Defining key concepts and associated indicators to measure NBS impact on urban regeneration within CLEVER Cities

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Contents

Executive summary

This deliverable explores four key social and economic facets of NBS in the context of urban regeneration, namely: *human health and well-being; sustainable economic prosperity; social cohesion and environmental justice*; and *citizen safety*. It defines each concept and proposes indicators for measuring their impact in order to create a shared understanding and common approach within the CLEVER Cities project. Purely environmental aspects and indicators are beyond the scope of this document and are explored elsewhere in the project.

The respective thematic sections have been designed to each be able to serve as a stand-alone factsheet for wider dissemination and include: a definition of terms, links with the planned NBS interventions in the frontrunner cities, a list of priority indicators recommended for measuring impact within the project, and considerations when selecting and applying these indicators in practice. The indicators in each thematic area are prioritised on a three-tiered scale, based on the ease of methods for data collection, availability of data from existing sources, and their relevance across cities given the context and objectives of CLEVER Cities. The information presented was collected on the basis of a grey and scientific literature review, exchange with other ongoing nature-based solution and/or green infrastructure-focused European projects, and expert input from the CLEVER Cities Advisory Board.

The document highlights the interlinkages of the four NBS impact areas within the context of urban regeneration. In terms of practical feasibility, the review emphasised that data is not always easily available at the right scale, and sometimes at all. At the same time, dedicated data collection is time and resource intensive. Additionally, it is often challenging to prove causality and measure the impact of specific local NBS, not least in CLEVER Cities due to the short timeframe of the project relative to the longer timeframe of evoking measurable impacts and the issue of physical scale (e.g. NBS being implemented within a single schoolyard, but data only being available on a city-wide, municipal or national scale), amongst other considerations.

1. Introduction

1.1. Aim and scope

This document serves to define key terms and concepts to be utilised within CLEVER Cities and propose indicators for measuring their impact in order to create a shared understanding and common approach within the project. The focus lies on four key social and economic facets of NBS in the context of urban regeneration, namely: *human health and well-being; sustainable economic prosperity; social cohesion and environmental justice*; and *citizen safety*. Purely environmental aspects and indicators are beyond the scope of this document and are explored elsewhere in the project.

1.2. Approach

The respective thematic sections have been designed to each be able to serve as a stand-alone factsheet for wider dissemination and include: a definition of terms, links with the planned NBS interventions in the frontrunner cities, a list of priority indicators recommended for measuring impact within the project, and considerations when selecting and applying these indicators in practice. The information presented was collected on the basis of a grey and scientific literature review, exchange with other ongoing nature-based solution and/or green infrastructure-focused European projects, and expert input from the CLEVER Cities Advisory Board.

The indicators in each area have been identified using the aforementioned sources, and subsequently prioritised based on the ease of methods for data collection and their relevance given the context and objectives of CLEVER Cities. Indicators for which data is likely to already exist or can be taken from existing sources and which are thought to be relevant across all frontrunner cities are categorised as ‘first priority’. Indicators in which data may be able to be extracted from existing sources to cover some aspects of the indicator or which are highly relevant to only some of the frontrunner cities are listed as ‘second priority’. Finally, indicators for which dedicated data collection would have to be carried out (likely extending beyond the available time and resources of CLEVER Cities) or which are of low potential relevance to the frontrunners are categorised as the ‘third priority’ (see Annex A). Ultimately, the selection of indicators to be used for monitoring the impacts of NBS in the CLEVER Cities project will be determined at a later date, taking into account data availability and the scope of the foreseen NBS interventions in each city.

2. Background and relation to CLEVER Cities

Urban regeneration [1] broadly encompasses the idea of improving, reorganising and upgrading an undesirable urban context (as opposed to the planning of new urbanisation). It can, for example, refer to the redevelopment of overcrowded areas of the city, economic growth in an area, or property development (2,3). Areas targeted for regeneration can be: spaces that have been abandoned (e.g. disused factory sites and buildings) or neglected (e.g. rivers that have been polluted); places facing particular environmental

[1] Other related terms which are often used interchangeably include: urban revitalisation, urban renewal or renaissance. The CLEVER Cities project has chosen to focus on the term urban regeneration as it is the most widely recognised and used by both policy makers and in academia (1).

challenges, such as lacking quality green spaces or high vulnerability to climate change impacts; or areas facing social and economic issues, such as reduced human health and wellbeing, inequality and crime.

In order to transform these areas from an undesired state into one offering diverse benefits, urban regeneration utilises multi-faceted interventions whose objectives and activities cut across traditional functions and responsibilities. The underlying idea is to make improvements to the economic, physical, social and environmental conditions of an area that has been subject to negative change, and is considered vulnerable (non-resilient) (1). Regeneration activities are further intended to promote engagement with stakeholders from public, private, voluntary and community sectors (ideally creating a collaborative, inclusive process), and to establish institutional structures that encourage lasting partnership amongst these groups (4,5).

Urban development discourse and related publications increasingly emphasise the need for 'sustainable urban regeneration'. This approach strives to bring about lasting improvements to a locality by considering interrelated dimensions in regeneration activities (see e.g. (6)), focusing in particular on environmental protection. Aspects such as reducing environmental impact, mitigating environmental risk, and improving environmental quality of urban systems, lifestyles and assets are to be considered high priority (6). This is a critical consideration as there are often conflicts between the more commercial drivers of urban regeneration, and environmental and social goals (7).

Table 1. Dimensions of urban regeneration and corresponding aims and activities (adapted from (1,5,8))

Dimensions of urban regeneration	Urban regeneration aims and activities
'People' (social, cultural, employment)	Increased/secure income, employment/employability, skills, capacities, aspirations, participation in local decision making, community building/social cohesion, equity, quality of life, health, education, crime mitigation, housing, quality of public services
'Business' (economic, employment)	Economic competitiveness, business performance, local business development, job creation and prosperity
'Place' (built and natural environment)	Improved Infrastructure, resilient built and natural environment, housing growth and improvement, sustainable transport and communications, improve general appeal of place to attract people and business

Sustainable urban regeneration requires changes to institutional behaviour, and presents a growing opportunity for utilising NBS as a tool to achieve urban development goals while also benefiting society and the environment (9,10). Implementing NBS can support a more inclusive urban regeneration towards a greater sense of community, combating social exclusion and inequalities within and between cities and regions (11). In the context of urban regeneration, NBS can, for example, be used to:

- Ensure sustainable growth that enables an inclusive city, with pleasant and healthy places to work and live in
- Promote healthier living, providing spaces for physical activity and relaxation
- Cool the city, clean the air and absorb stormwater to lessen the impacts of climate change

- Ensure a sustainable approach to the regeneration of deprived and neglected residential and industrial areas
- Demonstrate the multifunctional value of green rather than grey infrastructure
- Find new uses for underused and unused land that can provide community green spaces, with multiple benefits

The great promise of NBS to provide benefits for people, business and place can serve to help overcome the potentially negative impacts of urban regeneration more broadly (e.g. small dwellings, lack of affordability, shortage of green space, risks to respiratory health and increased crime) (12). As such NBS should be utilised to support more informed decision-making processes that minimise undesired eventualities and encouraged as a tool for supporting the sustainable regeneration of cities.

Urban regeneration and the CLEVER Cities demonstration sites

CLEVER Cities has identified key urban regeneration challenges in its three 'frontrunner' cities, i.e. London (UK), Hamburg (DE) and Milan (IT). Each city will co-create, -implement, and manage locally tailored NBS to deliver tangible social, environmental and economic improvements for urban regeneration. The planned interventions are presented below, highlighting the relevance to urban regeneration in each of the localities and are referenced again in each of the thematic subchapters.

Thamesmead is a town of over 45,000 people in south-east **London**, with a unique history and beautiful green spaces. The estate was built in the 1960's to address problems associated with 1950s social housing, where residents no longer knew their neighbours and community cohesion had declined. Although the area was designed to encourage social interaction and set within a landscape of waterbodies and green spaces to hold water and provide escape routes to higher ground in case of tidal flooding, these planned interventions did not work well for the residents. The elevated walkways for mobility/cohesion were badly planned, poorly lit, and considered unsafe and the lakes and greenspaces are underused due to poor access routes and orientation and a lacking appeal to the residents. Within CLEVER Cities, the original NBS interventions will be improved and enhanced - include the creation of new greenways/corridors and establishment of green nodes throughout the estate, supporting a reduction of health problems caused by low mobility and higher levels of community interaction and cohesion.

In the rapidly growing city of **Hamburg**, an increasing demand for housing has led to the construction of 10,000 new homes per year and of new transport networks. These projects are 'squeezing' existing settlements in the southwest of the city, where access to green space and options for mobility and transport are low, and community cohesion is strained. Urban regeneration activities under the CLEVER Cities project respond to these challenges and aim to redefine the identity of the area, in part by creating high quality public spaces for residents and increasing the cohesion between the district centre and these outskirts. Specific interventions include the redesign of a bicycle and pedestrian path and the restructuring of schoolyards. These NBS will close gaps in the green corridor and improve the mobility, well-being and health of local residents, increase the attractiveness of the area, and benefit community cohesion and businesses and job growth in the newly connected areas.

With its more than 1.3 million inhabitants in the city and 5 million in the metropolitan area, **Milan's** transport system is under immense pressure and posing growing challenges for urban populations. The planned

NBS interventions focus on two deprived areas in Milan which are especially affected by rail traffic and face noise pollution, a poor sense of place, lack of community cohesion, unsafe spaces and potential crime in abandoned rail yards and along poorly maintained rail banks. Regeneration in the unused space of the former rail yards and industrial areas along the line has not been exploited. The planned approach thus aims to tap this potential by engaging with residents to assess different types of green roofs and turn fragmented derelict spaces into a place for community farming and a natural oasis to increase community cohesion. The envisioned NBS interventions will not only benefit the residents, but also the environment through increased permeable surfaces and reduced run-off, lowered urban heat island effect, and decreased air pollution.

3. Thematic topics

3.1. Human health and well-being

Health is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (13). *Well-being* as a broader concept relates positive physical, social and mental state with fulfilment of basic needs, achievement of important personal goals, and participation in the society. These personal and social aspects are enhanced by economic aspects as well as healthy and attractive environment (14). Thus, good health is not only related to balanced diet, physical activity and healthy life-style advised by medical experts, but also to ‘daily conditions in which people live’ (15, p. 4). The conditions in which people are born, grow, live, work and age are known as the social determinants of health. They are influenced by the distribution of power and resources on different levels from global to local and mostly responsible for health inequities – “the unfair and avoidable differences in health status seen within and between countries” (16).

In this context, the importance of the *setting* (17) is a prevalent theme, with increasing links being made to the impact of one’s environment on health and well-being. Specifically, one important aspect of health-supporting urban environments is accessible urban green spaces (18). Urban green spaces are important for ecosystem services (19), but their impact goes beyond environmental or ecological aspects since they provide social and health benefits to all urban residents (20). Many research studies emphasise the influence of urban green spaces on both physical (21,22) and mental health (23,24) resulting in reduced morbidity (25) and mortality (26). Residential proximity to urban green spaces and their use is related to increased levels of physical activity that brings positive health outcomes like reduced obesity and cardiovascular disease (22) as well as reduced depressive symptoms (27). Even viewing urban green (e.g. out a window) is related to psychological relaxation and stress alleviation (28–30).

Causal models of the impact of urban green spaces on health and well-being (31) show a relation between green space characteristics and health status and well-being. Characteristics of the green space -like availability and accessibility, aesthetics, equipment and management - have an impact on the use and function of the green space, which in turn may have positive or negative impact on individual pathways to health as well as on environmental and social aspects resulting in positive or negative health status and well-being of the population. Specifically, health benefits of urban green spaces are related to environmental aspects such as reduced exposure to air pollutants, noise and excessive heat (32). Blue spaces (lakes,

rivers, sea) that are very often part of urban green spaces bring additional benefits to health and well-being (33). Beneficial aspects of urban green can be enhanced by adequate design and maintenance that would be reflected in better quality of urban green. Good quality of urban green is associated with increased physical activity and social cohesion (34,35) and a higher level of satisfaction with green spaces in deprived areas (36).

Besides the positive and desired outcomes of urban green interventions, it is possible that "adverse effects or unintended consequences" occur. Some examples of such side effects include: green gentrification processes, property damage, health and safety considerations (e.g. fear of crime, falling branches or injuries), anti-social behaviour, allergenic pollen, toxic plant components (seeds, blossoms are a potential risk for small children), exposure to pesticides and herbicides, vector borne disease, or overexposure to sunlight (20).

3.1.1. Human health and well-being in the CLEVER Cities demonstration sites

The city of **Hamburg** hopes to contribute to human health and well-being in its demonstration site through additional and restored green space and reduced temperatures from green roofs, as well as the reconstruction of schoolyards as multifunctional recreational green spaces. Attractive pedestrian walks and cycling lanes are supposed to partially change mobility choices of residents and visitors, thus contributing to better health. For **London**, the creation of greened walking routes, rain gardens and swales will soften the hard landscape contribute to well-being of residents in the demonstration site area. Finally, the envisioned NBS in **Milan** should function as noise barriers to the bordering railroad track. Smaller health and well-being benefits will also be generated, such as a reduction of the urban heat island and air pollution.

3.1.2. Potential indicators and methods for data assessment

Health and well-being impact assessment and indicators can help decision-makers and citizens to dynamically improve health and well-being when planning and implementing NBS interventions. Envisioned NBS interventions will have both short and long-term impacts on health, of varying degrees of directness. The two groups of indicators listed in **Error! Reference source not found.** consider these diverse impact types on different scales and with varying data availability, and highlights their usage within recent European projects[2]. For the first group of indicators, official data published by statistical offices is generally available. However, it is difficult to determine causal certainty between improvements in the listed outcomes (e.g. life expectancy) due to a NBS intervention, as a result of other influencing factors, the short duration of the project, and the long timeframe of evaluation for most indicators. The indicators in group two are deemed to be most insightful in terms of illustrating the impact and effectiveness of NBS. However, their assessment would require designing a dedicated study involving time and financial resource investments.

[2] Two research projects in the US and Australia, called PARCS and ShadePlus, are currently using quasi-experiments with matched control cases to analyse the health related effects of park redesign and renovation and park refurbishments respectively (37,38). These projects can provide further inspiration on indicators.

Table 2. Group 1 and 2 priority indicators for human health and well-being

	Code	Indicator	Scale(s)	Unit of measurement	Potential data sources	References
GROUP 1	Hd1	Overall mortality	City	annual mortality rate per 100 000 population	health statistics from death certificates, published by statistical offices	UnaLab ECLIPSE, TAPAS Health2020, SDG3
	Hd2	Change in lifespan	City	life expectancy at birth	official statistics of the cities	UnaLab ECLIPSE
	Hd3	Cardiovascular disease (CVD)	City	annual mortality rate – total CVD annual morbidity rate – total CVD per 100 000 population	health statistics from hospitals/doctors, published by statistical offices	URBAN, GreenUP UnaLab, EKLIPSE PASTA (39), SDG3, PHENOTYPE
	Hd4	Obesity	City	Proportion (%) of obese people – BMI over 30kg/m2	health statistics from hospitals/doctors, published by statistical offices	UNaLab, EKLIPSE PASTA, PHENOTYPE
	Hd5	Diabetes Type 2	City	mortality rate attributed to diabetes type 2	health statistics from hospitals/doctors, published by statistical offices	SDG3 T.3.4.1 (40)
	Hd5	Chronic respiratory diseases	City	mortality rate attributed to chronic respiratory disease	health statistics from hospitals/doctors, published by statistical offices	Health2020, SDG3
	Hd6	Allergies (pollen)	City	Proportion (%) of people suffering from allergies per 100,000 inhabitants, by age/sex	health statistics from hospitals/doctors, published by statistical offices	URBAN GreenUP UNaLab EKLIPSE (41)
	Hd7	Depression	City	major depressive disorder mortality rates from suicide and intentional self-harm per 100 000 population	health statistics from hospitals/doctors, published by statistical offices	Health2020, SDG3
	Hd8	Traffic injuries	City/ neighbour-hood	Motor vehicle accidents	official statistics from departments for transport	Health2020, SDG3

	Hd9	Weather-related mortality	City	mortality rate - heat-related causes (summer, age 65-75)	mortality statistics from death certificates published by statistical offices	UNaLab, (42)
GROUP 2	H1	Self-reported general health status	Regional to site	Proportion (%) of people feeling 1. 'good' and 'very good' in the past 12 months 2. 'bad' and 'very bad' in the past 12 months	Census data and dedicated study/survey, questionnaires3	GREEN-LULUS PHENOTYPE UNaLab BlueHealth (43,44) IWUN (45), (46)
	H2	Overall life satisfaction/ well-being	City / neighbour-hood /site	Percentage of people reporting overall life satisfaction ratings, on a scale from 0 to 10, by socio-economic class	Existing survey data or dedicated study based on qualitative interviews or questionnaire survey	(46)
	H3	Self-reported mental health status	City / neighbour-hood /site	Percentage of people reporting mental well-being on the scale from 0 to 5	existing survey data or dedicated study with interviews or questionnaire survey	WHO 5 Well-being Index, GREEN-LULUS UNaLab EKLIPSE (47) PHENOTYPE
	H4	Medication use	City / neighbour-hood /site	Percentage of people reporting medication use (hypertension, diabetes, pollen allergies, sedatives…)	Dedicated study questionnaire survey or data from health insurance	NAKO, (48)
	H5	Satisfaction with community/neigh-bourhood/NBS	Neighbour-hood / site	Percentage of people fairly or very satisfied with community/neighbourhood/NBS with places they like and places they avoid	Dedicated study - questionnaire survey and PPGIS (place-based survey – mapping places)	(46)
	H6	Number / share of people being physically active	City / neighbour-hood /site	Proportion (%) of people being physically active (min. 150 minutes per week)	Dedicated study with wearable sensors and app, qualitative interviews or questionnaire	UNaLab EKLIPSE + WHO recommend-dation

[3] Goldberg DP, Williams Paul DPM. A user's guide to the general health questionnaire. Windsor, Berks: NFER-Nelson, 1988.

				survey (or existing scientific studies)	
H7	Walking and cycling in and around areas of interventions	Site	Proportion (%) of people using NBS for walking, cycling outdoor activities (gardening)	Dedicated study with on-site counting, smartphone app, qualitative interviews or questionnaire survey	URBAN GreenUP
H8	Share of people using green space (formally or informally)	Site	Proportion (%) of people using green by: age; gender; ethnic or cultural group; socio-economic status	Dedicated study questionnaire survey; SOPARC: System for Observing Play and Recreation in Communities	(20)
H9	Frequency of green space use	Site	Proportion (%) of people visiting green space: 1. three or more times a week 2. less than once a month	Dedicated study questionnaire survey	(46)

3.1.3. Practical considerations and potential limitations

Overall, it is **challenging to assess the health and well-being benefits** of an NBS intervention **and prove causality** between factors, e.g. residential proximity to a green space and health improvements, due to a number of intervening factors (7,49). In efforts to do so, it is advisable to combine activity indicator measures (such as cortisol measurements or brain imaging) with questionnaire surveys based on self-perceived health and well-being to provide a comprehensive analysis of health and well-being benefits (7). The goal is not only to study (or expect) direct health outcomes related to the green (and blue) spaces but also the related mediated and moderated processes. For example, accessibility and quality of green can be a very important mediational variable that can regulate the health impacts. A number of tips for effective indicators and relatively simple data collection methods were identified based on the review of evidence and the case studies published by the WHO in 2017 (20):

- Use observational data of green space use as a relatively simple and cost-efficient way to assess how many people are using the green space, what types of people are using it, who they are using it with and for what purposes. [questionnaires including the measurement of performed vs. preferred activities]
- Use existing audit (50) and observational tools (51) to collect information on play and recreation in public areas.
- Consider simple and innovative monitoring techniques (e.g. user satisfaction counters like seen in public facilities).

- Engage with local networks and organizations as a way to collect feedback from community and green space users (e.g. engage with community councils or watchdog committees).
- Ensure that monitoring is considered from the start and that budget is allocated.
- Collaborate, where possible, with academic institutes and research centres which can aid with delivering effective monitoring and evaluation for the intervention as well as cost-efficient monitoring (e.g. through developing student research projects around the intervention).
- Consider proximity and accessibility of the intervention with regards to local residences, particularly in the context of park-based interventions.

For dedicated studies and survey data, it is important to ensure that data exists for the time before and after the NBS intervention to assure that health promoting attributes of the project are maximised and negative health effects are minimised[4]. **Statistical data** published by the statistical offices should be available on a yearly base. For comparisons across cities, one should keep in mind that numbers of disease outcomes are **not always available in a standardised and comparable manner** (44).

Furthermore, it is important to determine which population groups are not using the green areas and what the barriers in their use are. It is important to include equity aspects in the planning an implementation of the NBS interventions in order to assure that all population groups have equal opportunities to use green spaces that are beneficial to their health and to reduce existing inequities rather than intensifying them as the result of the intervention (see section 3.3).

3.2. Sustainable economic prosperity

Economic prosperity refers to a successful, flourishing, or thriving condition in terms of financial means (52). It is thus a key element to the quality of life of individuals, but is also necessary for a nation to be competitive in the world economy. For *sustainable* economic prosperity to be achieved not only economic growth needs to be ensured in the long-term, but also ecological health and social equity regarding the distribution of generated benefits. At this point, it is important to keep in mind that trade-offs or (socio-political) conflicts can occur through competition for space and due to uneven costs and benefits. For green roofs for instance, private and public benefits need to be added up to make green roofs a good investment, while the cost-benefit-ratio for private homeowners without any public subsidies is often negative (53–56).

The environment plays a critical role in achieving sustainable economic prosperity, as it contributes to the conditions for growth and economic security on the one hand, and provides healthy ecosystems on the other hand (57). Taking NBS as an example, the creation of new green and blue landscape features or the restoration of existing areas as part of urban regeneration efforts contribute to sustainable economic prosperity through, e.g. (57–60):

- **Job creation.** NBS and urban regeneration projects create jobs for the realisation and maintenance of urban green space. They also promote new, often socio-entrepreneurial business ideas (e.g. vertical gardening, urban food production, therapeutic programmes, outdoor workout, etc.).

[4] A Healthy Urban Development (HUD) Checklist developed by the New South West (NSW) Department of Health (2009) is a tool based on the Health Impact Assessment (HIA) designed to assist health professionals and urban planners to assess the health effects of the proposed development in order to provide better health outcomes.

- **External investments.** Green surroundings attract businesses (especially SMEs) that move in the respective areas.
- **Land and property values.** Property values increase near green spaces. NBS investment can therefore offer higher returns for the property sector. Higher property values in themselves are also believed to improve an area's image.
- **Labour productivity.** Being surrounded by urban green and using it for recreational activities makes workers happier, healthier and thus more productive.
- **Tourism.** Different NBS elements as well as the space they provide for cultural events contribute to a city's attractiveness for tourists. Tourists bring extra spending, support existing businesses that cater for them and encourage new ones.
- **Increased consumer spending.** Green space increases the attractiveness of city centres. It guides and slows down the flow of consumers in a city, and leads to a shift of spending power to businesses situated in more pleasant surroundings.
- **Reduced stormwater management costs.** Due to delayed and reduced stormwater runoff and better drainage, new storm water systems could potentially have a smaller capacity for water flow, while old storm water systems could support water flow for longer. Moreover, NBS help reducing the amount of untreated runoff discharged to surface waters.
- **Avoided costs for flooding.** Better drainage and reduced water flows can help to prevent overflowing stormwater drains, thus lowering the risk of urban floods. When planned in a specific way, urban green areas can even function as water retention basins in case of stormwater events, etc. Avoided costs include costs for the reconstruction/repair of infrastructure, property, habitats, etc.
- **Reduced energy costs.** NBS elements such as green roofs stop incoming solar radiation and therefore have the capacity to cool buildings in summer, thus reducing energy consumption. Older buildings also profit from insulation in winter, thus reducing costs for heating.

The manifold economic benefits of NBS highlight that they can save money at both the household and government level (7,60), when adopting a long-term investment perspective.

In the context of CLEVER Cities, the main urban regeneration objectives in terms of sustainable economic prosperity are to reduce high poverty rates and boost regional and local value chains by increasing access to job opportunities, and encouraging external investments and business start-ups. Additional indicators of relevance include those which help to measure economic benefits, such as reduced costs for water management and energy consumption as well as avoided damage costs, e.g. in cases of storms and severe precipitation events.

As outlined, the topic of sustainable economic prosperity has strong linkages to the issues of health and well-being, mainly in terms of reduced or avoided health costs, as well as social cohesion and justice. Besides the positive and desired outcomes of economic prosperity, it is also possible that adverse effects or unintended consequences such as gentrification and displacement of long-established residents can occur as a consequence of increased NBS deployment.

3.2.1. Sustainable economic prosperity in the CLEVER Cities demonstration sites

While the general objective of CLEVER cities in terms of sustainable economic prosperity is to reduce poverty rates and create new job opportunities, the front-runner cities explicitly mentioned various other economic benefits they hope to achieve through NBS deployment. Through the installation of green roofs, **Hamburg** expects to incur cost savings through improved rainwater management, reduced building temperatures and potentially a decrease in the heat island effect (thereby reducing health costs and increasing human well-being). Similarly, **Milan**'s foreseen green roofs will support a new stormwater management approach. The focus in **London** will be improving the wellbeing of residents by using NBS to make neighbourhoods more pleasant, feel safer, encourage active travel and make it more environmentally resilient.

3.2.2. Potential indicators and methods for data assessment

Assessing the economic value of NBS remains a work in process. In fact, compared to other areas like human health and well-being, only a limited number of EU-funded projects have identified and applied indicators to measure impacts on sustainable economic prosperity resulting from NBS implementation. This limitation is the reason why there is only a limited number of indicators proposed or used in various projects to measure sustainable economic prosperity which are outlined in the table below.

Table 3. First and second priority indicators for sustaianble economic prosperity

	Code	Indicator	Scale(s)	Unit of measurement	Potential data sources	References
FIRST PRIORITY	P1	Net outcomes into employment	City	Number of (un)employed people	Public employment agency	URBAN GreenUP KPIs (8)
	P2	Green jobs related to NBS (gardening, maintenance)	Regional to site	Number of employees or full-time equivalent jobs	Public employment agency, public administration in charge of green spaces, if site specific: survey or qualitative interviews	URBAN GreenUP KPIs / EKLIPSE framework (61)
	P3	Investment	Neighbour-hood to site	Amount of inward investment in property and business in project area	city administration data, business reports, data provided by real estate companies/ agents	(59)

	P4	Local tax revenue	City to Neighbour-hood	Increase in Council Tax/Business Rate revenue in project area	Tax revenues published by statistical offices	(59)
	P5	Commercial and domestic property prices	Regional to site	Property prices/ rent prices, characteristics of the neighbourhood/ community, environmental characteristics	(open source) geographical data, data provided by real estate agents/ companies, city administration (the latter also for socio-economic data)	Urban GreenUP KPIs/ EKLIPSE framework (8,59,62–64)
SECOND PRIORITY	P6	Number of jobs	Neighbour-hood to site	full-time equivalent jobs in project area	Public employment agency, if site specific: survey or qualitative interviews	(59)
	P7	Local employment	Neighbour-hood to site	Number of jobs taken by residents in project area	Public employment agency	(59)
	P8	Number of businesses and their business rates	City to site	Revenue from businesses in the NBS intervention areas, number of new shops/businesses opening in the environment of the NBS	Data from Opening Licences Department, companies business reports, economic data published by statistical offices , if site specific: Qualitative interviews or survey	URBAN GreenUP KPIs/ EKLIPSE framework (59)

P9	(Storm)water management costs	Neighbour-hood to city	Expenses for stormwater treatment facilities and erosion control measures, expenses of property owners to protect their property, predictions of flooding occurrences and their levels, potential impacts on property, infrastructure	Meteorological service, public administration/ public utilities, insurance companies	NAIAD (65)
P10	Energy costs for heating/cooling	Site	temperature differences (interior/exterior) or incoming and reflected radiation data, electricity prices	Dedicated study with technical measurement equipment needed for temperature differences, radiation data, Stock market for electricity	URBAN GreenUP KPIs (53,66)
P11	Numbers of visitors from outside town/city to intervention area	City to Site	Number of visitors pre and post NBS intervention	Tourism data published by statistical offices, survey (if site specific)	(59)

3.2.3. Practical Considerations

While data for sustainable economic prosperity indicators is generally available on a city level, challenges nevertheless arise due to issues of scale, accuracy, and difficulties in the measurement of multiple benefits. In general, the **dimension of time** always needs to be taken into account when selecting and applying indicators, as data points should be available pre- and post-NBS implementation.

The issue of **scale** becomes a challenge in trying to measure the positive effects of urban regeneration by specific NBS interventions. In these cases, dedicated studies will be necessary for a variety of indicators (for instance P2, P3, P6, P8, P10, P11), most of which could be available at higher levels, but will not be available specifically for the NBS intervention site. For P3, P4, and P8, it might be impossible to attain data at the intervention site. Some indicators will be available in principal, however, they always necessitate a dedicated study, as they are very sensitive to context-specific characteristics (cf. 8). The impact of green roofs for energy savings (P10) is, for example, not the same for any two buildings, climates or green roof systems (55). This means that data is not readily available, but has to be collected on a site and case-specific basis; the respective findings are then only applicable to the specific buildings.

Another limiting factor is **availability of accurate data**. Naturally, indicators such as reduced (storm)water management costs (P9) are fraught with uncertainties, as costs vary with levels of precipitation, percentage of impermeable surfaces, age and condition of existing infrastructure, etc. Similarly, Saint-Geours, Grelot, Bailly, and Lavergne (67) state major uncertainties for flood damage assessments, as input data is inaccurate or missing, knowledge is often incomplete, and model assumptions and measurement errors may distort results. Even Tyler et al. (8) who explicitly base their valuing of urban regeneration benefits on established techniques and market-based data that is commonly available in most countries note that "we should not lose sight of the considerable conceptual and measurement problems that evaluations of urban policy are subject to and thus the limitations of evaluation evidence that can only ever be regarded as providing broad orders of magnitude" (8).

Due to the existing trade-offs, assessing the manifold benefits of an urban regeneration project for various users gives a fairer account of the impacts than focusing on a specific green element, target group or a few individual indicators only. However, this is a very challenging task in general and with regards to economic benefits in particular, as methods for capturing the multiple benefits of NBS for sustainable economic prosperityare still lacking (cf. 7,60).

3.3. Social cohesion and environmental justice

Social cohesion refers to "the capacity of a society to ensure the well-being of all its members, minimising disparities and avoiding marginalisation" (68). *Environmental justice* refers to the (in)equality of inclusiveness and fairness in participation and decision-making, distribution of environmental benefits and negative environmental impacts, and acknowledgement of discrepancies between social groups (69).

Traditionally, the concept of environmental justice links environmental, social, and health aspects and emphasises the influence of environmental hazards on the health of disadvantaged population groups, specifically racial and ethnic groups (70,71). Contemporary views on environmental justice are expanded to include the equal right to access goods and services (72) as well as to opportunities like education, job and engaged participation in decision-making (15). Environmental justice is reflected in the broader concept of sustainability by establishing a decreased level of economic and social inequities as a basis for a sustainable society (72).

The environmental quality of different types of urban green spaces and their distribution in the city are linked to (un)equal opportunities among different socio-economic and demographic groups to use and benefit from these spaces (73). Perceived accessibility related not only to geographic distance but also to cultural aspects and perceived safety determine the park use behaviour of different population groups (74). As a result, in some areas insufficient number or inappropriate size of urban green spaces may contribute to park congestion, while in other areas urban green spaces unsuitable for the needs of ethnic groups living in the neighbourhood may go underused (75). The quality of physical environment has significant influence on outdoor activities and social cohesion with increase in social activities in high quality environments (76).

Nature-based solutions can improve social cohesion by, for example, creating safe and pleasant connections between neighbourhoods, employment areas, and environmental amenities, or by creating quality public green spaces accessible to all in which social activities can occur (77). Such solutions can also contribute positively to environmental justice in the context of urban regeneration by mitigating

detrimental impacts of development. This can include for example NBS that remediate brownfield sites or polluted landscapes, or reduce noise pollution. Interventions like community gardening can also be used to contribute to social cohesion and, in some cases, increase access to nutrient rich food amongst low-income populations (73).

However, implementing nature-based solutions in urban areas can also have negative societal impacts. In the case of "green gentrification" (78), for example, creating new green features or improving the quality and aesthetic appeal of existing features can lead to increased property values, rents, competition in housing markets and prices (alongside numerous other factors which contribute to gentrification). These changes can in turn displace local populations who can no longer afford to live in the area (79), resulting in an unequal distribution of benefits. In such cases, the original residents and users of the space are deprived of nearby access and enjoyment of quality green spaces while the benefits are enjoyed by the newer affluent portions of the population moving into the area (69,79,80). The "just green enough" approach provides a strategy to avoid these unintended consequences: it employs alternatives co-created with the local community to reinforce urban green projects that incorporate the needs of local populations to promote ecological and social justice and prevent green gentrification (81).

Environmental justice also has overlaps to other impact areas of NBS for urban regeneration, which need to be considered holistically when designing and implementing NBS projects. Distributional aspects of health impacts, for example (i.e. who receives health benefits from urban regeneration NBS projects and who does not) are relevant to environmental justice. Being aware of wider potential impacts is therefore of key importance to ensure that such solutions accomplish their intended urban regeneration effects and do not induce or exacerbate social cohesion and environmental justice challenges. Understanding the reasons behind poor social cohesion is an important step to achieving this objective in NBS projects.

3.3.1. Social cohesion and environmental justice in the CLEVER Cities demonstration sites

The following characteristics of the site in **Hamburg** have relevance to social cohesion and could help be addressed by NBS: there is a differentiated social structure with 60% of residents coming from Russia, Poland, Kazakhstan, and Turkey; residents who are refugees need access to German courses, integration programmes, and higher education in order to participate in society. There is a high percentage of households with children in the area, with 22% of residents under 21 years of age. In **London**, social cohesion-relevant aspects include issues relating to anti-social behaviour and intimidation resulting in residents avoiding spending time in communal courtyards or greenspaces and not letting children play freely. Thamesmead has suffered from lack of investment and maintenance resulting in homes and public spaces that are of poor environmental quality. In **Milan**, social cohesion related issues that the site experiences include a poor sense of place and a lack of community cohesion and social connections.

3.3.2. Potential indicators and methods for data assessment

The following indicators have been adopted to the extent possible from other indicator frameworks for NBS, green infrastructure, or related concepts. Adjustments and additions have been made when necessary to fit the topic and pilots as covered in CLEVER Cities. Effort was made to maintain as much consistency as

possible, to facilitate comparability. Demographic measures are included given their importance to understanding the distributional justice of the benefits and impacts of urban NBS and noting how NBS implementation affects movement of different age groups to/from an area, how accessible jobs are, how high the level of education is of a population living close to a NBS, etc.

Table 4. First and second priority indicators for social cohesion and environmental justice

	Code	Indicator	Scale(s)	Unit of measurement	Potential data sources	References
FIRST PRIORITY	SJ1	Availability of parks and/or ecosystem services with respect to specific individual or household socioeconomic profiles	Regional / city / neighbour-hood	Availability of (public) green space within 300m walking, segregated by household socioeconomic characteristics (e.g. income, degree of education, ethnic background/nationality, age)	Geospatial data, census data, surveys	EKLIPSE framework (69), RECREATE case study (77), (79)
	SJ2	Changes in tenancy turnover rate in the site area	Neighbour-hood	Number of tenancy changes in a given area within a given timeframe	Data from citizen address registration	GRABS project in RECREATE (77)
	SJ3	Population density	City / neighbourhood	Number of people per area (Population (N)/sq km)	Official statistics of the city	
	SJ4	Children from 0-18 yrs	City / neighbourhood	Proportion of children (0-18 yrs) in the overall population, in %	Official statistics of the city	
	SJ5	Adults from 18-64 yrs	City / neighbor-hood	Proportion of adults (18-65 yrs) population, in %	Official statistics of the city	
	SJ6	Adults from 65+ yrs	City / neighbor-hood	Proportion of elderly (65+ yrs) population, in %	Official statistics of the city	
	SJ7	Population with higher education level	City / neighbor-hood	Proportion of population with more than 13 years of education (Hochschulabschluss in Germany), in %	Official statistics of the city	
	SJ8	Long term unemployment	City / neighbor-hood	Proportion of economically active population (15-65yrs)	Employment agency or ministry of social affairs	

				unemployed over 12 months, in %		
	SJ9	Proportion of population receiving social benefits	City / neighbor-hood	Proportion of population that receive social benefits, in %	Employment agency or ministry of social affairs	
SECOND PRIORITY	SJ10	Level of political participation	City / neighbor-hood	Voter turnout rate, number of individuals and organisations participating in political organisations and actions, offline engagement actions, and/or online engagement (online consultation, social media, etc.)	Voting statistics, counting participants in events or online engagement, dedicated study (survey, Interviews, and Participant Observation)	EKLIPSE framework (69), URBAN GreenUP KPIs (82), see GREENSURGE methodologies (83)
	SJ11	Distance travelled to urban green space	Neighbour-hood / site	shortest network distance / perceived distance	dedicated study	
	SJ12	Access/barriers to green spaces	Neighbour-hood / site	Proportion (%) of people perceiving 1. good access 2. barriers to green space/ NBS	dedicated study	

3.3.3. Practical considerations

Several practical considerations play a role in measuring social cohesion and environmental justice, such as the need to: conduct dedicated data collection, select a few indicators to segregate by socioeconomic variables, consider the different impacts of social bonds, and account for limited voting rights of immigrants. These issues are outlined in more detail below.

For measures SJ10-13, **dedicated data collections** (e.g. surveys) would have to be undertaken within the case study. Notably, as socioeconomic data is key for determining the justice-related impacts of NBS projects, depending on the existence and availability of socioeconomic data on different spatial scales, additional surveys may need to be done to obtain this data in/near sites.

Segregating all indicators by socioeconomic variables (e.g. income, degree of education, ethnic background/nationality, age, sex) can provide more comprehensive insights into the justice impacts of NBS – yet this concern should be weighed against feasibility. It is therefore recommended to **segregate results of indicators SJ1 and 10-12 by socioeconomic status**, to give an indicative picture of important aspects of environmental justice. Indicators SJ3-9 measure socioeconomic data.

Different types of social bonds can play different roles in increasing or decreasing social cohesion. Research indicates that neighbourhoods in which family ties were predominant tended to show fewer indicators of tolerance, whereas friendships and participation in organised groups seemed to promote trust, attachment to neighbourhood, and tolerance (84). This should be accounted for in survey design and result analysis for making conclusions from indicators on social bonds, if they are chosen.

Depending on the country's voting rights laws, voting statistics may not be a useful reflection of political participation in areas with high immigrant populations. In some countries, immigrants have only **limited voting rights**. Immigrants without citizenship in their country of residence may only be allowed to vote in local municipal elections, and in some countries are not allowed to vote at all. In these cases, other forms of political participation could be taken into consideration. At the least, voting rights laws need to be considered as a contextual factor that may influence political participation differently between groups.

3.4. Citizen security

Citizen security refers to the actual and perceived freedom of movement and security against violent crime. In the context of nature-based solutions, the design, maintenance, and local context of the projects, including cultural attitudes towards different types of green features, can influence its impacts on citizen security (85). This means that impacts may vary between individuals and groups in a city, and in different locations. In Finland, for example, urban forests are perceived differently amongst demographic groups. For native Finns and certain immigrant groups, e.g. Russians, forests were perceived as relaxing. For others, such as immigrants from Asian and African countries however, forests were perceived as places of fear (86). Such cultural attitudes about different types of green features should therefore be kept in mind when designing urban regeneration NBS projects.

Implementing new green spaces in disadvantaged urban areas has been shown to reduce violent crimes and increase perceived security in the area (87). Similarly, landscapes that look well-maintained and well looked after have been found to discourage crime (69,88). For example, in a study of vacant lots in a de-industralised town in the United States, crime rates were found to be lower in lots that were developed and improved through maintenance than in lots which were not improved (88).

However, inappropriately maintained or designed green spaces can also be places that decrease actual and perceived security. Spaces with poorly maintained vegetation or which are dirtied with litter or dog feces, for example, may not be perceived by the users as safe (89). Poorly designed and maintained urban green areas can provide spaces for anti-social behaviour and crimes, such as vandalism and graffiti, loitering, theft, and underage drinking as well as violent crimes such as assault, homicide, and sexual assault, deterring people from using the space (89–91). Visual obstacles, such as poorly designed or maintained vegetation or lack of light, can decrease perceived safety – approaches such as crime prevention through environmental design (CPTED) can lead to reduced crime through well-designed spaces (92).

3.4.1. Citizen security in the CLEVER Cities demonstration sites

In **Hamburg**, areas in the demonstration site are perceived as unsafe due to missing and/or inappropriate infrastructure (e.g. poorly lit pathways and sidewalks perceived as places of high crime risk). However, there is a discrepancy between the actual crime rates and residents' subjective feeling of insecurity. **London** is tackling the perception of crime by attempting to animate and activate underused spaces. Through creating a hierarchy of streets and greening desired main thoroughfares it is hoped to have more people visible in the streets and therefore more natural surveillance. Finally, concerns at the demonstration site in **Milan** relating to citizen security include: potentially unsafe areas with high crime risk in abandoned rail yards and poorly maintained railway track banks.

3.4.2. Potential indicators and methods for data assessment

Indicators are grouped into two categories in Table 5 below. While the first priority group would not require the execution of a dedicated data collection or surveys, the second priority would require such activities being conducted in order to assess the impact of the planned NBS interventions across cities.

Table 5. First and second priority indicators for citizen security

	Code	Indicator	Scale(s)	Unit of measurement	Potential data sources	References
FIRST PRIORITY	CS1	Crime in the immediate vicinity of a green area	Neighbour-hood	Number and types of crime committed in the demonstration area per inhabitant OR user	Crime statistics (segregated by type and time of day)	New indicator, assessment method derived from EKLIPSE framework, UNaLab, and STAR Communities (93); see (94) for detailed typology of crimes
SECOND PRIORITY	CS2	Level of devices contributing to the safety of users in the neighbourhood (e.g. lighting of public space areas, access control, presence of technical or specialized staff, etc.)	Site	Percentage of area covered by devices contributing to safety OR Number of devices contributing to the safety of users in the neighbourhood	Survey of buildings/ built environment	EKLIPSE framework
	CS3	Perception of safety	City /neighbour-hood / site	Residents' and area users' perceptions of safety	Interviews and/or surveys with local communities and users	NATURVATION (91), assessment method from EKLIPSE framework; SDG 16: 16.1.4

3.4.3. Practical considerations

For the above listed indicators to measure citizen security, it is necessary to conduct targeted data collection activities, contextualise crime statistics with general public space usage information, and account for potential positive *and* negative impacts of green space management. These aspects are outlined in more detail below.

CS2 and CS3 require **targeted data collection activities**, which can be resource and time intensive.

Statistics and information on usage of public space should also be kept before and after interventions, to contextualize changes in safety measures (CS1-3), and provide insights to adjust security strategies in the future. As usage increases, it could be that crime rates per user decrease, while absolute crime numbers actually increase. In one study (88), for example, absolute numbers of car thefts near improved public green spaces increased following the improvement intervention – however, this is likely due to the presence of more cars near the sites as the number of visitors increased, and may not necessarily reflect how the overall security and perception of the area changed (88).

Differences in the design and features of public spaces, including the height of trees/bushes, vegetation density, or degree of maintenance of plots, can **impact a site's effect on crime and security - either positively or negatively** (92,94) . When measuring crime statistics (CS1) or perceived safety (CS3), impact evaluations should also keep a detailed measurement of the changes made to sites, in order to facilitate analysis of impacts of specific elements on security.

It may also be considered whether crime monitoring in nearby areas should be incorporated, to measure whether crime is reduced or simply displaced from the site area.

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Annex A. Third priority indicators across themes

Table 6. Third priority indicators across four thematic areas

Code	Indicator	Scale(s)	Unit of measurement	Potential data sources	References
P12	Business returns	Neighbour-hood, Site	Business returns of companies near NBS intervention	Dedicated study based on companies business reports	URBAN GreenUP KPIs
P13	Gross value added	Regional to city	Regional/city-level data on national accounts	Economic data published by statistical offices	URBAN Green UP KPIs/ EKLIPSE framework (8)
P14	Earnings of people that enhanced their skills in the design and implementation of NBS	Regional to city	Earnings of people designing and implementing NBS pre- and post-intervention	Qualitative interviews or social survey	EKLIPSE framework (8)
P15	Fuel costs in NBS intervention area	Neighbour-hood, Site	Average fuel consumption per vehicle, Number of people using bicycle instead of car because of new NBS	Onsite counting or survey for bicycle use, data of automobile companies or independent studies on actual fuel consumption	URBAN GreenUP KPIs
P16	Visitor spend	City	Aggregate amount spend by visitors pre and post NBS intervention	Tourism data published by statistical offices	(59)
SJ4	Level of participation in the development and delivery of GI interventions	City, neighbour-hood, site	Number of individuals and organisations participating in meetings, offline engagement actions, and/or online engagement (online consultation, social media, etc.)	Counting participants in meetings or online engagement, survey, Interviews, and Participant Observation	EKLIPSE framework (69), GREENup KPIs (82), see also GREENSURGE methodologies (83)
SJ5	Changes in participation in organised associations	Regional, urban, neighbour-hood, site	Number of organised associations OR	Surveys, local statistics on registered organisations (if	EKLIPSE framework (69)

			Percentage of population with membership in organised association	available and at appropriate scale)	
SJ6	Change in accessible green public space	City, neighbour-hood, site	Change in absolute amount OR share (%) of green space accessible to elderly, young, and people with disabilities (i.e. lacking barriers, with adequate safety features)	Dedicated qualitative survey of green space	Urban GreenUP KPIs (82)
SJ7	Attachment to place	Neighbour-hood	Self-reported measures of attachment to place	Survey	(84) in EKLIPSE framework
SJ8	Level of empathy and positive emotions towards social environment	Neighbour-hood	Self-reported measures of empathy and emotions	Survey	(84) in EKLIPSE framework
SJ9	Level of family and social ties	microscale (neighbour-hood, site)	Self-reported measures of family and social ties	Surveys	(84) in EKLIPSE framework