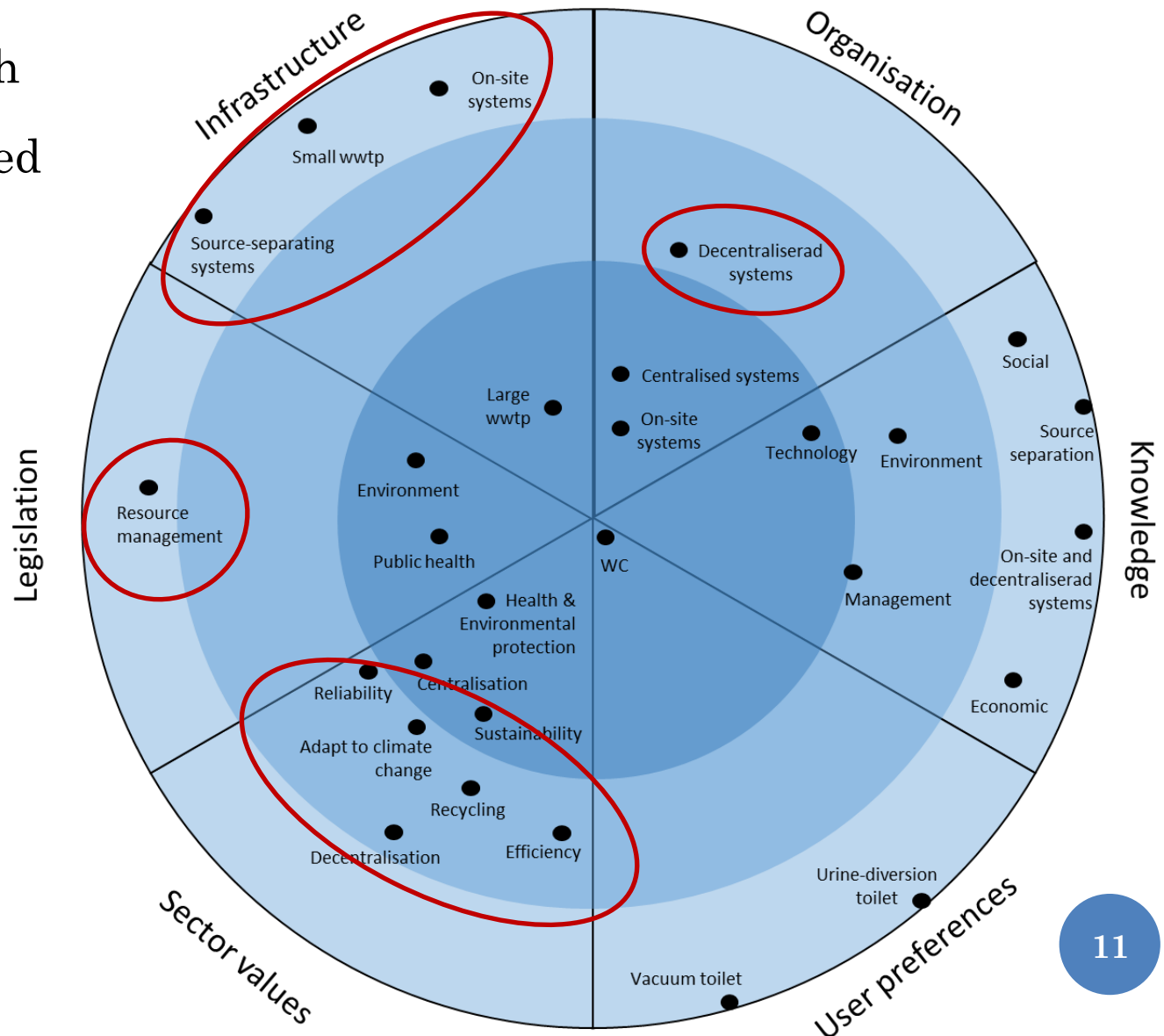
SCB Statistics Sweden, 2014. Discharges to water and sewage sludge production in 2012 Municipal wastewater treatment plants, pulp and paper industry and other industry. Stockholm, Sweden.

# RESULTS: REGIME

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## Target points

- Values and legislation of resource use, efficiency & sustainability
- Alternative infrastructure and organizational structure



# RESULTS: LANDSCAPE

## *Opportunities*

- Increasing public environmental awareness → supportive legal & policy incentives (national/international)
- Agricultural crisis (e.g. fertilizer price spike 2008)
- Housing shortages create innovation opportunities

*None of these are likely to independently topple the regime*

<i>Social</i>	<i>Technological</i>	<i>Economic</i>	<i>Environmental</i>
<b>Changing environmental awareness</b>	Innovation at WWTPs	Economic recession	Environmental disasters
Dietary trends (e.g. meat consumption)	Parallel innovations in other sectors	<b>Fertilizer shortage</b>	Deteriorated agricultural conditions
Waste handling practice, e.g. separation		<b>Tax/subsidy policies</b>	Impacts of nutrient emissions
Media influence		Purchasing power	Water shortage
<i>Political</i>	<i>Legal</i>	<i>Ethical</i>	<i>Demographic</i>
Internal conflicts	Fertiliser regulations	Precautionary principle	<b>Urbanisation</b>
Knowledge bias of decision-makers	<b>Stricter pollution legislation</b>	Sustainability ethic	Local population growth
International agreements	Green procurement		Increasing immigration
Time frame of politicians			

# RESULTS: LANDSCAPE

## *Threats*

- Other innovations do it better, e.g:
  - More efficient nutrient recovery at central WWTP
  - Innovations in N-fertiliser extraction process
- Economic or environmental crisis divert funding to other needs
- Risk aversion and “fecalphobia” limit acceptance & create legal/ethical barriers

<i>Social</i>	<i>Technological</i>	<i>Economic</i>	<i>Environmental</i>
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# CONCLUSIONS – WINDOWS OF OPPORTUNITY?

## *Within the niche*

- Strengthen entrepreneurial activity to iron out bugs
- Quantify potential risks
- Clarify system advantages – using holistic costing perspectives?
- Improve knowledge dissemination and networking

## *Within the regime*

- New organisational & infrastructure models
- Push for legal precedent regarding resource efficiency

## *Within the landscape*

- Link to global sustainable development movement
- Work with the agricultural sector – provide reliable fertilisers
- Look for opportunities in new housing stock

# THANKS FOR LISTENING!

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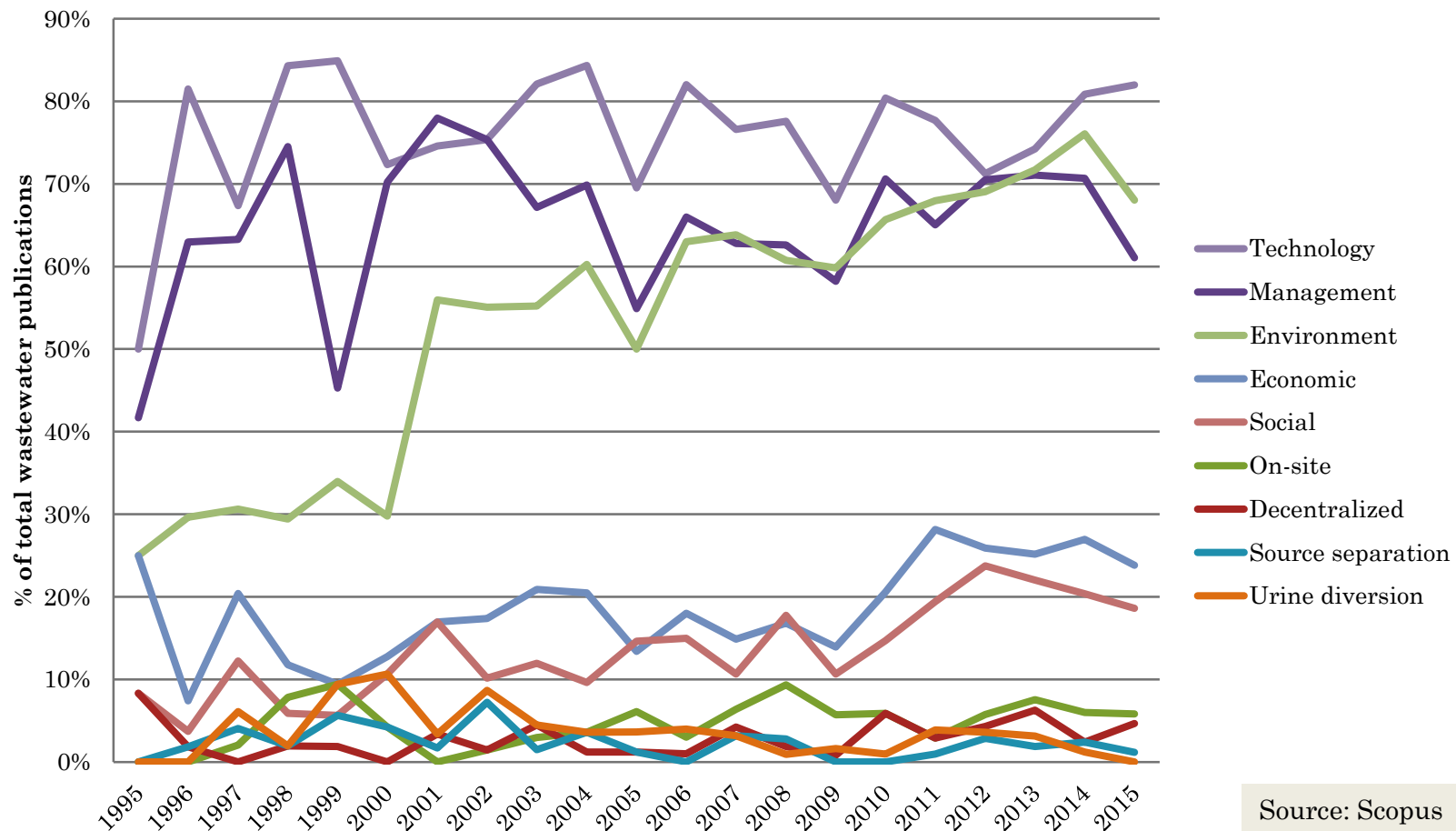
# REGIME RESULTS - ORGANISATION

- > 90% of the population is connected to centralised systems within wastewater jurisdictions
  - Public Water Services Act (LAV: lag om allmänna vattentjänster) requires municipalities to provide water and wastewater services
  - Self-financing through user-fees
- On-site systems
  - Responsibility of individual households
  - Subject to inspection and regulation by the municipal environmental authority – permit required
- Decentralised systems
  - Regulated similar to on-site systems
  - Several organisational forms are common, ranging from formal to informal
  - Often in grey zone regarding applicability of LAV

# REGIME RESULTS - KNOWLEDGE

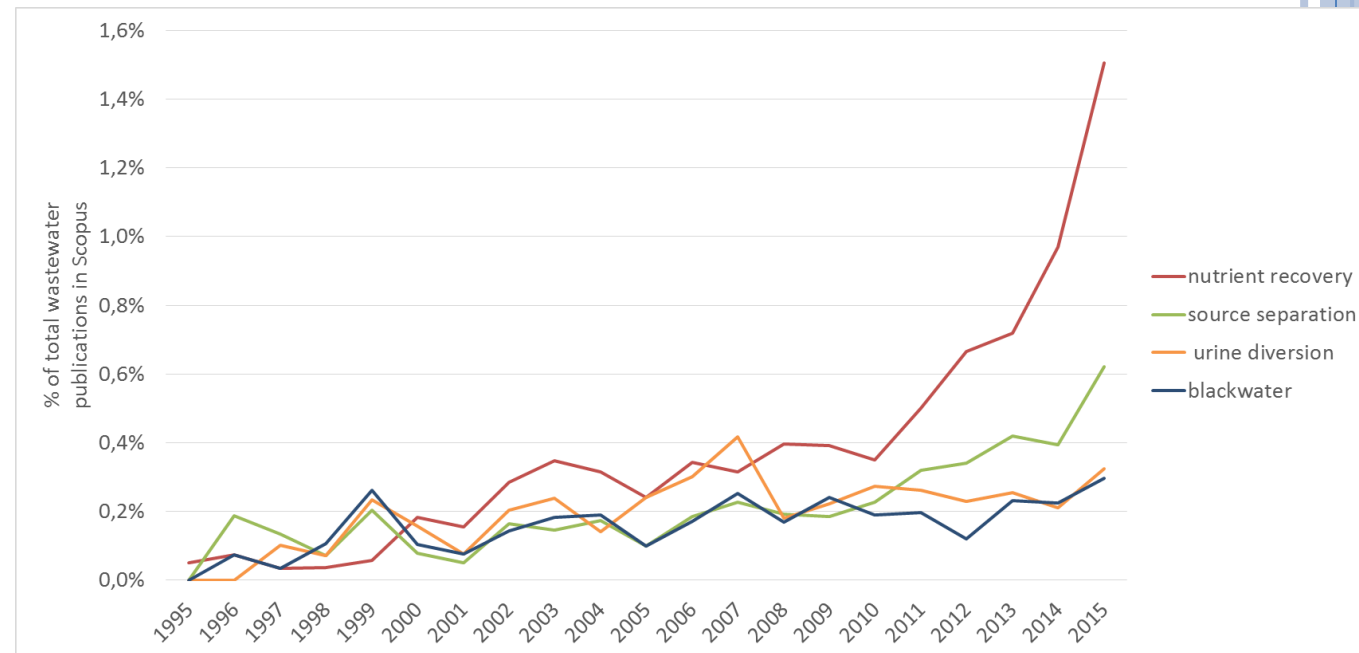
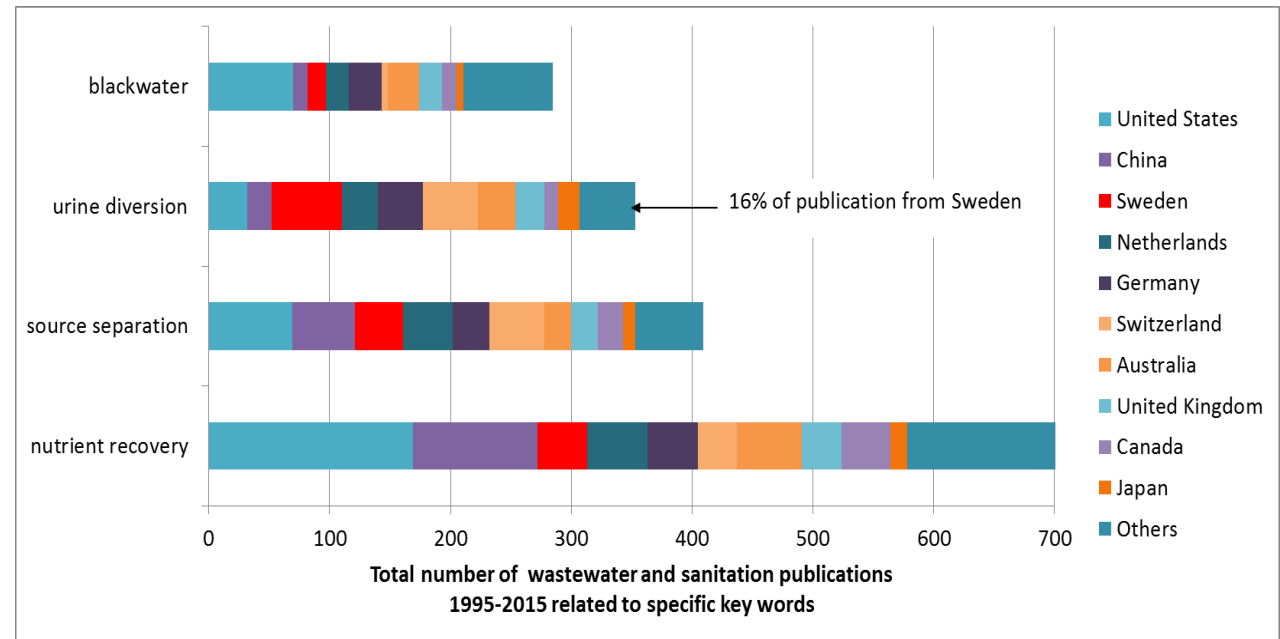
- Low level of knowledge for alternative systems
- Increasing trend for environmental impacts

*Knowledge trends in Swedish wastewater literature*



# GLOBAL KNOWLEDGE TRENDS

- Increasing interest in resource & nutrient recovery
- Sweden is leader in knowledge related to urine diversion



# REGIME RESULTS – USER PREFERENCES

- 99% of Swedes use a WC (*SCB Statistics Sweden, 2014*)
  - Alternative toilets are more acceptable in vacation homes than at home (*Wallin et al. 2013*)
  - Alternatives to WC must provide equivalent levels of comfort, convenience and cleanliness
- Users are surprisingly open to new technologies – especially if informed of the benefits (*Lienart & Larsen 2010*)
- Most enduring urine diversion systems in Sweden have been collectively designed by the users (*Fam & Mitchell 2013*)

Fam, D.M., Mitchell, C.A., 2013. Sustainable innovation in wastewater management: lessons for nutrient recovery and reuse. *Local Environ.* 18, 769–780.

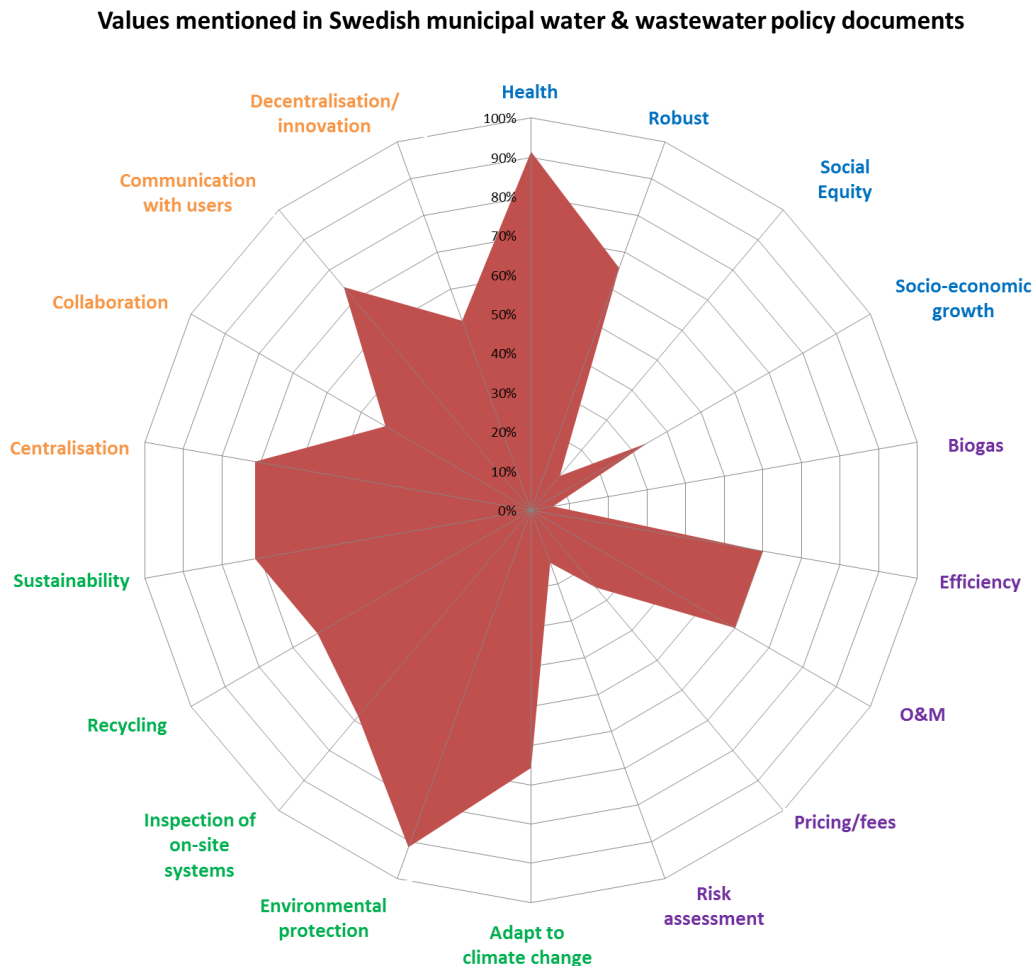
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# REGIME RESULTS – SECTOR VALUES

- Sample of 35 municipalities
  - 29% of population
  - 12% of municipalities
  - 20 of 21 counties
- Strong environmental & public health values
- Strong trend towards centralisation
- But willingness to explore alternative management options
- Strong economic values in efficiency and maintenance of existing infrastructure



# REGIME RESULTS – LEGISLATION

- Swedish Environmental Code (1999) is a compilation of 15 previous health and environmental acts
  - Legal system for wastewater regulation has been built over +150 years
  - New laws are layered on in concord with previous ones
- Regulations require resource efficiency
  - EC requires resource management, emphasizing recycling and efficient use of natural resources (EC chapter 2 §5)
  - Swedish EPA's guidelines for on-site sanitation are based on the best-available technology (BAT) principle, instead of prescribing specific technologies (since 2006)
  - European Water and Wastewater Directives and non-binding policy goals of the EU 7th Environment Action programme (2013) specify resource management as goal for 2020
- BUT legislation related to resource management is relatively new and untested in the courts
  - Surprisingly little legal precedent of (EC chapter 2 §5) after 17 years
  - Catch-22 moment in regulation where on one hand the courts have ruled that a municipality cannot make demands for, e.g. source-separating systems, if there is no recipient for the collected nutrients, while on the other hand a farmer cannot legally be forced to use a product (e.g. source-separated urine) that is not available on the market.
  - Planning and Building Act (2010) gives the municipalities the faculty to single-handedly decide on the spatial planning and infrastructure development in the local situation but this is hardly ever used to enable closed-loop approaches for wastewater systems.