Leibniz Centre for Agricultural Landscape Research (ZALF)

2nd Seminar of the UsinoVerT Chair

"Planning Green Infrastructures for Industrial Cities"

ESALQ-Piracicaba, Brazil & UniLaSalle-Rouen, France

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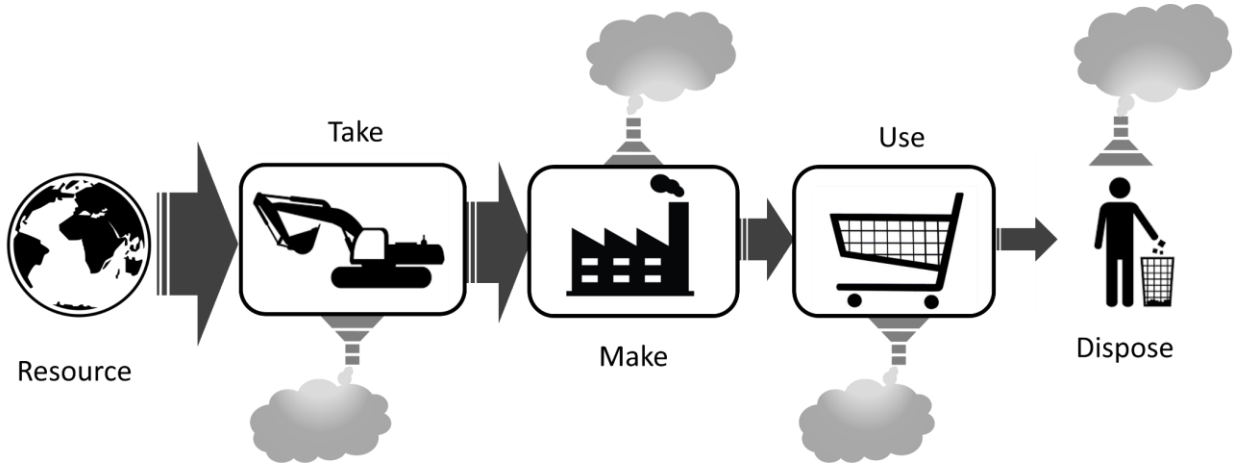
A framework for upgrading of contaminated urban land and soil by nature-based solutions: possibilities and challenges

Shaswati Chowdhury, Postdoctoral researcher. Zalf, Germany

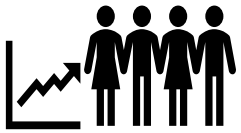
Presentation outline

- Introduction: Potential for realizing brownfields as Urban Greenspaces (UGS) with Nature-based solutions (e.g Gentle Remidiation Options (GRO))
- A framework exploring possibilities of combining UGS with GRO on brownfields
- Case study demonstration
- Conclusion: Summary and implications for further research

Linear Economy



Difficulties in sustaining Linear Economy



Populatio
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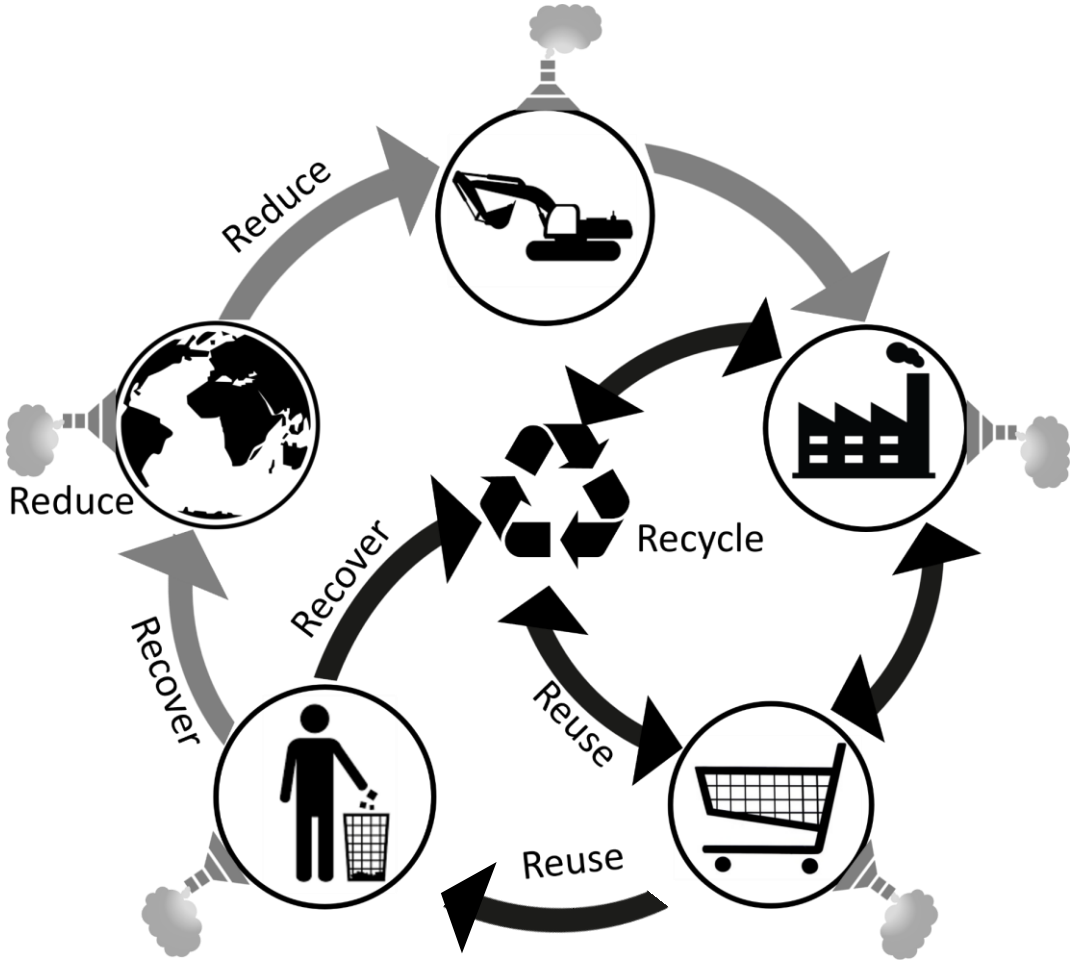
Finite
Resources

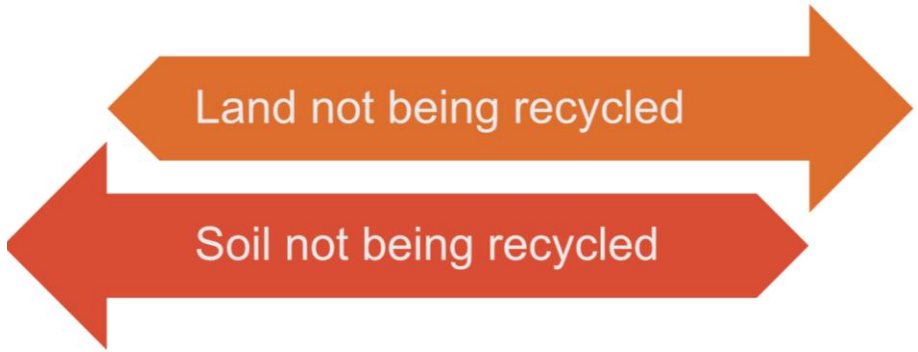
Climate
change

Circular Economy



Difficulties in sustaining Linear urban land-use

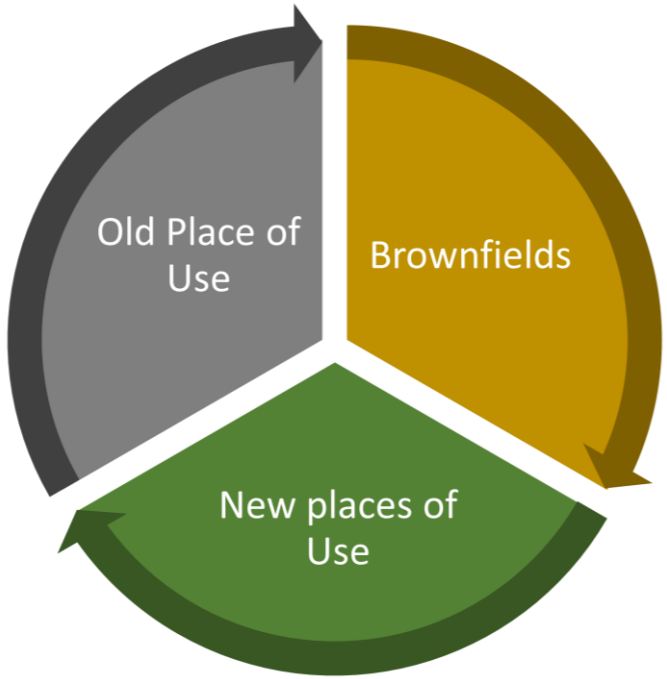
- Land and soils are limited resources (Breure et al, 2018)
- Cities grow at the expense of mostly fertile arable lands and forests (EEA, 2017)



Circular urban land-use

Brownfields

Urban Greenspaces (UGS)



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Urban park

Greenspaces are proven to be essential for the physical and mental well-being of the citizens as well as providing a multitude of Ecosystem Services (ES)

Provisioning services	Regulating services	Supporting services	Cultural services
Food	Local climate and air quality regulation	Erosion prevention and maintenance of soil fertility	Habitats for species	Recreation and mental and physical health
Raw materials	Carbon sequestration and storage	Pollination	Maintenance of genetic diversity	Tourism
Fresh water	Moderation of extreme events	Biological control		Aesthetic appreciation and inspiration for culture, art, and design
Medicinal resources	Wastewater treatment			Spiritual experience and sense of place

TEEB, 2011

Confirmed through literature, review available doi:%2010.13140/RG.2.2.27579.54566

Problems with Dig & dump remediation

- Pushes the problem in future by storing the contaminated soil
- Treats soil as a disposable resource, reduction of soil functions and often worst, disposal of soil

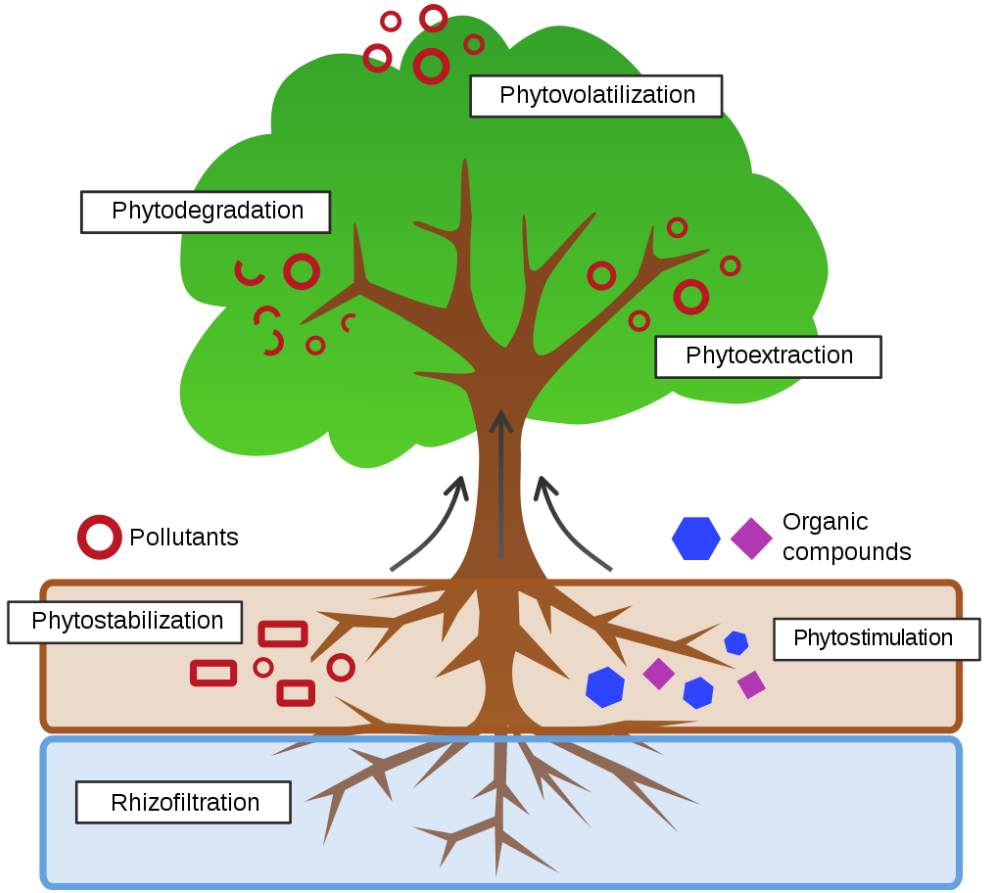
COM(2021) 699

Restore degraded land and soil and strive to achieve a land degradation-neutral world

Nature-based remediation measures

Nature-based solutions (NBS) refers to actions that are "inspired by, supported by, or copied from nature"*

- **Gentle Remediation Options (GROs)** are a subset of NBS for contamination risk management
- GROs result in a net gain (or at least no gross reduction) in soil function
- GROs include technologies using plants, fungi and/or bacteria-based methods, with or without chemical additives or soil amendments



By Townie (Arulnangai & Xavier Dengra from the original in .png extension) - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=53861918

* van den Bosch, M., Sang, A.O., 2017.Urban natural environments as nature-based solu-tions for improved public health - a systematic review of reviews. Environ. Res.158, 373–384.

Brownfields

GRO

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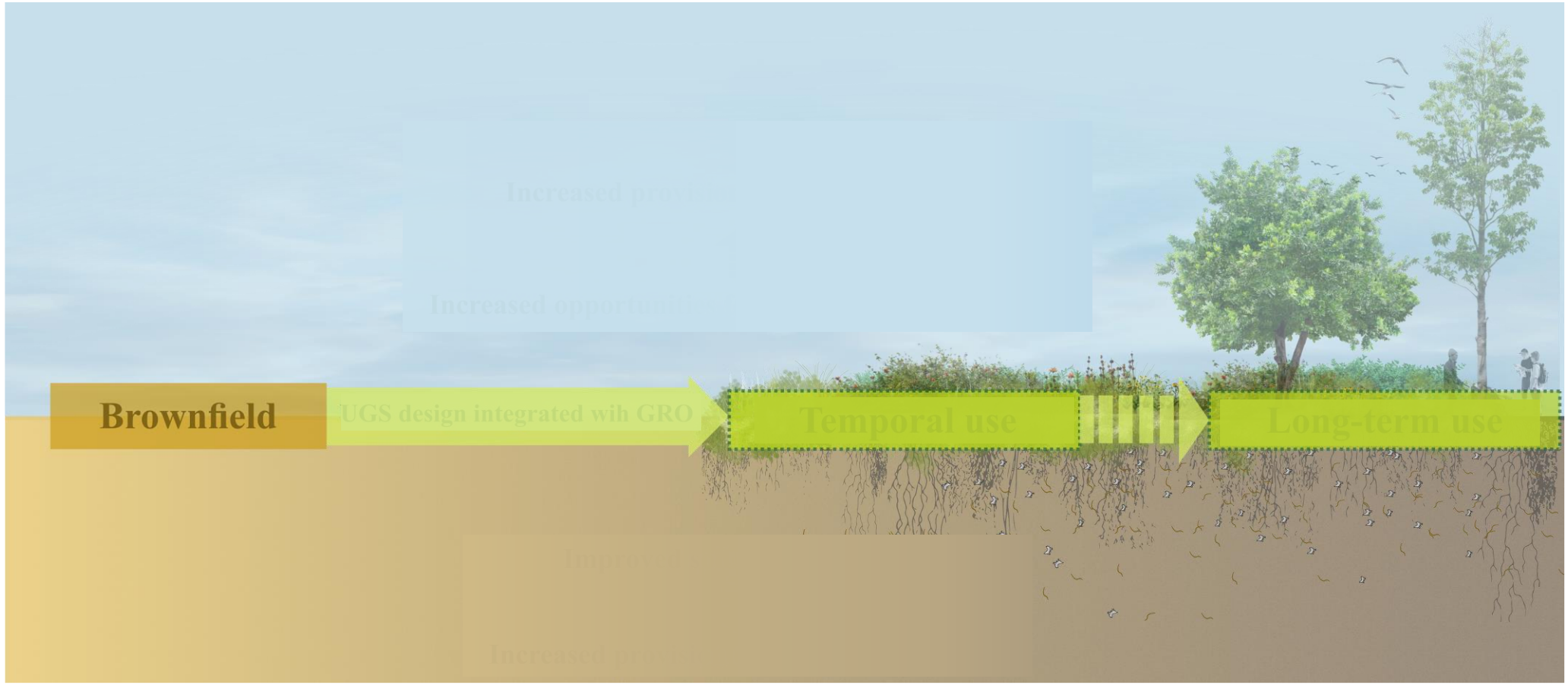
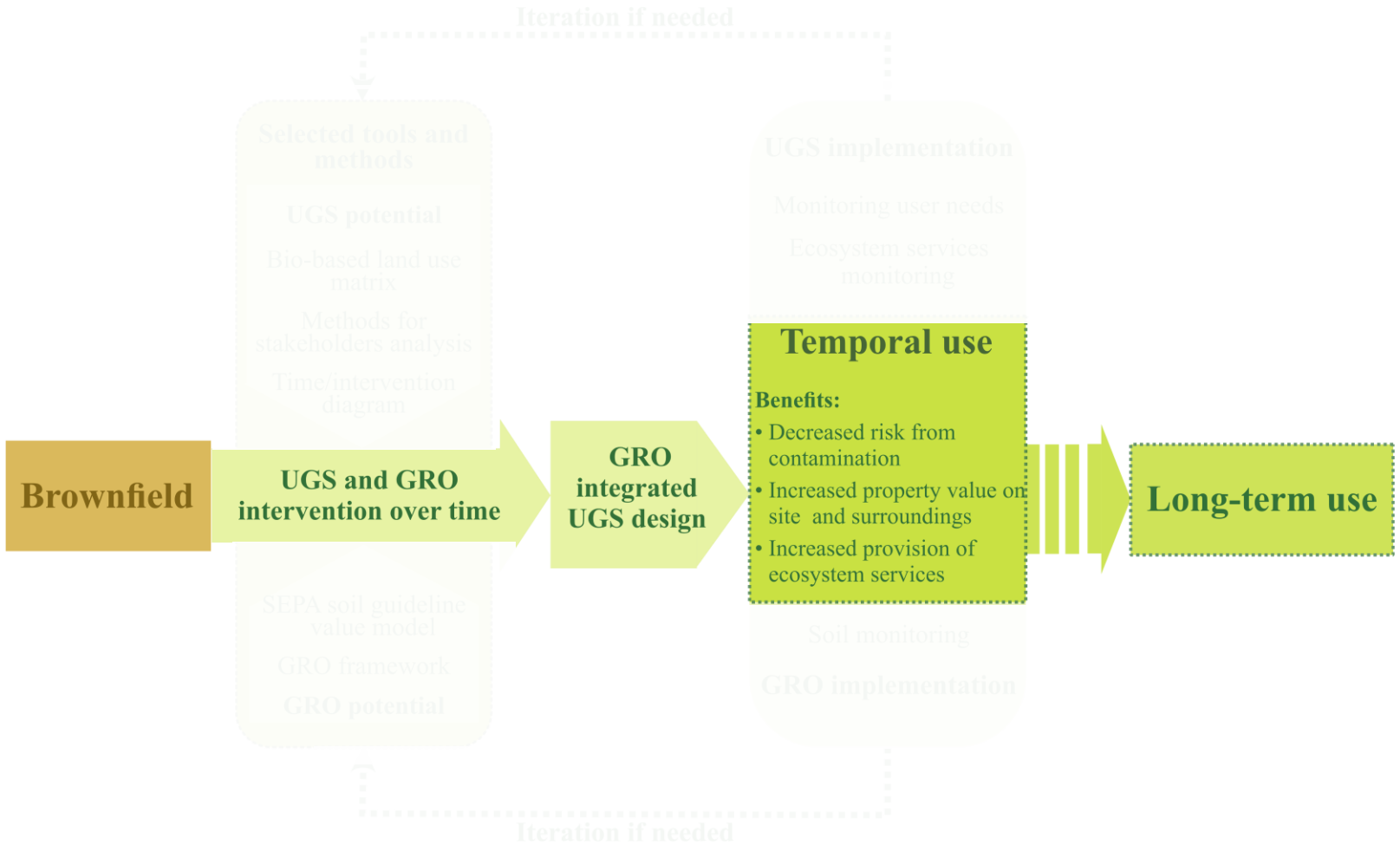
UGS

A framework exploring possibilities of combining UGS with GRO on brownfields



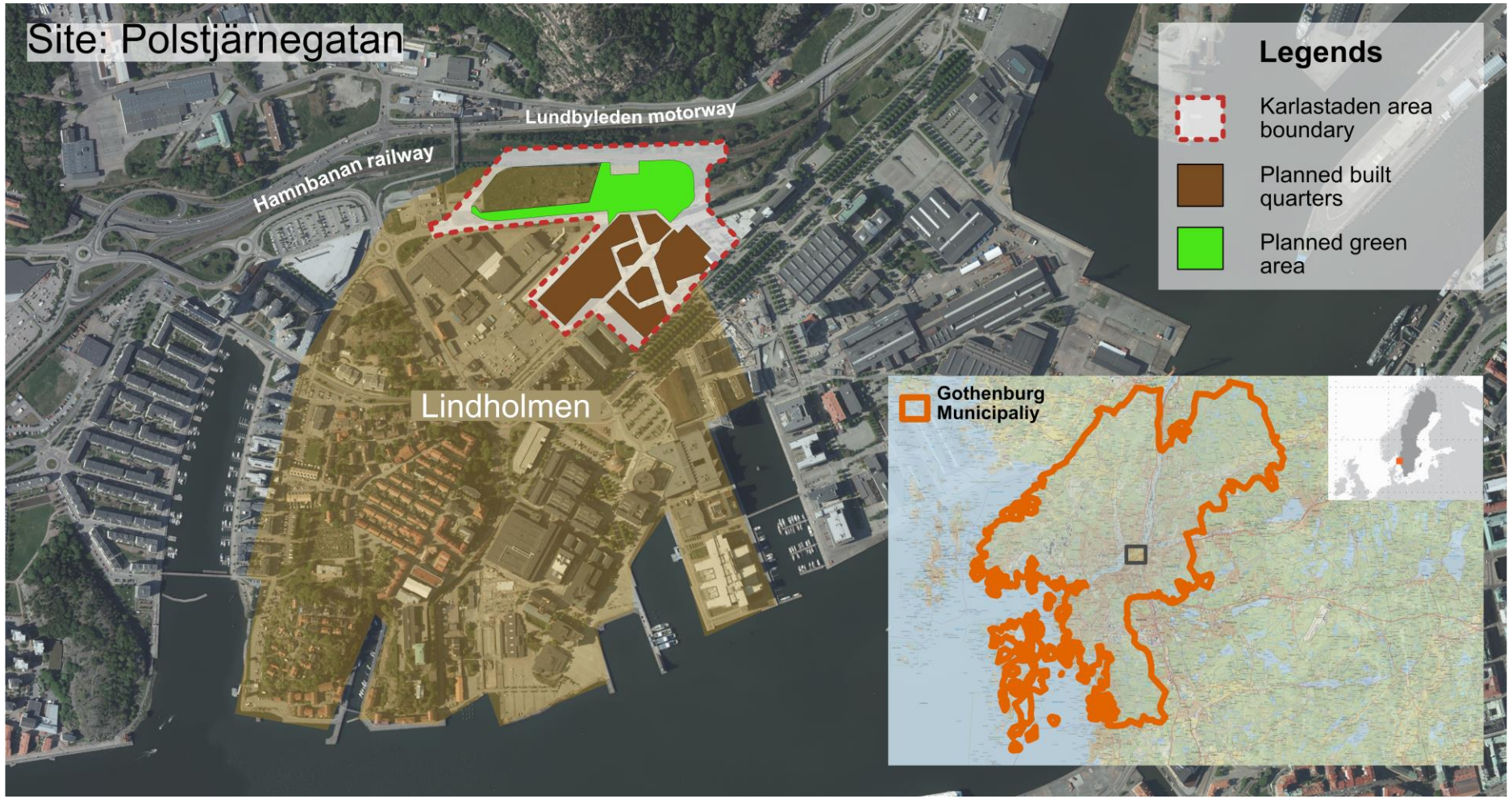
Conceptualisation of a temporal regeneration of brownfield

A framework exploring possibilities of combining UGS with GRO on brownfields



Schematic diagram of the suggested framework

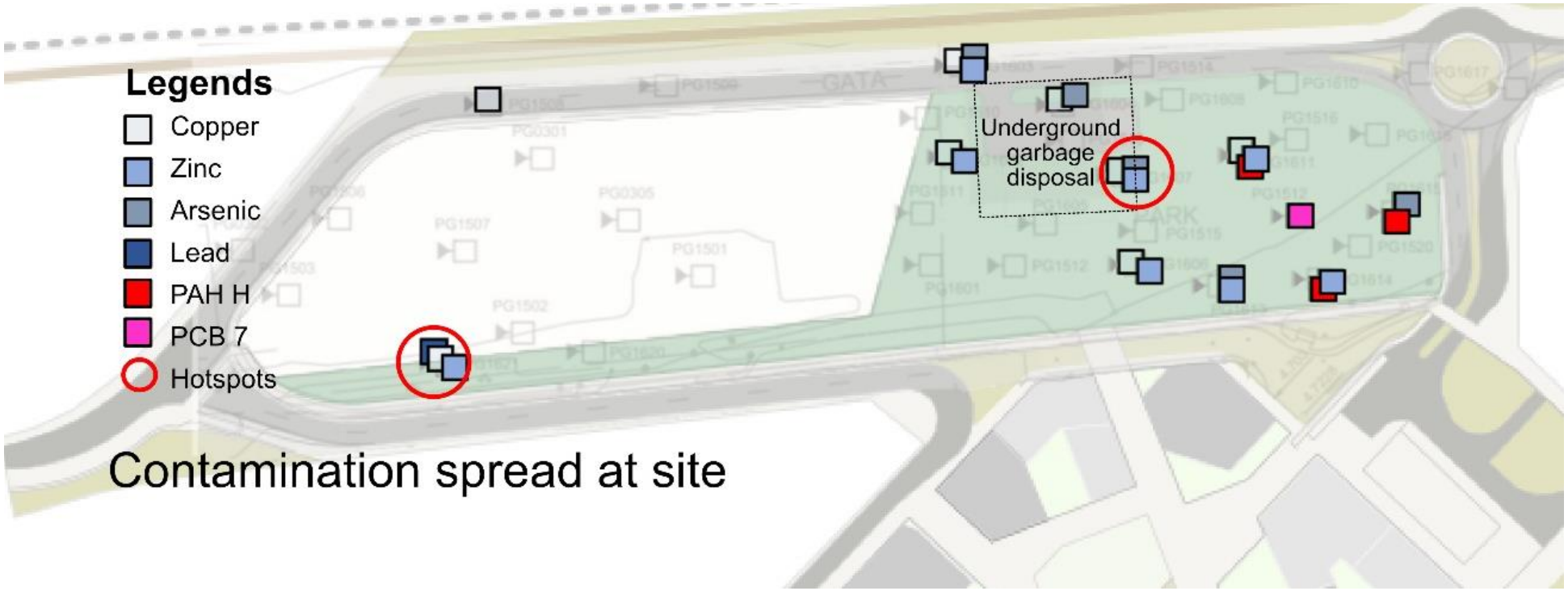
Case study: Polstjärnegatan



- Located in Lindholmen district which is a rapidly developing area
- A railway (Hamnbanan) as well as a motorway (Lundbyleden) to the north

Case study: Polstjärnegatan

- Most of the area has previously been used as a railyard
- It was turned later into a golf course which closed in early 2000s and since the site is unused
- The contaminant concentrations levels at hotspots correspond to Swedish criteria for hazardous waste



UGS Potential

Selected tools and methods
UGS potential
Bio-based land use matrix
Methods for stakeholders analysis
Time/intervention diagram
UGS and GRO intervention over time
SEPA soil guideline value model
GRO framework
GRO potential

A tool for selecting appropiate UGS on a site (detailed out in the journal paper doi:%2010.3390/su12156278)

UGS / Basic Conditions		Building green	Bioswale	Riverbank green	Urban park	Historical park	Neighbour-hood greenspace	Institutional greenspace	Allotment	Community garden	Grassland	Meadow orchard	Biofuel production	Horticulture	Shrubland	Spontaneous vegetation
Pre-condition		Buildings	-	River	-	History	Adjacent housing	Institution	-	Community	-	-	-	-	-	Derelict
Density	Site	Preferably dense	Dense or sparse	Sparse	Sparse	Sparse	Dense or sparse	Dense or sparse;	Dense or sparse	Dense or sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Dense or Sparse
	Surroundings	Dense or sparse	Dense or sparse	Dense or sparse	Dense or sparse	Dense or sparse	Dense	Dense or sparse	Preferably dense	Preferably dense	Dense or sparse	Dense or sparse	Dense or sparse	Dense or sparse	Dense or sparse	Dense or sparse
Sealing		Sealed, but unsealed is possible	Unsealed, but sealed is possible	Unsealed	Unsealed	Unsealed	Unsealed, but sealed is possible	Unsealed, but sealed is possible	Unsealed, but sealed is possible	Unsealed, but sealed is possible	Unsealed	Unsealed	Unsealed	Unsealed	Unsealed	Unsealed, but sealed is possible
Size		Preferably small	Preferably small or medium	Large, but medium possible	Medium or large	Medium or large	Preferably small or medium	Medium or large	All sizes	Preferably small or medium	Large	Large, but medium is possible	Large, but medium is possible	Medium or large	Large	All sizes
Access		Private, semi-public or public	Preferably public	Preferably public	Public	Public	Semi-public or public	Semi-public or public	Semi-public or public	Semi-public or public	Preferably public	Private, semi-public or public	Private	Private or semi-public	Preferably public	Private, semi-public or public
Management		Individual, communal, private or public	Private or public	Private or public	Private or public	Private or public	Communal, private or public	Private or public	Communal, private or public	Communal, private or public	Private or public	Communal, private or public	Private or public	Communal, private or public	Public	Individual, communal, private or public
Profit		Needed, there is a market	Not needed	Not needed	Not needed	Not needed	Not needed or needed, there is a market	Not needed or needed, there is a market	Not needed or needed, there is a market	Not needed or needed, there is a market	Needed, there is a market	Needed, there is a market	Needed, there is a market	Needed, there is a market	Not needed	Not needed
GRO potential		Yes, if unsealed	Yes, if unsealed	Yes	Yes	Yes	Yes, if unsealed	Yes, if unsealed	Yes, if unsealed and the produce is not for consumption	Yes, if unsealed and the produce is not for consumption	Yes, if not used for cattle grazing	Yes, if the produce is for consumption	Yes	Yes, if the produce is not for consumption	Yes	Yes, if unsealed
Regulation		Depends on site specifics and local regulatory systems														

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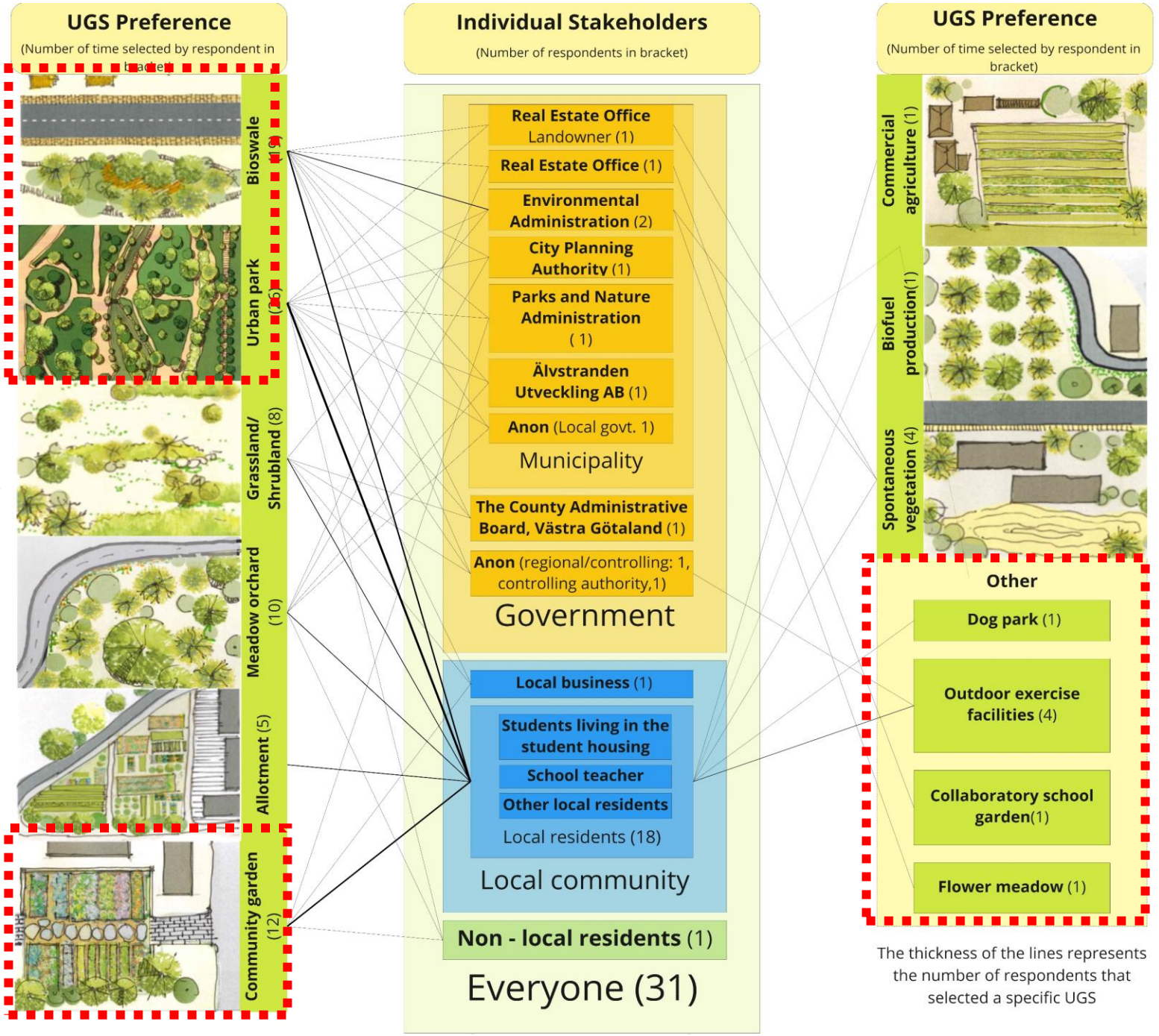

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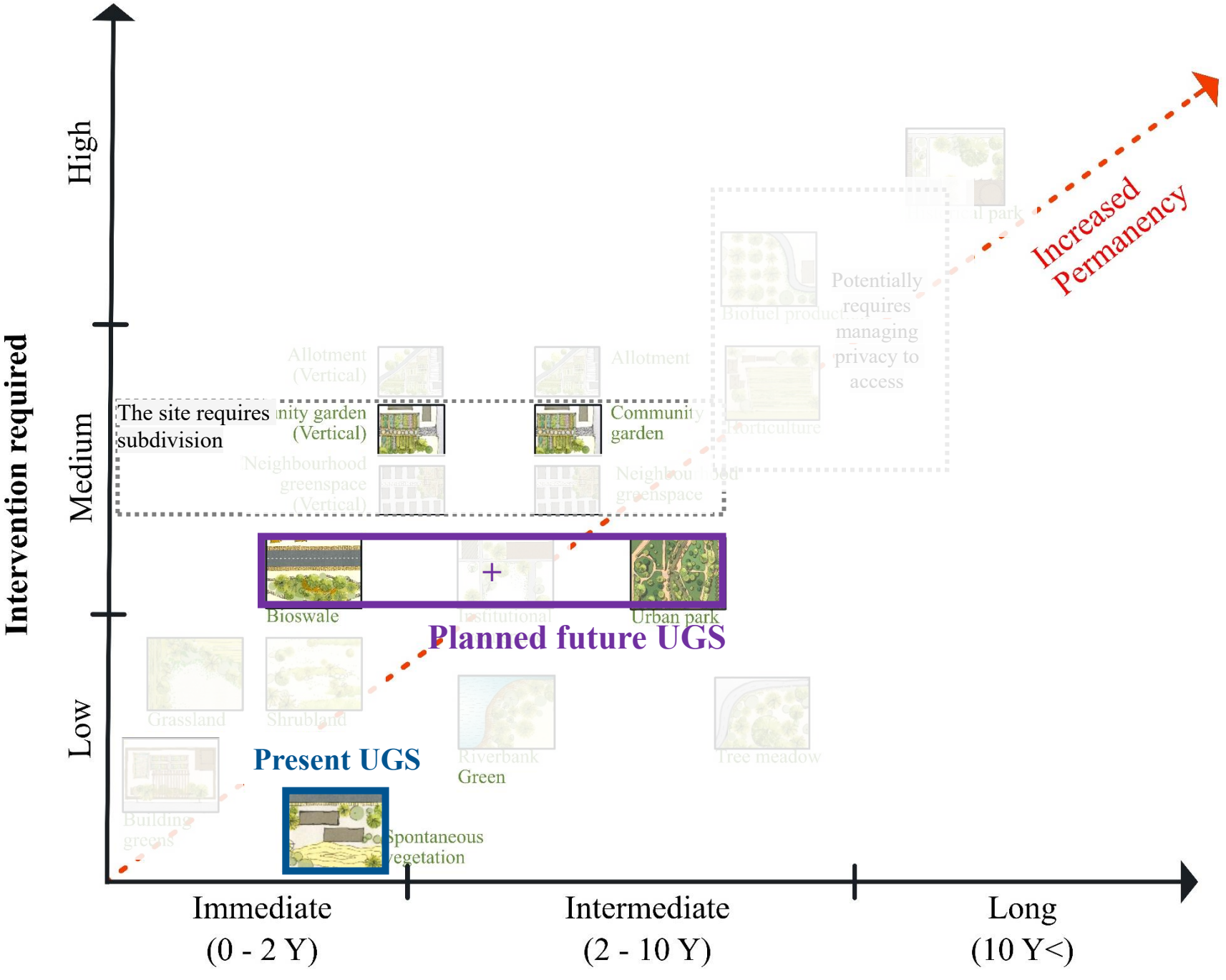
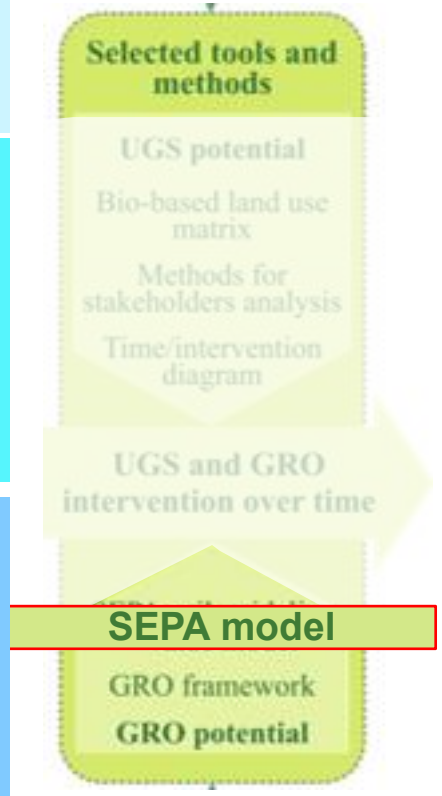


GRO potential



SEPA (Swedish Environment Protection Agency, Naturvårdsverket)

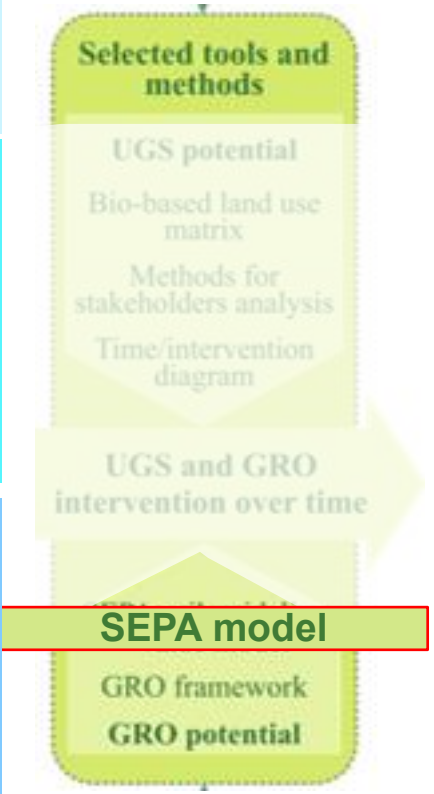
SEPA model helps us to estimate guideline value for soil contaminants for safe use

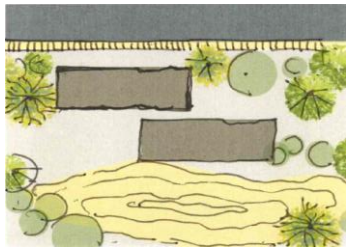
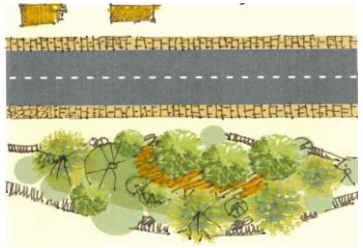
$$\textbf{Risk Quotient (RQ)} = \frac{\text{Existing level of contamination in the soil at site}}{\text{Guideline value for safe use}}$$

RQ >1

means the contamination level at site is higher than safe measure

GRO potential



Spontaneous vegetation	Bioswale	Urban park	Community garden
			
As (1.0)		As (1.0)	As (1.0)
Cu (0.0)		Cu (0.0)	Cu (0.1)
Pb (0.2)		Pb (0.4)	Pb (0.9)
Zn (0.0)		Zn (0.0)	Zn (0.1)
PAH-H (0.4)		PAH-H (0.2)	PAH-H (1.1)
PCB 7 (0.7)		PCB 7 (0.5)	PCB 7 (2.8)
As (0.5)		As (0.5)	As (0.5)
Cu (1.5)		Cu (1.5)	Cu (1.5)
Pb (0.3)		Pb (0.3)	Pb (0.3)
Zn (1.1)		Zn (1.1)	Zn (1.1)

A bioswale is a nature-based solution specifically designed to manage stormwater (quantity & quality), but will not handle soil contamination

Human Health

Environment

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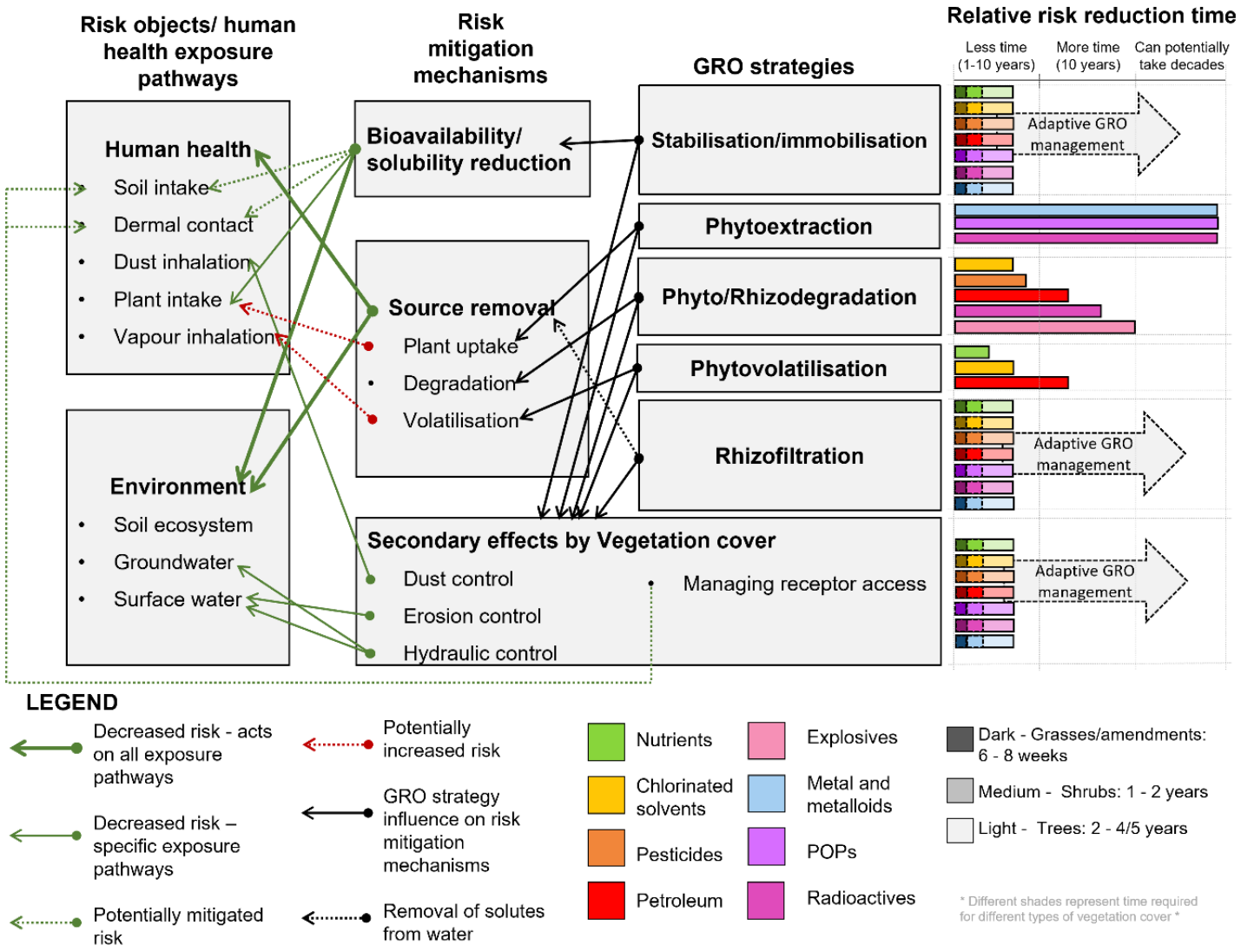
GRO potential

10.1016/j.scitotenv.2021.149880



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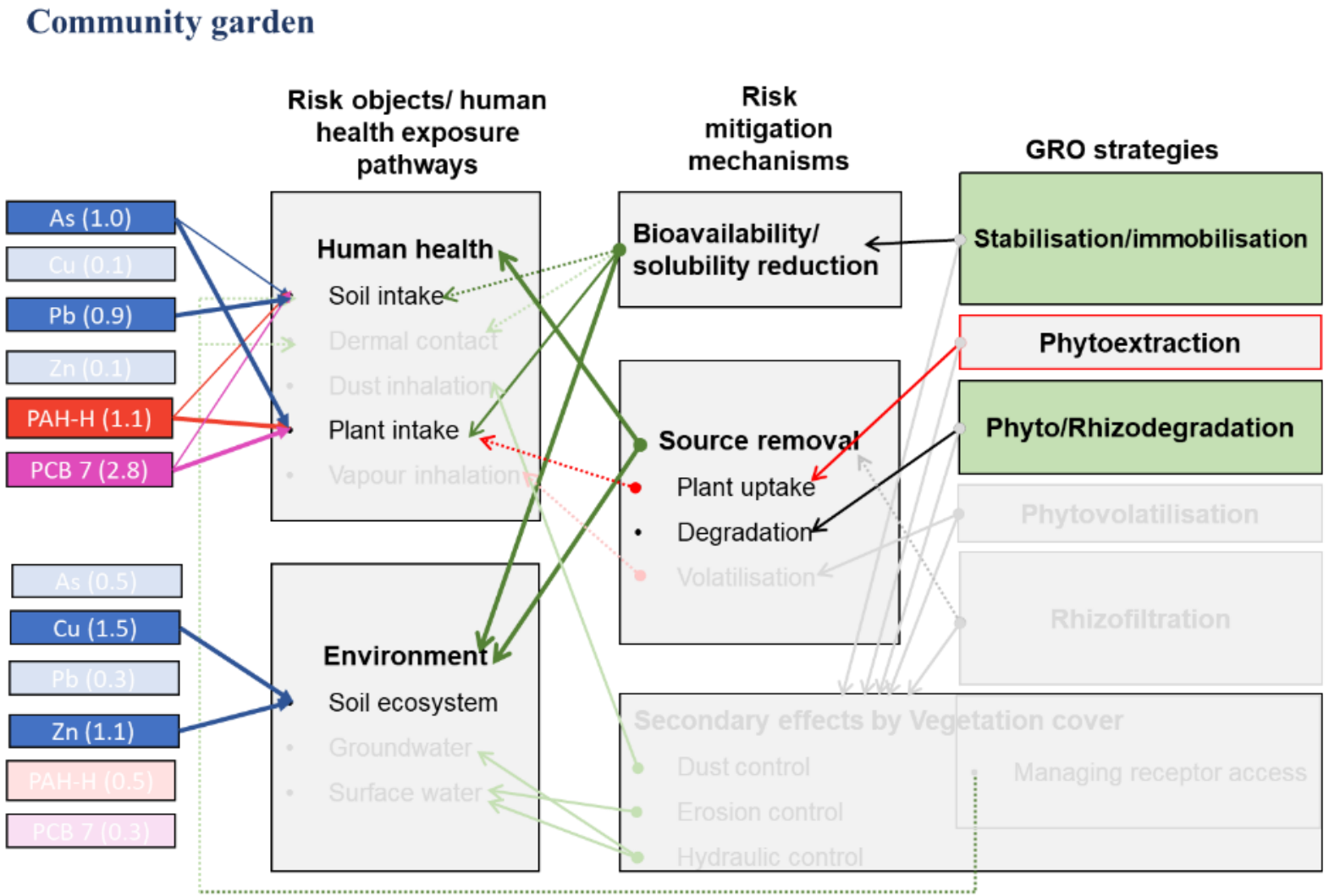

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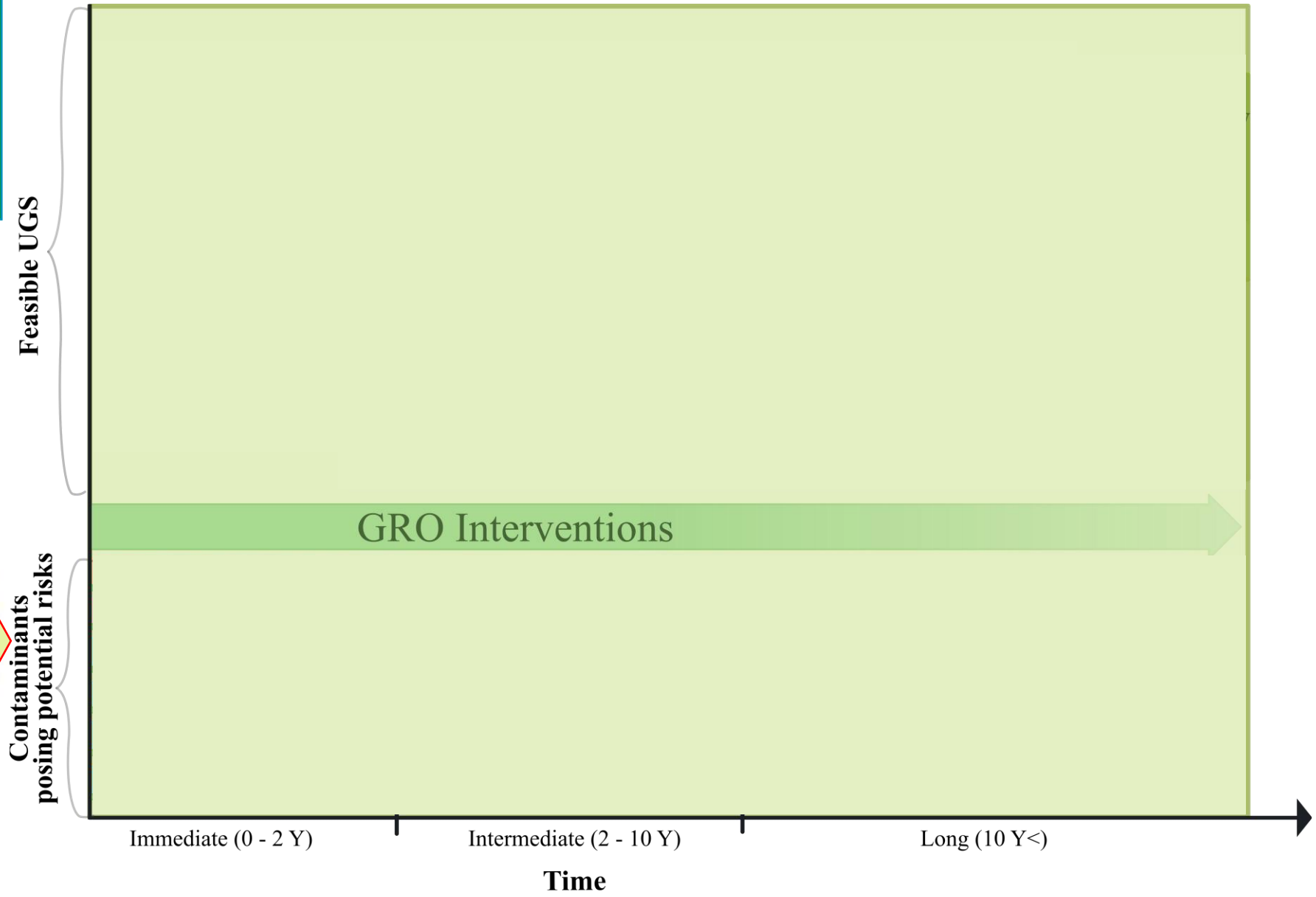

The set of tools and methods presented with the framework should be complemented with methods, tools, or databases to:

- make predictions of time requirements, and thus cost estimates, of GROs to reach acceptable risk levels;
- make quantitative, preferably monetary, valuations of non-market benefits such as ecosystem services associated with urban UGS and GRO to communicate benefits to decision-makers; and
- support the selection of plant, bacteria, fungi, and soil amendments for various GROs and contaminants in a Swedish setting

- In the circular urban land-use system, **brownfields** are **valuable resource in the transition** from abandonment to reuse
- **Urban greenspaces (UGS)** are fundamental for urban wellbeing by providing the citizens with numerous **ecosystem services (ES)** if brownfields are to be brought back as usable greens
- UGSs **in combination with gentle remediation options (GROs)**, a subset of nature-based solutions (NBS) can potentially be used to **manage risks to humans and ecosystems** posed by contamination present on the brownfields
- **Several tools** have been developed and some are illustrated in the case study, Polstjärnegatan, to filter out the possible UGS on the site and the associated GRO strategies and conceptualises a plan over time
- The application of the framework is challenged in a workshop with the relevant stakeholders which indicates that there is a **need for more exact estimates of time required for risk reduction with GRO** as it is essential for the cost estimates required for site development.

Paper 1: Chowdhury, S., Kain, J.-H., Adelfio, M., Volchko, Y., & Norrman, J. (2020). Greening the Browns: A Bio-Based Land Use Framework for Analysing the Potential of Urban Brownfields in an Urban Circular Economy. *Sustainability*, *12*(15), 6278. https://doi.org/10.3390/su12156278

Paper 2: Paul Drenning, Shaswati Chowdhury, Yevheniya Volchko, Lars Rosén, Yvonne Andersson-Sköld, Jenny Norrman,
A risk management framework for Gentle Remediation Options (GRO),
Science of The Total Environment,
Volume 802, 2022,149880, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2021.149880.

Paper 3: Chowdhury S, Kain J-H, Adelfio M, Volchko Y, Norrman J (2023) Transforming brownfields into urban greenspaces: A working process for stakeholder analysis. PLoS ONE 18(1): e0278747. https://doi.org/10.1371/journal.pone.0278747

Paper 4: Chowdhury, S., Volchko, Y., & Norrman, J. (2024). A Framework for Upgrading Contaminated Urban Land and Soil by Nature-Based Solutions: Demonstration with a Swedish Case. *Urban Science*, *8*(4), 198. https://doi.org/10.3390/urbansci8040198

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