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To Do or Doughnut: Defining the Limits of the Urban Safe and Just Operating Space

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Declaration

I, Wies Ann-Beitske Dijkstra, declare that this thesis is a result of my research investigations and findings. All sources of information other than my own have, to the extent of my knowledge, been cited and referenced accordingly. This work has not been previously submitted to any other university for the award of any type of academic degree.

Signature:……………………………………………………, Date: May 15th, 2023

Acknowledgements

Summary

This master thesis explores the relevance of the doughnut for sustainable urban planning and decision-making in the context of planetary urbanisation. The doughnut economics model outlines an ecologically safe and socially just operating space for humanity to operate in. The objectives of the study are to describe recent advances in downscaling the doughnut to the local context, explore the doughnut's relevance for sustainable urban planning and decision-making, and evaluate these findings in light of ongoing planetary urbanisation.

The study is relevant because of the urgent need for urban planning and decision-making practices that consider the global impact of local actions and the emergence of the local as a battleground for global sustainability. The thesis used a qualitative research approach, specifically a literature review and case study method, to describe the application of the doughnut model in the local context. Semi-structured interviews were conducted with seven participants who were involved in applying the doughnut model locally. The interviews were transcribed, coded, and analysed thematically to identify patterns and trends between cases.

Results show that working with the doughnut can enhance strategic planning practices by providing a meaningful definition of sustainability that can be communicated both internally and externally. A shared definition of sustainability, among others, promotes goal coherence, and ex-ante consideration of impacts. The findings indicate that local governments have limited capacity to address the different dimensions associated with broader sustainability considerations, calling into question the dominant narrative of the role of cities in saving the planet. The findings indicate that applying the doughnut is mostly relevant for enhancing local exchange processes between actors and strategic planning, but provides limited support for addressing urbanisation impacts at different scales. Working with the doughnut does not inherently challenge the hegemony around local urban and economic growth, as these remain key in meeting the needs of urban dwellers.

The results highlight the need for greater efforts to integrate intergovernmental and academic sectors in sustainability planning to address the cross-scale interactions of urbanisation. Recommendations are made for future research and practice. Working with the doughnut stimulates cities to consider the broader impacts of local actions; this provides an opportunity to change the status quo of interactions between actors in the local governance system, possibly redirecting the operations of local institutions. However, this study raises questions about whether incremental actions of local actors will be enough in halting the rate and pace of socio-ecological deterioration in the age of the urban.

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Introducing the Challenge

Humanity is facing an accumulation of socio-ecological crises as a result of the accelerating rate and pace of socioeconomic processes (Steffen, Broadgate, et al., 2015), causing some to designate this time as the Anthropocene (Crutzen, 2002; Steffen, Broadgate, et al., 2015). We live in a time during which humanity has become one of the driving forces behind biophysical changes at a global scale, resulting in the complex socio-ecological challenges we face today (Steffen, Broadgate, et al., 2015). The most recent Global Risk Report identifies ten short- and long-term risks ranked by the perceived severity of their impacts according to different sectors including academia, business, government, and civil society (World Economic Forum, 2023). The increasing concern about the sustainability of modern societies is reflected in that eight out of ten crises for both terms are socio-ecological challenges. These are related to the rising cost of living, social polarisation, and involuntary migration, as well as natural disasters, ecosystem collapse, failures of climate change mitigation and adaptation measures, and natural resource crises (World Economic Forum, 2023)

These crises are increasingly urgent (Benjaminsen, 2021b) and are contingent on the ability of modern societies' capacity to operate between ecologically safe and socially just boundaries (Gómez-Baggethun & Naredo, 2015). The notion of limits to growth was introduced in the 70s by the Club of Rome (Meadows et al., 1972) and though the topic has been strongly contested (Benjaminsen, 2021b; Gómez-Baggethun & Naredo, 2015), it is important to understand the practical relevance of limits in guiding planning and decision-making for sustainability. One reason why the notion of limits is contested is because of their use in hegemonic Malthusian narratives that potentially perpetuate colonial attitudes towards development and conservation, marginalising vulnerable groups in the process (Mehta et al., 2019; Mehta & Harcourt, 2021; Robbins, 2020a). The Club of Rome identified urbanisation as a key driver of the accelerating rate and pace of global resource use and, in the age of ongoing urbanisation, the notion of limits may be more intuitive, yet also more ambiguous to address (Kaika & Swyngedouw, 2014).

The doughnut economics model builds on the notion of limits to inform policy and practice; it outlines a social foundation and an ecological ceiling which together shape the 'safe and just operating space for human development'(Raworth, 2017b). The visually appealing nature of the model makes it a suitable heuristic for communicating sustainability (Drees et al., 2021; Raworth, 2017a) and both theory and practice are exploring its use across scales. However, global sustainability models based on a limited set of indicators might fail to comprehensively address the complexity of sustainability challenges (Drees et al., 2021), especially in light of uncertainties with downscaling the model to the (sub-) national scales where decision-making

occurs (Häyhä et al., 2016; Steffen, Richardson, et al., 2015). Despite uncertainties and ambiguities regarding downscaling, defining a local safe and just operating space is an emerging topic in theory and practice. Hence, the local application of the doughnut economics framework is a relevant topic for further study, especially considering the need for 'cities that think like planets' (Alberti, 2016).

Humanity is increasingly urban; in 2021, 56% of the global population was living in cities (World Bank, 2023) and this number is projected to keep rising (UN-Habitat, 2020). Urbanisation causes negative ecological impacts because of sprawl, land-use change, biodiversity loss, and high rates of resource and energy consumption and waste production (Inostroza et al., 2013; UN-Habitat, 2020). Urban areas contribute an estimated 50% of the total greenhouse gas emissions (Marcotullio & Solecki, 2013), while climate change exacerbates existing socioeconomic urban inequalities (Nazrul Islam & Winkel, 2017). Cities influence their own local and regional climate via the urban heat island effect and changes in precipitation patterns (Seto et al., 2013). Urban regions are major drivers of environmental change and the current scale of urbanisation and its associated impacts drive the overshoot of the ecological ceiling (Alberti, 2016). Despite this, the common discourse around urbanisation is a win-win/modernisation discourse: sustainable urban development is seen as a solution, rather than a process contributing to environmental crises, and sustainable urban development is to be achieved through increased efficiency and technological advances in planning and design (Asafu-Adjay et al., 2015). This discourse reflects the ecomodernist stance on limits to growth, namely that limits are relative and can be circumnavigated using technology (Asafu-Adjay et al., 2015).

The Purpose of This Study

It is relevant to explore the capacity of local institutions to address global urbanisation challenges using the doughnut, as cities recently have started to explore how the doughnut could be adapted to urban settings (DEAL, 2023a). Few studies have addressed these local doughnut applications and, to the extent of my knowledge, a study of local doughnut applications involving multiple cases has not been conducted. The local is emerging as a key scale for addressing issues of sustainability (Brugmann, 1996; Evans et al., 2006; Næss, 2001), but these efforts can be undermined if their cross-scale interactions are not considered (Alberti, 1996; Elliot, Torres-Matallana, et al., 2022; Ottelin et al., 2020). This study aims to explore the relevance of doughnut economics for sustainable urban planning and decision-making in the context of planetary urbanisation. Using qualitative methods, I will describe recent advances in downscaling the doughnut to the local context, explore the doughnut's relevance for sustainable urban planning and decision-making, and evaluate these findings in

relation to planetary urbanisation. I use empirical data, including academic literature and interviews with practitioners to answer the questions:

- How is doughnut economics currently applied at the local scale?
- What is the perceived relevance of the doughnut for sustainable urban planning and decision-making?

The scope of this thesis is to explore recent advances in local doughnut applications using qualitative methods, departing from and ending with insights from critical urban studies and local sustainability governance. Within this scope, differences and similarities between cases working with the doughnut locally are explored. This study is focused on formal institutions that work with doughnut economics locally and is not limited to a geographical area. This study does not measure how applying the doughnut changes the quantitative performance of urban systems, nor does it explore the context-specific particularities of applying the doughnut in a given location.

In this thesis, I will first present background information about limits, the doughnut economy, and the question of scale, followed by a reflection on theories that help us understand the doughnut in the age of urbanisation. I explain my method of exploration and describe results that show how the doughnut is downscaled to the local context, including a literature review, case descriptions, and lessons learned from using the doughnut in local institutions. I discuss the relevance of the doughnut in the age of the urban by answering the research questions, interpreting findings and discussing their implications, as well as providing theoretical and practical recommendations. I end the document with concluding thoughts about the current relevance of the doughnut in enabling local action for global sustainability.

Limits, Doughnuts, and the Question of Scale

On the Nature of Limits

Back in the 70s, there was recognition of the fact that the ever-increasing consumption of resources on a finite planet would pose a problem in terms of limits to growth (Meadows et al., 1972). Limits are contested; it is considered vital to keep the activities of human societies within the safe ecological operating space of planet Earth (D'Alisa et al., 2015; Gómez-Baggethun, 2020). However, in practice, limits and scarcity can also be constructed and invoked to marginalise or dispossess communities (Mehta et al., 2019; Mehta & Harcourt, 2021; Robbins, 2020a). Hence, focusing on concepts such as ecological limits, scarcity, or carrying capacity when informing policy-making can lead to neglecting the social dimensions of sustainability. Perspectives on the use of limits in policy and practice can loosely be divided into those with modernist (eco) socialist and degrowth paradigms.

Modernist (eco) socialist visions entail the equitable use of technology to create an industrial system in which free time is maximised while ecologically harmful impacts are minimised (Huber, 2021). The elements that constitute production systems (resources, capital, labour, and technology) are constant, but their interrelations are dynamic, resulting in different ways of using nature and organising society (Benjaminsen & Svarstad, 2021; Robbins, 2020b). The perspective of modernist socialism is premised on the idea that ongoing capital accumulation requires technological development, but technological development does not necessitate capital accumulation (Luque-Lora, 2021). The modernist socialism perspective states that modernisation in the face of increasing labour scarcity, while renewable energy sources are abundant, will be required (Robbins, 2020a). For socialist modernists, technological development is the way towards a safe and just world (Huber, 2021).

Degrowth is a critique of the dogmatic neoclassical notion of growth, stating that perpetual economic growth is socially unjust and ecologically unsustainable (D'Alisa et al., 2015). Repurposing the economy to fit within the earth's ecological limits is required for moving towards sustainability (Gómez-Baggethun & Naredo, 2015). Degrowth states that, although limits can be conceptualised in different ways, the existence of ecological thresholds is a very real phenomenon (Gómez-Baggethun, 2020). It is important to be critical of limits, but by completely deconstructing the narrative, one ends up paying service to those who favour 'business as usual' scenarios (Gómez-Baggethun, 2020). Moreover, the premise of modernisation relies on the notion of decoupling economic growth from ecological impacts, something for which empirical support is currently lacking (Dorninger et al., 2021; Gómez-Baggethun, 2020; Wiedmann et al., 2015).

Modernist socialism and degrowth perceptions of limits to growth can be understood to have weak and strong conceptualisations of sustainability respectively, meaning they have different positions on the extent to which different forms of capital (social, ecological, built) can substitute one another (Costanza et al., 2017; Goodland, 1995). The perception of the ability of different forms of capital to substitute one another depends on how environmental problems and prospects of technology are understood (Hornborg, 2016). Socialist modernism understands environmental problems to be the result of capitalist production and technology to be the solution if equitably managed, while degrowth positions perceive environmental problems as the result of the neglect of the material reality of the economy and that physical laws (entropy) limit the potential of technology to address challenges of sustainability (Hornborg, 2016). Practically, weak sustainability conceptualisations might not be enough because it does not provide early warnings of reaching tipping points, and if they provide insight it might be ex-post the occurrence of impacts. Moreover, weak sustainability relies on markets to give these warnings, but markets can (and do) fail (Randall, 2022).

The doughnut is classified as a 'reformist circular society' perspective; it holistically considers social, environmental, economic, and political dimensions and has an optimistic outlook on the use of technology to avoid ecological catastrophe (Calisto Friant et al., 2020). This type of discourse assumes decoupling economic growth from environmental impacts under changed modes of capitalism is possible, aims to achieve well-being for all within ecological limits, and sets out to achieve these aims through enhanced regenerative and distributive socioeconomic systems (Calisto Friant et al., 2020).

Doughnut Economics

Doughnut economics proposes seven ways of thinking for economists in the 21st century (Raworth, 2017b). It states that the current neoclassical economic paradigm is at the root of many of the socio-ecological crises we face today, and proposes an alternative that should enable humanity to operate within a safe and just space across scales (Raworth, 2017b). The seven ways of thinking are 1) change the goal, 2) see the big picture, 3) nurture human nature, 4) get savvy with systems, 5) design to distribute, 6) create to regenerate, and 7) be agnostic about growth (Raworth, 2017b). Changing the goal refers to moving away from the hegemonic focus on GDP growth to focusing on economies that balance development needs with staying within planetary boundaries (Raworth, 2017b). Seeing the big picture implies not only relying on the market as ultimate efficiency but carefully using the market in combination with the state, households, and the commons as key actors in the embedded economy (Raworth, 2017b). Nurturing human nature means moving away from the rational, self-serving idea of 'homo economicus' and recognising that humans are adaptive, reciprocal creatures that do not only influence but are also influenced by their environments (Raworth, 2017b) Getting

savvy with systems refers to focusing on complexity and evolutionary dynamics in socio-ecological systems, rather than trying to model economies according to the laws of physics (Raworth, 2017b). Distributive by design states that economies do not have to create the extreme inequalities we see today and can be designed to not only 'redistribute income', but 'pre-distribute wealth' (Raworth, 2017b). Creating for regeneration refers to the negative impacts associated with the linear design of industrial processes and how these can be made more circular (Raworth, 2017b). Lastly, being agnostic about growth means whether or not economies grow should not be the principal question, but whether people living in those economies are thriving (Raworth, 2017b). The doughnut theory does not aim to prescribe specific policies for what it perceives to be context-dependent challenges of future uncertainty, instead, it aims to collect evolving economic ideas that can guide humanity to a safe and just future (Raworth, 2017b).

In this study, I will be looking at point one, changing the goal from GDP growth to operating within the doughnut (Figure 1), because of the global nature of the model and how this translates into local applications. The doughnut economics model (hereafter the doughnut) consists of a social foundation, informed by the UN Sustainable Development Goals (SDGs), as well as an ecological ceiling as prescribed by the planetary boundary concept (Raworth, 2017b). The framework highlights how human well-being is inextricably linked to planetary health. It emphasises 1) the importance of a stable earth system to meet the basic needs of a growing population, 2) current inequalities both within and between countries highlighted by ecological overshoot and social shortfall, 3) the need to redesign economic theory and policy to align more with regenerative and distributive principles, and 4) the urgent task of better understanding the future socio-ecological landscape in which human development will occur (Raworth, 2017a). The doughnut can assist in showing trade-offs between meeting human needs for a growing population while staying within acceptable levels of risk regarding the planetary boundaries (O'Neill et al., 2018) and can serve as a guideline for the sustainable management of socio-ecological systems (Raworth, 2017a).
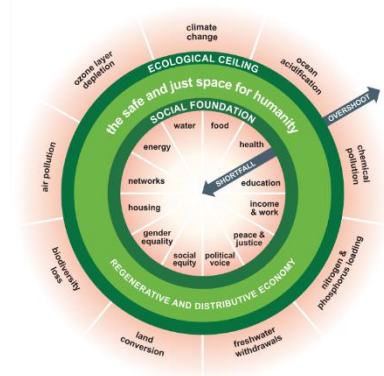

Figure 1. The Doughnut of social and planetary boundaries. Kate Raworth and Christian Guthier. CC-BY-SA 4.0 (Raworth, 2017b)

The doughnut is also subject to criticism. Specifically, Spash (2021) argues that the doughnut is a 'passive revolution', lacking a fundamental critique of capitalist structures and mechanisms. Despite critiquing neoclassical models of development, doughnut economics does not challenge the underpinning rationale that growth is necessary for development (Spash, 2021). This is reflected in that the doughnut presumes it is possible to meet the basic needs of all while staying within planetary boundaries, while others argue there is a need to define societal self-limitation is needed in the face of urgent socio-ecological crises (Brand et al., 2021).

The Ecological Ceiling

The planetary boundary concept was originally developed by authors from the Stockholm Resilience Centre and it highlights nine earth system processes and the different risks associated with perturbation (Rockström et al., 2009; Steffen, Richardson, et al., 2015). In doing so, the authors aim to identify a safe operating space for social and economic development to occur while keeping the earth system in a stable, Holocene-like condition (Rockström et al., 2009; Steffen, Richardson, et al., 2015). In an update to the framework, climate change and biosphere integrity are identified as key planetary boundaries, indicating there is a hierarchy in the framework (Steffen, Richardson, et al., 2015). The authors identify five planetary boundaries that are relevant to consider at a regional scale; biosphere integrity, biogeochemical flows, land-system change, freshwater use and atmospheric aerosol loading (Steffen, Richardson, et al., 2015). When the planetary boundaries framework is used in decision-making, it is relevant to consider both interactions and scale (Steffen, Richardson, et al., 2015). The former is because there is currently a lot of uncertainty regarding feedback mechanisms between the boundaries but they need to be understood as an interdependent set of processes that together shape the 'behaviour' of Earth as a 'single, integrated system' (Steffen, Richardson, et al., 2015). The latter is important because the planetary boundaries framework was not developed to be downscaled, however, the authors do recognise that many smaller-scale ecological processes affect the planetary boundaries and that relevant decision-making often occurs at the (sub-) national scale (Steffen, Richardson, et al., 2015).

The Social Foundation

The SDGs have been set by the United Nations and they serve as the basis for the social foundation of the doughnut economics concept (Raworth, 2017b). The doughnut economics framework articulates 12 social conditions that need to be met to achieve an acceptable social foundation. A review of socioeconomic indicators suggests an extension to the social foundation and proposes that relevant categories of indicators to consider are family and relationships, perception of self and social security (Custodio et al., 2023). Operating above

the social foundation while staying below the ecological ceiling is implicated by the suggestion that achieving the social needs of a growing population will be possible for some, but not all of the social dimensions under current provisioning systems (O'Neill et al., 2018). One study comparing both the doughnut economics framework to a multi-indicator approach to The SDGs reports that the use of a single or a limited set of indicators to measure the different dimensions of the social foundation raises questions about accuracy (Drees et al., 2021). Though the same authors recognise that the approach, when treated with proper scrutiny, can still be relevant to the local science-policy interface (Drees et al., 2021).

Scaling the Assessment of the Safe and Just Operating Space

The safe and just operating space illustrated by the doughnut is considered relevant for earth system governance processes (Biermann, 2012). However, decisions regarding levels of pollution and resource use are often made at the (sub-)national level (Häyhä et al., 2016). Downscaling the doughnut to the national levels reveals interesting trends: currently, countries that meet the social foundation also commit to ecological overshoot while countries that stay within planetary boundaries do not meet basic human needs (O'Neill et al., 2018). Articulating a regional safe and just operating space is a useful way of communicating challenges of equity and sustainability, and it could be used to start identifying the impact of regions on planetary boundaries (Dearing et al., 2014). However, the planetary boundary framework does not consider the complex interactions between and within the social and ecological domains that represent the boundaries (Dearing et al., 2014). Moreover, a challenge in defining a regional safe and just operating space is to account for how imports and exports allow for the externalisation of socio-ecological impacts between regions (Dearing et al., 2014). The framework needs to be linked to the global dimension to avoid trade-offs between scales, such as achieving regionally increased sustainable outcomes at the expense of other boundaries that are not equally visible at this scale (Dearing et al., 2014).

To operationalise planetary boundaries, and possibly the social foundation across scales consistently, their biophysical, socioeconomic and ethical dimensions need to be considered (Häyhä et al., 2016). The biophysical dimension needs to address both the scale and interactions of and between planetary boundaries, the socioeconomic dimension addresses patterns resulting from economic activity, and the ethical dimension ought to consider matters of fairness and equity (Häyhä et al., 2016). The authors conclude that 1) a distinction needs to be made between processes that directly affect 'the stable global baseline of the earth system' and 'spatially heterogenous, interacting processes that affect multiple components', 2) there is a need for better integration of bottom-up and top-down methods to operationalise planetary boundaries to more local contexts, and 3) there is a need for an interdisciplinary

effort to develop new concepts, tools and techniques that can inform decision-making across scales and sectors (Häyhä et al., 2016). The integration of top-down and bottom-up approaches is especially relevant in light of how socio-ecological impacts can be externalised via trade; bottom-up approaches can account for the upstream effects of production, or the impacts it has generated before the place where it is assessed (Feng et al., 2022).

Thriving Cities and Downscaling with DEAL

The Thriving Cities Initiative, a collaboration between the Doughnut Economics Action Lab (DEAL), Biomimicry 3.8, C40, and Circle Economy developed a city doughnut methodology called the 'city portrait' in 2019 and did a pilot of the method in Amsterdam, Portland, and Philadelphia (DEAL, 2023b). The Thriving Cities Initiative aims to explore tools for holistic thinking, governance, and policy for socially just and ecologically sustainable outcomes (C40 Cities, 2023). The city portrait guide aims to make the method freely available and recommends those applying it to do so in collaboration with multidisciplinary research teams, a diversity of municipal departments, and civil society actors and initiatives (Thriving Cities Initiative, 2020a). The Thriving Cities Initiative guide is developed as a pilot methodology and ought to evolve as cities working with it share their feedback and learning. In future updates, the guide aims to include considerations of historical context and power relations, approaches suitable for less affluent cities, and making the method applicable across multiple scales (Thriving Cities Initiative, 2020a).

The Doughnut Economics Action Lab (DEAL, 2023a) aims to support places that want to explore the doughnut by creating tools, direct communication with governments and initiatives, and facilitating the sharing of best practices and public events. DEAL has further developed tools for cities and regions to downscale the doughnut. The question central to these tools is: "How can our place be a home to thriving people, in a thriving place while respecting the wellbeing of all people and the health of the whole planet?" (DEAL, 2023a). By asking this question, the doughnut is 'unrolled' to reveal both local aspirations and global responsibilities regarding the social foundation and ecological ceiling, creating four 'lenses' elaborated in the following section. DEAL identifies ways in which local governments are exploring the doughnut, such as using it for strategic guidance, measuring and monitoring, and policy and decision-making (DEAL, 2023a).

Unrolling the Doughnut: a Toolbox

Core tools for cities that want to start working with the doughnut have been further elaborated in the DEAL 'doughnut unrolled' toolbox. The toolbox includes an introduction to the four lenses, an exploration of the four lenses, a data

Introducing the four lenses & their dimensions

There are two tools available as an introduction to and an explanation of the dimensions of the four lenses (Raworth et al., 2022; Shorter, Raworth, et al., 2022). These lenses illustrate local aspirations and global responsibilities of a place regarding the social foundation and ecological ceiling four lenses can also be used for ex-ante policy development and analysis.

The local-ecological lens asks: "How can this place be as generous as the wildland next door?" and focuses on designing places inspired by local nature and the delivery of ecosystem services. The dimensions associated with the local-ecological lens are: cleanse the air, house biodiversity, store carbon, recycle water, harvest energy, regulate temperature, build and protect soil, and enhance well-being (Raworth et al., 2022; Shorter, Raworth, et al., 2022). These ecosystem services are considered crucial for creating conditions for life. The global ecological lens asks: "How can this place respect the health of the whole planet?" and focuses on the impacts associated with the metabolism of a place. The dimensions associated with the global-ecological lens are the planetary boundaries. The planetary boundary framework should be considered as a whole, though some boundaries may receive special attention in some places (Raworth et al., 2022; Shorter, Raworth, et al., 2022).

The local-social lens asks: "How can all people of this place thrive?" and focuses on the perceptions and experiences of the inhabitants of places (Raworth et al., 2022; Shorter, Raworth, et al., 2022). The global-social lens asks: "How can this place respect the well-being of all people?" and focuses on global sociocultural connections (Raworth et al., 2022; Shorter, Raworth, et al., 2022). The dimensions associated with the local- and global-social lens are: Water, Food, Health, Education, Income and work, Peace and justice, Political voice, Social equity, Gender equality, Housing, Networks, and Energy (Raworth et al., 2022; Shorter, Raworth, et al., 2022). For the local-social lens, these dimensions can be further unpacked to relate to context-specific experiences. Regarding the global-social lens, these dimensions' global interconnections may result in the development of a place undermining possibilities of socioeconomic development elsewhere (Raworth et al., 2022; Shorter, Raworth, et al., 2022).

Looking at a place through the four lenses should allow for setting up a 'portrait of a place' which in turn should help with identifying interconnections and possibilities (Raworth et al., 2022; Shorter, Raworth, et al., 2022). To turn the portrait of a place into transformative action, one needs to 1) reflect on the current state of a place, 2) create a future vision of a thriving place, 3) bring together stakeholders and change-makers to turn the portrait into action, 4) identify existing initiatives, 5) embrace new values, 6) use complementary tools to keep expanding portrait of the place, 7) create iterative processes that drive cycles of transformation, 8) monitor and assess progress, 9) make it fun and creative (Raworth et al., 2022; Shorter, Raworth, et al., 2022).

Data Portrait of a Place

The data portrait of a place is the follow-up version of the initial Thriving Cities Initiative guide and provides cities with information and tools for identifying targets and indicators that can be used to create a data-led portrait of a place using the doughnut. The tool describes the methods that were used in Amsterdam, Portland, and Philadelphia to create data portraits of place. According to DEAL, this is the most holistic way of downscaling the doughnut. It is a place-based approach that incorporates a) local aspiration & global responsibility, and b) it's scalable (Fanning et al., 2022)

DEAL has developed design principles for the portrait: 1) be locally relevant rather than aiming to compare between places, 2) aim to compare desired outcomes to current performance, 3) offer a holistic 'snapshot' for discussing complex issues, 4) create an opportunity for tracking progress, 5) take the long view, 6) combine data with community perspective (community portrait of place) (Fanning et al., 2022). The data portrait outlines steps to assess the four lenses:

The local ecological lens is assessed by 1) selecting a local-ecological reference habitat, 2) selecting local-ecological dimensions, 3) identifying and selecting methods and data, and 4) selecting place-based indicators to track performance (Fanning et al., 2022). The global-ecological lens is assessed by 1) selecting global-ecological dimensions and gathering data, 2) defining a place-based share of planetary boundaries, and 3) defining a place-based share of national environmental footprints (Fanning et al., 2022). The local-social lens is assessed by 1) selecting local-social dimensions that constitute a place's social foundation, 2) assessing what official targets exist and if they are sufficient, and 3) selecting local-social indicators to track performance (Fanning et al., 2022). The global-social lens is assessed by 1) selecting global-social dimensions and targets and 2) identifying interconnections and place-based performance indicators (Fanning et al., 2022).

By using this approach, the data portrait allows places to identify and/or develop targets and indicators relevant to that place for all four lenses. The data portrait ought to be complemented with the community portrait so that a diverse group of stakeholders is brought together (Fanning et al., 2022).

Community Portrait of Place

This tool presents participatory approaches that places can use to explore the four lenses and focuses on how to prepare workshops, how to start the community portrait and how to enrich the community portrait. In preparing for the workshop, it is important to consider how the four lenses will be presented to participants and what the format of the workshop is (Shorter, Grcheva, et al., 2022a). The tool identifies four ways to start the community portrait: 1) initial

perspectives (what already exists in a place), 2) deepening inquiry (questions to go deeper in the understanding of the four lenses), 3) history of the place (history, global interconnections over time and how they relate to the present), and 4) sense of place (explore outdoor sensations of a place) (Shorter, Grcheva, et al., 2022a). These approaches can be considered complementary. The community portrait can be enriched by drawing up interconnections between the lenses, identifying gaps in the initial exploration, and identifying possibilities for new initiatives (Shorter, Grcheva, et al., 2022a).

Exploring a topic

This tool presents approaches that can be used to explore a specific topic through the four lenses and how a chosen topic can help bring humanity into the doughnut. When exploring a topic, prepare to start by familiarising yourself with the 4 lenses, choosing a specific topic (one of the dimensions from one of the four lenses), and a format through which the topic will be explored (what kind of workshop) (Shorter, Grcheva, et al., 2022). The tool identifies three ways of exploring a topic: a holistic inquiry into what is known about the topic, identifying interconnections between elements of the topic, and identifying possibilities by exploring future visions of the topic (Shorter, Grcheva, et al., 2022).

The doughnut unrolled tools developed by DEAL are supposed to provide a place with complementary information on their safe and just operating space. Both the tool for exploring a topic and creating a community portrait ask their users to explicitly consider whose voices have not been heard in the process (Shorter, Grcheva, et al., 2022).

The Age of Urbanisation

Recent advances in critical urban studies, used here to summarise interdisciplinary efforts to advance our understanding of urbanisation as a process, highlight significant implications towards urban sustainability, raising the question; 'why do we think cities can save the planet?'(Keil, 2020). Understanding cities and urbanisation not only as places in space but as processes in time, requires us to rethink the matter of urban sustainability (Inostroza & Zepp, 2021; Solecki et al., 2013). Defining the relevance of an urban safe and just operating space for informing planning and decision-making requires a closer inspection of what the urban is, as well as the local institutional capacity to deal with questions of its sustainability.

Critical Urban Studies

In this section, I will highlight important advances in the field of critical urban studies that enable a better understanding of the city and the urban. I use the term critical urban studies to refer to a range of disciplines, including urban, industrial, and political ecology, that critically engage with the nature of the city and its associated urbanisation process.

To define an urban safe and just operating space, we first need to closely inspect what the urban is. We live in the age of planetary urbanisation, referring not only to the increasing number of urban dwellers but to the extended impacts the urbanisation process has on places and people far beyond the geographical boundary of the city (Heynen, 2014; Kaika & Swyngedouw, 2014; Swyngedouw, 2006). The urban and the city are not one and the same; the former is a socio-ecological process and the latter is the outcome of that process in a specific place in space and time (Angelo & Wachsmuth, 2015). Planetary urbanisation and its associated environmental impact could lead to exceeding the planetary boundaries (Alberti, 2016). Despite the challenges related to urbanisation, the concept remains poorly understood. Urbanisation is measured along a dichotomous gradient ranging from urban to natural and where on this gradient a region falls is determined by population size (Inostroza et al., 2019). This conceptual confusion about the definition of urbanisation greatly hinders a better understanding of urban sustainability challenges (Brenner & Schmid, 2011; Inostroza et al., 2019). The rate and pace of urbanisation taking place globally necessitate a comparative science of urbanisation that provides a better explanation of what socio-ecological processes constitute urban systems and how these interact with other systems across scales (Solecki et al., 2013). A science of urbanisation processes can inform decision-makers about the sustainability of urban systems from a multi-scale perspective (Solecki et al., 2013).

Planetary urbanisation necessitates an understanding of urban systems as hybrid systems, referring to both the system structure (the city), but also its metabolism; the exchange relationships that build, maintain, and advance the complexity of the urban system (Alberti,

2016; Broto et al., 2012; Newell & Cousins, 2015). Urban metabolism can be considered a boundary metaphor, a term that allows for interaction and engagement with a topic by different scholarly disciplines (Broto et al., 2012; Newell & Cousins, 2015). Marx was one of the first to use the term metabolism to describe the socio-ecological processes of transformation he saw unfold during the industrial revolution (Swyngedouw, 2006). He was inspired by the chemist von Liebig, who used the German word 'schtoffweschel' to refer to the mechanism by which living things arranged material and energy exchanges both internally and with their environments (Swyngedouw, 2006). A review of interdisciplinary literature on urban metabolism identifies six main themes: 1) studying the city as an ecosystem, 2) looking at the material and energy flows that move through urban systems, 3) metabolism as the material basis for the economy, 4) as an economic driver of core-periphery relations, 5) as a material expression of the reproduction of urban inequality, and 6) as a means of re-signifying socio-ecological relationships, where material flows are influenced by the political-historic context in which they occur (Broto et al., 2012). An interdisciplinary perspective on urban metabolism sheds light on how transitioning towards urban sustainability requires significant transformations in patterns of production and consumption (Broto et al., 2012). Building on industrial, urban, and political ecology approaches, the metaphor of the 'metabolism of urban ecosystems' can be further specified as: "a global circulatory process of socio-natural relations that transforms and (re)creates urban ecosystems through the exchange of resources, capital, humans, and non-humans into and out of the spaces of global urbanisation" (Newell & Cousins, 2015 p. 721). Urbanisation as a metabolic process has significant implications for current dominant discourses on urban sustainability (Kaika & Swyngedouw, 2014).

The urban can be conceptualised as a space of flows in which processes of socio-ecological change and transformation result in the production of cities (Inostroza & Zepp, 2021; Swyngedouw, 2006). From a material perspective, urban metabolism studies focus mostly on inputs and outputs moving through the urban system, treating the city itself as a 'black box' (Inostroza, 2014). Urban metabolic flows can be divided into urban anabolism and urban catabolism, referring to the accumulations of materials in and the flows of materials through the urban system, respectively. The quantified accumulation of stuff, such as buildings, infrastructure, and other consumer goods in a given area of land can be defined as technomass (Inostroza, 2014). Technomass provides a better understanding of urban metabolism by highlighting how the production, transformation, circulation, and consumption of resources and energy results in material accumulation in the form of urban tissue (Inostroza, 2014). When looking at cities as hybrid systems composed of technomass, they can be understood according to some principles from ecology. This reveals that technomass structures, as opposed to biomass structures, have a metabolism that corresponds to size;

the metabolism speeds up, rather than slows down, as the city grows (Alberti, 2016). Metabolic urban networks can be used to conceptualise how urban function relies on resources extracted from spatially and temporally distant places and periods, showing how urbanisation is a strategy of colonising other urban and non-urban ecosystems where material and monetary flows are recursively related (Hornborg, 2016; Inostroza & Zepp, 2021). We need to understand the city as a system in which technomass, anthropogenic material expressed as volume/area, rather than biomass, is accumulated, and urbanisation as the associated metabolic process of that ecosystem (Alberti, 2016; Hornborg, 2016; Inostroza, 2018; Inostroza & Zepp, 2021). Urban metabolism helps us understand the phenomenon of planetary urbanisation by showing how urbanisation is contingent on the operation of spatially and temporally distant systems in providing the energy and resources needed for the (re)production of form and function (Inostroza & Zepp, 2021). The urban metabolism perspective shows that urban sustainability is not only a matter of nature in the city, but a matter of the urbanisation of nature through complex multi-scalar social metabolic arrangements (Keil, 2005; Swyngedouw, 2006).

Indicators used to assess the sustainability of urban systems need to connect patterns of urbanisation to the conditions of resource use to provide meaningful information on whether or not the system is sustainable across scales (Alberti, 1996). The use of indicators to measure local sustainability is beneficial for multiple reasons, including monitoring changes, setting targets, and public communication (Alberti, 1996). Indicators of urban sustainability should consider urban quality (physical and socioeconomic conditions), urban flows (resource flows mediated by information and infrastructure), and urban patterns (how patterns of urbanisation affect urban quality and flows) (Alberti, 1996). The local scale is confronted with amplified issues of data availability and quality, and local governance systems tend to opt for a limited number of meaningful indicators, as opposed to global actors that seek to harmonise the measuring and monitoring of urban systems (Alberti, 1996). Dealing with issues of complexity, scale, and uncertainty, as well as identifying relevant measurements and reference conditions are important scientific challenges to assessing the sustainability of the urban (Alberti, 2016).

Cities are human habitats, and urban metabolisms are therefore not governed by the same principles as natural ecosystems (Alberti, 2016). Recognising that human institutions and agency are key in shaping the accumulation of technomass in urban centres raises the question of power and justice, as the accumulation of technomass in one place necessitates the extraction and transformation of resources from and in different places in the world system (Hornborg, 2016). In this way, planetary urbanisation can be understood as the accumulation of technomass in urban centres, at the expense of socio-ecological impacts externalised in space and time (Alberti, 2016; Hornborg, 2016). From a sociocultural perspective, urban

metabolism reveals how metabolic flows are subject to actors, institutions and power relations, producing uneven outcomes both locally and globally (Dorninger et al., 2021; Elliot, Goldstein, et al., 2022; Swyngedouw, 2006). Locally, political ecology studies show how urban systems can have differentiated metabolisms for specific resource flows that are reproduced along class divides (Swyngedouw & Kaika, 2014), and how the negative impacts of urbanisation are locally borne by vulnerable and marginalised groups (Heynen et al., 2006). From a global perspective, urbanisation implies improving the living conditions of some at the expense of other people and places in the world system (Arboleda, 2016; Hornborg, 2016; Swyngedouw, 2006). This relates to the aforementioned material nature of urbanisation, which is contingent on the dissipation of energy and resources for the maintenance and reproduction of form and function (Alberti, 2016; Inostroza, 2018). Urban systems rely on their hinterlands for the extraction of resources but globalised and specialised commodity production has resulted in hinterlands being embedded in larger systems of supply chains, making it difficult to connect areas of production and consumption (Brenner & Katsikis, 2020). The process of metabolic rift leads to the progressive exhaustion of ecological surplus for the sake of maintaining the urban system, reinforced by decreasing returns on resource extraction from existing frontiers (Brenner & Katsikis, 2020).

The use of fossil fuels has enabled certain parts of the world system to separate the energy and land requirements for maintaining their metabolism from their geographical territory (Hornborg, 2016), and this becomes especially visible in the relationship between cities and their hinterlands. Networked megaregions are made possible socio-metabolic networks between centres and peripheries (Alberti, 2016; Hornborg, 2016). An empire can be defined as an expansive entity that seeks to extend its spatial territory by engulfing other (in)formal societies, to control those societies' resources (Hornborg, 2016). Cities and their associated metabolism speed up the process of space-time compression (Alberti, 2016) and political ecology has to understand urbanisation as contingent on modern technology; a social strategy for shifting social and environmental burdens elsewhere (Hornborg, 2016). The city relies on asymmetric exchanges with other parts of the world system; the accumulation of technomass at the core is not only because of ingenuity, but because of different market prices for labour and resources in different parts of the world system (Hornborg, 2016; Inostroza & Zepp, 2021). World systems analysis shows how local conditions are dependent on wider, less visible fields of interaction, and can be applied to the urban by looking at cities as the core (zone of accumulation) that unequally exchanges manufactured products for raw materials from its hinterlands, or the periphery (zone of degradation) (Arboleda, 2016; Hornborg, 2016; Inostroza & Zepp, 2021).

The logic of unequal exchange is such that production = destruction; in the process of producing economic value through the urbanisation of nature (Swyngedouw, 2006), the productive potential of that transformed nature is progressively reduced (Hornborg, 2016). In other words, unequal exchange is the outcome of interactions between material and monetary flows, where the output of economic processes results in both greater utility and entropy than was originally put in (Hornborg, 2016). In urban systems, the accumulation of technomass at the core is facilitated by metabolic urban networks (Hornborg, 2016; Inostroza & Zepp, 2021) that degrade socio-ecological conditions in hinterlands (Arboleda, 2016), a process mediated by flows of money (Hornborg, 2016; Inostroza & Zepp, 2021). The use of 'general purpose money' allows for anything to be expressed as interchangeable and conceals the asymmetries between flows of matter and money as they move from and to different parts of the world system (Hornborg, 2016). Increased dissipation of productive potential in the production of modern cities equates to greater monetary value generation, in turn allowing for that monetary value to make claims on more resources to dissipate in the urbanisation process (Hornborg, 2016).

Local Sustainability Governance

To study urban systems we have to integrate multiple boundaries and analyse processes at multiple scales (Alberti, 1996). We need to explicitly consider human agency and link urban structure and human behaviour to ecosystem functions (Alberti, 2016). If ecosystems can exist in more than one stable state, each state delivering a different set of functions, then deciding which set to preserve becomes a matter of social preferences (Vatn, 2015). There may be trade-offs between processes that support desired human functions (Alberti, 2016). Biophysical systems create emergent configurations in response to change and in social systems there are partly emergent configurations of agent interactions, but also shaping and planning of structural transformations; "what makes cities unique ecosystems is human agency" (Alberti, 2016 p. 23).

The local scale is emerging as a key level in taking action towards global sustainability (Brugmann, 1996; Evans et al., 2006; Næss, 2001). A distinction should be made between local governance and local government, where the latter is comprised of political institutions operating at the local scale, while the former includes deliberation, negotiation, and partnerships with civil and economic sectors (Evans et al., 2006; Vatn, 2015). Changing trajectories to move into a safe and just operating space might imply changing governance structures (Vatn, 2015). Governance structures are made up of actors (political, economic, civil) and institutions that facilitate interactions between actors (Vatn, 2015). Governance structures affect actions and outcomes because they influence the distribution of rights and responsibilities, the level of transaction costs (cost of building and maintaining institutions),

perceptions, and preferences (Vatn, 2015). Perceptions of the state of the environment can be influenced by visual communication (Benjaminsen, 2021a). Visuals are a powerful tool for influencing environmental discourses because of denotation (literal meaning), connotation (cultural values), and myth (ideological ideas) that can be communicated in an image, but visual communication is an understudied subject in environmental discourse (Benjaminsen, 2021a).

It is important to distinguish between spontaneous and designed change, which happen bottom-up and top-down respectively while recognising that formal institutions, like governments, will always be partly designed (Vatn, 2015). Changing institutions to improve environmental outcomes is demanding because of path dependence. The initial conceptualisation of path dependency is centred around three aspects; 1) what is perceived as a small event has considerable effects, 2) these effects lead to the 'lock-in' of development paths, and 3) locked-in paths are in a stable state until exposed to shock or disruption (Evenhuis, 2017). The path dependency approach has been criticised as it does not say much more than that the history of an institution matters, it can only explain stability as opposed to change, and because the normative dimension of the approach is often unaddressed (Kay, 2005). Subsequent evolution of the concept has addressed these critiques by analysing institutional path dependence as a dynamic process, focusing on how self-reinforcing feedback mechanisms create either conditions of lock-in or dynamic changes (Evenhuis, 2017). Changes in institutions are mediated by actor-structure interactions; actors influence the structures in which they operate, while structures also influence the operations of actors (Evenhuis, 2017; Vatn, 2015). Changes are conditioned by already existing institutions through a dynamic and ongoing process referred to as 'path plasticity', the role of agent-structure interactions in bringing about changes (Evenhuis, 2017). The urgency of environmental issues might drive actors to bring about incremental changes to the structures in which they operate by utilising path plasticity effects (Evenhuis, 2017; Vatn, 2015).

Urban planning and design have been strongly influenced by modernist approaches including rational and mechanic perspectives on the operation of urban systems (Heymans et al., 2019; Marshall, 2012) and sustainable development implies urban planning practices cannot continue under a business-as-usual scenario (Næss, 2001). The advancing of critical urban studies necessitates a new urban planning and design paradigm that can achieve more harmonious socio-ecological relationships by understanding cities as complex hybrid systems (Alberti, 2016; Heymans et al., 2019). Complex urban systems necessitate new planning structures that facilitate the management under the inherent uncertainty of the system, rather than management assuming predictability of the future (Batty & Marshall, 2012; Portugali, 2012).

In terms of spatial planning, minimising energy and resource use, limiting urban encroachment, halting the use of environmentally harmful construction materials, transitioning to circular economies, and planning for the health and well-being of urban dwellers are considered important in terms of sustainable development trajectories for cities in affluent countries (Næss, 2001). Traditional environmental planning can be adapted to facilitate planning approaches for urban sustainability by employing participatory approaches to involve communities in development, articulating current ideas on development and related systematic problems and requirements, measuring the global impacts of local activities, and ensuring local strategic control (Brugmann, 1996).

Two urban development models that claim to be sustainable are compact city development (focused on densification) and green city development (focused on creating green spaces within the city), and the former appears better suited to address the sustainability of spatial planning (Næss, 2001). The existing building stock in affluent countries challenges sustainable urban development because it calls into question the ability of circular economies to be sustainable if they serve to keep increasing the building stock (Inostroza, 2014; Næss, 2001). Sustainability policies focused on minimising impacts within the city boundary can produce severe negative impacts on the extended urban fabric, highlighting the urgent need to conceptualise cross-scale urbanisation impacts (Elliot, Torres-Matallana, et al., 2022). Urban sustainability strategies should not only focus on local ecological restoration but also on changes in consumption and distant ecological restoration (Elliot, Goldstein, et al., 2022), and need to pay special attention to rebound effects in consumption and 'leakage' or trade-offs between environmental goals (Ottelin et al., 2019, 2020). Local planning practice should ensure that socio-ecological impacts that manifest themselves at other scales ought to be accounted for (Næss, 2001).

In planning for sustainable urban development, neither market forces nor incremental government planning seems sufficient to address the concerns of sustainable development, but incremental approaches offer an opportunity for institutional learning (Næss, 2001). The successful adaptation of sustainability initiatives at the local scale is influenced by different variables, such as political culture, institutional structure, interactions between different scales of government, and the prosperity of the local economy (Saha, 2009). Goal-oriented planning processes are important, however, setting goals to maximise utility in planning can also lead to the marginalisation of the interests of minority groups (Næss, 2001). In response to this, a recent focus on participatory planning processes is emerging, however, this does not ensure more sustainable outcomes (Næss, 2001).

Urban planners can promote sustainable development by employing scenario-planning approaches to evaluate the impacts of different development trajectories and use their professional experience to devise plans that are most in line with meeting The SDGs (Næss, 2001). Sustainable urban development requires integration between assessment, planning, development and management processes so that they are strategically aligned (Yigitcanlar & Teriman, 2015). To avoid political retaliation against individual planners, impact assessments and monitoring of strategic urban plans should be in the legislation (Næss, 2001). The use of urban metabolism has the potential to improve the accountability of strategic planning (Zengerling, 2019).

A review of sustainability principles of modern cities concludes that the required interventions are extensive and that the governance of future cities ought to consider circular economy models, as well as building principles that allow for the built environment to mimic natural cycles (i.e., carbon and water) (Sodiq et al., 2019). However, local governments face capacity issues when engaging with sustainability initiatives because there is a trade-off between allocating capacity to sustainability versus ongoing processes (Bridges, 2016). Changing local institutions means redirecting path dependencies to enhance institutional capacity by experimentally and iteratively learning to deal with complex sustainability challenges (Bridges, 2016).

Method of Exploration

Philosophical Worldview

This study is underpinned by a critical realist worldview. Critical realism is a comprehensive philosophy of science that ontologically arranges reality into three layers; the empirical, the actual, and the real (Fletcher, 2017) and is considered relevant in the context of the urban (Næss, 2015). The empirical layer of reality consists of those phenomena that can be observed and measured by humans, the actual are those phenomena that occur regardless of human observation, and the real are the causal mechanisms that cause certain phenomena to take place (Fletcher, 2017; Næss, 2015). Making an ontological distinction between these layers of reality is relevant for the subsequent analysis because critical realism makes use of retroductive reasoning to identify tendencies under which certain causal mechanisms occur (Fletcher, 2017). Critical realism does not aim to prove causation, rather it aims to identify 'demi-regularities', trends and patterns identified through qualitative coding, which are then explained through a process of retroductive reasoning, using theory to understand how causal mechanisms produce the observed empirical results (Fletcher, 2017). The critical realist view is useful because it allows for the integration of multiple disciplines in the exploration of the safe and just operating space of urban systems, investigating causal powers of agents and structures and their influence on urban processes, and making generalisations about the relevance of the doughnut for sustainability in the context of planetary urbanisation (Næss, 2015).

Methodological Approach

To address the aim of exploring the relevance of doughnut economics for sustainable urban planning and decision-making in the context of planetary urbanisation, this study uses an exploratory qualitative approach. A qualitative research approach was the most appropriate considering the relative novelty of applying doughnut economics in urban settings. Therefore, a qualitative approach is useful to address emergent questions (Creswell & Creswell, 2018) related to doughnut economics in the context of planetary urbanisation. Specifically, this study relies on content analysis of relevant literature and exploratory case study research of cities applying the doughnut to describe recent advances in downscaling the doughnut and explore its relevance for sustainable urban planning and decision-making. An exploratory qualitative case study approach indicates information was gathered on several cases to illustrate how they may differ or converge in terms of their respective experiences with doughnut economics, the findings of which are used to reflect on local doughnut applications in the context of planetary urbanisation.

Data Collection

I used different combinations of the search terms 'urban/local/city' and 'doughnut economic/safe and just operating space' to gather studies about local doughnut applications. Google Scholar was used because it would ensure the broadest inclusion of literature, rather than only indexed studies. The content analysis is by no means exhaustive and should be considered an exploration. After the initial search, only documents that related specifically to doughnut economics in urban settings or to methods for downscaling the doughnut to the urban scale were selected. These were consequently read and summarised using the template in Appendix A.

Data collection for the case study primarily relied on semi-structured interviews with planners and policy-makers from cities working with the doughnut and complemented with web pages and policy documents (Table 1). Via the DEAL web page on cities and regions, a sample of cities was selected. A total of 7 interviews were conducted with planners and decision-makers from the following cities:

City	Country
Amsterdam	The Netherlands
Bad Nauheim	Germany
Barcelona	Spain
Cornwall	United Kingdom
Dunedin	New Zealand
Nanaimo	Canada
Tomelilla	Sweden

Table 1. Cases investigated in this study

Initially, only cities that had taken steps to operationalise the doughnut were approached, however, due to few responses, the final sample included all cities featured on the DEAL web page. Cornwall is included despite not being a city because of limited responses and because their approach to the doughnut adds an interesting complementary perspective. These cities were approached via e-mail/contact form, depending on what was available, with the request to interview planners and decision-makers who had been involved in the process of applying the doughnut. Purposive targeting of interviewees is appropriate considering the research design, as the overall population is small, hence it is relevant to address interviewees as directly as possible. Interviewees were sent an information letter with additional information about the aims of the study and received the interview questions in advance if they explicitly requested that. The interview protocol that guided the semi-structured interviews can be found in Appendix C. The interviews were conducted between November 2022 and December 2023, they lasted around an hour and were recorded using MS Teams ©. After the interviews were

conducted, information on the case was complemented with information from planning/strategic documents and/or government web pages if the information was available in English. This data was collected both through web searches as well as via interviewees who sent additional documents after the interview.

Data Analysis

The selection of documents for the literature review yielded a list of 25 documents specifically concerned with applying the doughnut to the local scale. These documents were synthesised based on the table in Appendix A. These studies were categorised and described in how they relate to our understanding of the urban safe and just operating space, resulting in the themes of urban planning and design, institutional use, and assessment.

The case descriptions were created based on a case codebook found in Appendix B. The case codebook is by no means exhaustive, but aims to elucidate the different and converging processes of integrating doughnut economics in local decision-making settings of the studied cases. To this end, the codebook seeks to identify what motivated the city to work with the doughnut, the context in which the doughnut is applied, how the application of the doughnut was initiated, what approach the city is taking, and what challenges they face. The case descriptions were created based on information provided by the interviewees, complemented with information that is available online (web pages, administrative documents, plans etc.). The extent to which each case could be complemented with additional data sources other than interviews was highly dependent on the extent to which the city had applied the doughnut.

Interview transcripts were analysed using a flexible deductive coding approach (Fletcher, 2017). First, transcripts were printed and subject to exploration for initial conceptual codes. The transcripts were further analysed with MAXQDA © using both the initial list of conceptual codes, as well as important themes from the interview questions that would inform the case descriptions. The list of conceptual codes was further refined through three rounds of coding and the coded segments for each code and each transcript were summarised to contrast trends and patterns between cases. This was done to identify 'demi-regularities' (Fletcher, 2017) or similarities and differences between local governments working with the doughnut. Lessons learned between the different cases included in this study were divided according to the themes of 'holistic thinking about sustainability', 'governance structures', 'influence, capacity, and funding', 'champions and political uncertainty', 'application', 'assessment and data', 'scale', and 'the matter of growth'. These are illustrated using quotes from the interviews, however, to protect the identity of interviewees, I have opted to introduce the quotes as anonymous statements rather than as statements associated with specific cases.

Quality Assurance

The quality of the literature review and case descriptions was ensured by using a format that allowed for the extraction of diverse information as coherently as possible. This was done iteratively by exploring the available information on both literature and cases and adapting the summary table and codebook as new insights emerged. Interviews were conducted by mostly adhering to the semi-structured interview guide, diverging on topics that were of interest to that specific case. For example, if a case had focused on participation rather than assessment in applying the doughnut, more questions were asked about that. After the first two interviews, the topic of growth was brought up without being included in the interview guide, and was therefore added. Also, a question about the interviewees' experience in urban planning and design, in general, was taken out as I concluded this did not result in highly relevant information and interrupted the flow of the interview. Only these questions were added and removed after conducting the first two interviews, otherwise, the guide remained the same. Interviews were transcribed and coded multiple times to ensure the most appropriate bottom-up approach was selected for the final presentation of results. One interview failed to record and could not be transcribed; the findings from this interview were based on notes taken while it was conducted and elaborated after the interview ended. I ensured all relevant alternative information on this specific case was accurately reflected and only include consideration of the most important finding of this interview in the overall results.

Strengths and Weaknesses

These findings need to be considered in light of the following strengths and weaknesses of this study.

The weaknesses of this study are that it only interviewed one government official per city, meaning it does not include alternative perspectives from within the government or the governance system of that place. Because only one person per case was interviewed, possible opposition to the doughnut was not explicitly investigated in this study. The study has only investigated cases that work with the DEAL approach to downscaling and all cases follow a top-down approach to applying the doughnut, providing no insight into how alternative, bottom-up doughnut applications take place.

The strengths of this study are that it is the first to compare the local use of the doughnut between cases, elucidating lessons learned from multiple experiences rather than an in-depth single case study. In this study, the practical use of the doughnut in local institutions is contrasted with theories on critical urban studies and local sustainability governance, to further explore its ability to address urban sustainability and the institutional constraints of dealing with sustainability at this scale. Contrasting theory and practice is a strength in sustainability

science, as the urgency to address socio-ecological crises necessitates greater integration between information that accurately assesses the sustainability of systems across scales and information that is practically useful to meaningfully change the sustainability of those systems.

Reflexivity

I started this study with a sceptical outlook on urban doughnut applications. Due to previous knowledge of urban metabolism, defining a safe and just urban operating space raised questions about the accuracy of such assessments and relevance for sustainable urban planning and decision-making. Conducting this study has changed my outlook on urban doughnut applications. I am still sceptical about the accuracy of the assessment of the doughnut given the complex nature of urban systems, but through the interviews, I learned about the value of the doughnut in facilitating enhanced local communication. Moreover, the model is used by actors that, despite operating under severe constraints, are making significant efforts to improve the sustainability of local systems. These actors are aware of the complex, cross-scale nature of socio-ecological impacts, but are also limited in their capacity to address this in their role as local administrators. Interviewing these actors was a humbling experience because it revealed the practical difficulties of locally acting for global sustainability, as well as the creativity employed by practitioners to address this challenge.

I found it challenging to present the interrelated challenges that local governments face when applying the doughnut in my results section. I addressed this by switching back and forth between writing up results and organising an initially long list of bottom-up codes into coherent themes, allowing for a more thorough exploration of patterns and trends and their interrelations in the data. In light of this challenge, as well as due to some explicit requests, I provided interviewees with the option to comment on the results before completion.

In this study, I have opted to synthesise a range of literature to come to a better understanding of emergent practical phenomena and I experienced a trade-off between synthesising diverse perspectives versus the ability to discuss these in more detail. Connecting theory and practice was a challenge, however, reflecting on the science-policy interface of urban sustainability was considered an important aspect of this study that strengthened its relevance for theory and practice.

Ethical Considerations

This study was approved by the SIKT and data collection and analysis were performed following their standards. SIKT is the Norwegian agency for shared services in education and research, a public institution that seeks to facilitate infrastructure for data management, sharing of data, and data protection services (SIKT, n.d.). The interviewees were provided with information about the project before consenting to participate and given the opportunity

to comment on the results before completion. No personal data of interviewees was used and their identities are only known by the individuals involved in this study. In line with general research ethics, I adhere to the principles of respect, good consequences, fairness, and integrity. I consider the principles of respect and good consequence to be of special importance; the efforts made by respondents to partake in the study ought to be met with respect for their contributions and the aim to create good consequences for respondents through my study (The National research ethics committees, 2019)

Downscaling the Doughnut

I start by describing recent advances related to downscaling the doughnut to the local scale. I do so by reflecting on academic literature published on the topic and practical examples of the doughnut being applied locally.

Literature Review

In the following section, I briefly synthesise the results from reviewing the literature on local doughnut economics. This review should not be considered exhaustive, rather, it serves to illustrate how academia is engaging with the local safe and just operating space. The reviewed papers were divided into the themes of urban planning and design, institutional use, and assessment.

Urban Planning and Design

Four of the articles included in the review deal with how the doughnut can be used in specific urban planning and design practices. Two of these articles relate to using the doughnut for identifying synergies and trade-offs in the built environment (Benites & Osmond, 2021; Hassan, 2022). One uses the doughnut as a means of comparing inequality in transportation (Moghaddam et al., 2022), and the other uses it to explore the sustainable use of the urban underground space (Paraskevopoulou et al., 2019). Bioconnections are proposed as a framework to link the urban built environment to the different dimensions of the doughnut by looking at ways to enhance regenerative circularity in urban planning and design choices (Benites & Osmond, 2021). A thesis developing and testing a framework for assessing trade-offs and synergies between dimensions of the doughnut in urban development projects uses a case study and concludes that the doughnut is a suitable heuristic for urban planning, but requires additional steps to be used as a concrete planning tool (Hassan, 2022). The doughnut is used as a lens to study future inequality related to different types of transportation and make recommendations on what modes of transportation are most effective to stay within a safe and just operating space (Moghaddam et al., 2022). Another study uses the doughnut as a lens to look at the social, economic, and environmental sustainability of the urban underground space and concludes that this allows for greater consideration of different dimensions of sustainability when designing and planning for the use of underground spaces (Paraskevopoulou et al., 2019).

Institutional Use

Eight articles discuss the use of doughnut economics in local institutions. These articles cover a range of topics related to how the doughnut is or could be used in local institutions, including the role of participation and partnerships, critical examinations of the doughnut's transformative potential, and cases where the doughnut has been applied.

One article examining the role of community-led initiatives in achieving regenerative urban transitions concludes that bottom-up community initiatives have the potential to bring about transformative change regarding the doughnut economy (Crowley et al., 2021). However, this requires community-led initiatives to have the power to change existing structures, which is currently lacking and therefore, these initiatives operate at the margins of urban transitions (Crowley et al., 2021). Another paper established the role of public-private partnerships as crucial in sustainable urban development by looking at how these partnerships relate to different doughnut dimensions and what role they play in housing development (Fell & Mattsson, 2021). The doughnut is used in a photovoice study where participants living in slums document perceived health risks related to the ecological ceiling and social foundation, highlighting the importance of participation and citizen engagement (Ssemugabo et al., 2021).

One study investigates the progress towards safe and just operating spaces at the village level by employing a three-dimensional justice, rather than a basic needs perspective (Pasgaard & Dawson, 2019). The authors conclude that what is considered safe and just is highly context-dependent and that universal basic needs may poorly reflect local concerns of injustice (Pasgaard & Dawson, 2019). There are trade-offs between the ecological ceiling and social foundation that should not be ignored. The aggregated use of indicators in simplified graphics for science-policy communication is a means of discursive power that condenses complex issues and the authors argue for an approach that allows for complexity to unfold instead (Pasgaard & Dawson, 2019). One paper investigates the transformative potential of resilience thinking by illustrating how it disrupts neoclassical economic rationalities and promotes alternative economic rationalities, such as the doughnut (Olsson, 2020). It looks at narratives of practice in municipal resilience thinking and identifies four tension points; 1) 'growth disruptive resilience thinking vs the neoliberal growth discourse', 2) 'regenerative by design vs neoliberal environmental rationalities', 3) 'distributive by design vs neoclassical distributive rationalities', and 4) 'socially adaptable vs self-interested drivers of resilient behaviour'. The author concludes that these tension points, despite having disruptive potential, are not likely to challenge the core of neoclassical economic rationalities, especially in more affluent countries (Olsson, 2020).

Other studies look at specific cases where the doughnut has been applied. One paper investigates how the doughnut engages with growth and urbanisation, as well as perceptions of the model in the municipality of Tomelilla, Sweden (Eriksson, 2022). This paper concludes that the doughnut offers a useful visualisation that promotes holistic thinking about sustainability, the importance of circularity, and the use of green technologies but that there's no perceived contradiction between economic growth and urban development while staying within the doughnut; in this way, the doughnut does not address the underlying rationale of

neoclassical economics (Eriksson, 2022). Another study engages with the use of the doughnut in Amsterdam using an actor coalition framework to reveal how coalitions of actors are working with the doughnut, revealing the strengths of collaborative governance when coalitions can align beliefs, enhance learning, and bring forward policy changes (Moretti, 2022). The authors of one paper draw on their experience with downscaling the doughnut in Cornwall and relate it to the wider literature on local sustainability governance (Turner & Wills, 2022). They identify three challenges related to the use of doughnut economics in local governance: 1) Representing, understanding and responding to complex systems, 2) goal coherence across scales, and 3) navigating power dynamics, inequalities and trade-offs. There are significant barriers to assessing the doughnut at the local scale, requiring consideration for data availability, appropriate downscaling methodologies, normative choices, historical responsibility, and the context-specific nature of human needs (Turner & Wills, 2022). The authors conclude that adaptive and reflexive governance is required to break institutional path dependencies and that participation can ensure the continuity of the approach. The doughnut stimulates debates, but local institutions do not have the capacity to engage with complex cross-scale system science, hence transdisciplinary research efforts may be the way forward (Turner & Wills, 2022).

Assessment

Thirteen of the reviewed papers relate to assessing the doughnut at the local scale. These papers assess the doughnut in a variety of ways; by seeking to establish absolute sustainability targets for cities, by developing multi-scale approaches to the safe and just operating space, assessing specific doughnut dimensions, or assessing differences in overshoot and shortfall of the doughnut along the urban-rural gradient.

Several papers seek to assess the absolute sustainability of urban systems. One paper proposes a life-cycle-based method for the absolute environmental sustainability assessment of anthropogenic systems, concluding that the results are influenced by the choice of indicators, sharing principles, and spatial resolution (Bjorn et al., 2020). Another study investigating the absolute sustainability of urban systems looks at how absolute sustainability indicators and consumption-based accounting are used in urban sustainability assessment. The paper concludes that urban sustainability assessments could benefit from being benchmarked against planetary boundaries to say something about absolute sustainability because it provides insights into rebound effects and leakage (Goodwin et al., 2021). One study assessing different allocation principles for downscaling the planetary boundaries to different sectors develops a framework for downscaling planetary boundaries to individual stakeholders so they can be upscaled to the desired level of organisation. Different allocation and upscaling methods lead to different outcomes and require uncertainty and sensitivity

analysis before they are applied to real systems. The authors conclude that the proposed method is a transparent and robust way to assess sustainability ratios that can inform prioritisation in policy-making (Hjalsted et al., 2021). One paper calls into question the relevance of planetary boundaries for absolute sustainability assessment across scales and argues the techno-ecological synergy framework is more applicable (Xue & Bakshi, 2022). This is because planetary boundary-based absolute environmental sustainability assessment divides ecosystem functions to everyone equally, regardless of place, while the techno-ecological synergy approach is based on mismatches between ecosystem service supply and demand, which is more locally relevant (Xue & Bakshi, 2022).

A study investigating multiscale orientation values (planetary boundary targets across scales) for some of the planetary boundaries uses a bottom-up assessment method to identify the environmental impacts of local governments, providing information on the scale of household consumption. Translating the planetary boundaries to sub-global scales requires that the control variables for the boundaries are converted into global budgets (annual or over time) and global budgets are allocated using an appropriate sharing approach. Different allocation approaches have different effects on the assigned budgets, making it difficult to define orientation values across scales (Froemelt et al., 2021). A paper specifically focusing on the freshwater planetary boundary develops the water exceedance and consumption footprint to respectively measure overconsumption and surplus (Li et al., 2020). The authors show how interregional water trade can be used to meet shortages in one place with the surpluses of another, though these calculations should consider future climate changes (Li et al., 2020). In a paper seeking to contribute to the smarter ecological management of urban systems, the authors propose an alternative ecological boundary based on the gap between the ecological carrying capacity and total ecosystem services extracted from that ecosystem, applied in Beijing (Wang et al., 2022). The authors conclude the ecological boundary can serve as an early warning system for decision-makers as prolonged periods of overconsumption of ecosystem services reduce overall resilience (Wang et al., 2022). In a study synthesising current approaches to assessing urban sustainability, the authors conclude that footprint indicators and consumption-based accounting methods are useful in assessing the local-global integration of urban sustainability because it considers the embodied impacts of traded goods and services (Wiedmann & Allen, 2021). One paper proposes to assess the safe and just operating space of the mobility sector using a sustainable consumption corridor and composes a set of indicators for this purpose. These authors conclude that downscaling planetary boundaries to the urban infrastructure scale is morally and mathematically challenging and were not able to select thresholds for the selected indicators (Dillman et al., 2021).

One paper uses a modified doughnut to assess the concept of sustainability at the urban and regional scale by investigating how impacts on the doughnut dimensions differ along the urban-rural gradient, concluding that this provides the potential to reduce a region's impact on the doughnut through enhanced regional sustainability planning (Chapman et al., 2021). The relevance of computer science, specifically artificial intelligence, is investigated in assessing the safe and just operating space at a municipal level and found to provide relevant decision-support for urban planning, though it also highlights the relevance of good data availability (Dahl & Moreno-Navarro, 2022).

In investigating the local operationalisation of the safe operating space, it was found that there are no consistent ways for downscaling planetary boundaries and that despite challenges in addressing how planetary boundaries interact, this is crucial (Ferretto et al., 2022). The paper proposes a method for setting boundaries at the ecosystem level and relating these to the relevant administrative scale so that the information can inform decisions while the global relevance of the planetary boundary framework is maintained (Ferretto et al., 2022).

Case studies

In this section I describe how the doughnut is locally applied in practice, building on the experiences shared by interviewees and possibly additional documents and web pages. I describe how the doughnut is applied in Amsterdam, Bad Nauheim, Barcelona, Cornwall, Dunedin, Nanaimo, and Tomelilla looking at what motivated the place, in what context the doughnut was applied, how the use of the doughnut was initiated, how the doughnut is applied, and what challenges the place encountered.

Amsterdam

The city was motivated to work with the doughnut because as an evaluation framework, it is said to provide a 'holistic snapshot' of the city (Thriving Cities Initiative, 2020b). The Amsterdam city doughnut was developed in collaboration with the Thriving Cities Initiative and applied through collaboration with a wide range of city staff. The city developed a version of the city portrait that reflects Amsterdam's targets (if available) and a current snapshot of where they stand in the local-social, local-ecological, global-social, and global-ecological lenses. Amsterdam considers the city portrait relevant for policy development as it can assist in highlighting trade-offs and synergies between alternative policies at the outset. Amsterdam is applying the doughnut as an evaluation framework for its circularity strategy (Amsterdam Circular, 2020). The circularity strategy and doughnut model have been adopted as official policies in Amsterdam.

The city of Amsterdam has the political ambition to be 100% circular by 2050 (Amsterdam Circular, 2020) and Amsterdam aims to achieve circularity in the value chains of the built environment, organic waste, and consumer goods. For each value chain, Amsterdam has outlined several ambitions. Regarding organic waste, Amsterdam aims to shorten value chains and stimulate local food production, create more healthy and sustainable diets by focussing on plant-based protein and reducing waste, and improve the processing of organic waste by focussing on waste separation and specialised collection of organic waste to work on closing nutrient cycles (strategy public version). In terms of consumer goods, the city aims to reduce consumption by focussing on access to use and stimulating circular product development, by promoting sustainable use of products by improving their quality and access to repair services, and by focussing on giving a new life to discarded products by collaborating with the business sector to make value from waste (strategy public version). The built environment is to become circular by focussing on collaboration in urban development using new guidelines to reduce the impacts of materials used in construction, by the city upholding circular guidelines for its own development and procurement, and by making the existing urban fabric more circular when committing to renovations. As part of this circular strategy, Amsterdam has developed a circularity monitor; a dashboard for mapping resource flows that

move through the city. The 'snapshot' provided by the doughnut, showing impacts both within and outside of the city, was used as a basis for the circularity monitor, using an input-output analysis (City of Amsterdam, 2020). The circularity monitor is set up to provide an overview of the socio-ecological impacts associated with the life cycles of products and services flowing through Amsterdam, providing decision-support about priorities in moving towards a circular economy.

The doughnut is considered highly relevant for stimulating cross-departmental working within the municipality, as well as for communicating with external stakeholders. Currently, doughnut thinking and the circularity strategy are being applied through multiple projects/processes in different departments and in collaboration with different partners.

Amsterdam sees its role as setting the right example regarding circularity through its own practices, as well as creating legislation and stimulating innovation, and collaborating with key stakeholders in the identified value chains. The city considers itself a partner in the upcoming transitions and states that being open to new kinds of collaboration is crucial. The city is supported by European and national circularity ambitions. The city has both a top-down and bottom-up approach to becoming circular; the municipality outlines where to go and how to get there, while there's also room to scale up bottom-up initiatives.

The application of the doughnut is also supported by the Amsterdam Doughnut Coalition, a network of more than 40 organisations that aims to bring doughnut thinking into practice (Amsterdam Doughnut Coalition, n.d.). The doughnut is also being applied in a bottom-up way through "Doughnut Deals"; local initiatives that combine one ecological aspect with multiple social goals to implement community-based sustainability interventions in collaboration with other partners from the neighbourhood (Amsterdam Doughnut Coalition, 2020).

The private sector is involved in Amsterdam's circularity strategy, especially in the mapping of specific resource and energy flows for the circularity monitor. Ultimately, different sectors, e.g., the textile industry, need to map out their value chains and where they can have an impact on these. Generally, Amsterdam tries to collaborate with other parties such as consultants or other scales of government who can support the transition towards a circular economy.

The city considers that working with the doughnut requires a paradigm shift where the city sees itself as a partner, rather than a manager of the circular transition. It requires urban administrators to find new ways of approaching both cross-departmental collaborations as well as with external partners. Though the doughnut stimulates cross-departmental collaboration, departments may still pursue projects and programmes that conflict with the doughnut. Applying the doughnut highlights existing trade-offs, such as how to address extreme housing

demand in an environmentally sound and socially just way, but does not guide how to manage these trade-offs.

The assessment of the doughnut as the circularity monitor is considered challenging. It requires intensive collaboration between the public and private sectors to provide data for the circularity monitor, while the quantification of resource flows and associated socio-ecological impacts remains challenging. It is considered especially difficult to assess the social dimension of the doughnut and the city is experiencing issues with data availability that limit the accuracy of the assessment.

Bad Nauheim

The city of Bad Nauheim was motivated by the holistic understanding of sustainability the doughnut offered, providing a shared conceptual understanding of what sustainability means. The doughnut is being adopted in the context of developing a wider sustainability strategy for the city and is helping in formulating visions of what a sustainable future might look like. The use of the doughnut was initiated by an advisor on sustainability and consequently adopted by the city council. In the case of Bad Nauheim, this advisor was a champion for the use of doughnut economics.

A group of citizens from Bad Nauheim was already advocating to become part of the German "engaged cities" network, which maps civil society actors and initiatives according to the SDGs, and recently achieved this in collaboration with the city. Now this collaboration is also used in applying the doughnut, as the doughnut builds on the SDGs it's an easy match.

The city has been applying the doughnut by working on different projects in parallel. Firstly, they aim to develop a sustainability management tool for the city administration and daughter companies (service providers). This tool ought to help the different city departments and service providers to understand the cross-impacts of their decisions on different dimensions of the doughnut. In this process, the doughnut was adapted to the local context in a co-creative process of senior management of the city and the daughter companies; selecting ecological boundaries for the Bad Nauheim context and adapting the terminology of the social foundation.

The city is also applying the doughnut by incorporating it in a wider sustainability strategy, for which they have held an extensive participation process to get citizens' input on the prioritisation of the doughnut. Bad Nauheim operationalised its participation process by inviting 100 randomly selected citizens to draft 21 initial doughnut measures. These 21 measures were taken out into a wider participation process with an online tool to gather feedback from citizens and interest groups from Bad Nauheim. Currently, the city is analysing the feedback they have gathered with the online tool which will be used to further polish the initial measures,

to finally be presented to the city parliament. These final measures will be part of the sustainability strategy, but the overall strategy will go beyond those measures.

The city is in the process of assessing the doughnut quantitatively and follows Amsterdam's methodology in doing so. The doughnut assessment is also something the city aims to incorporate into its sustainability strategy. The city is adapting the doughnut to make it more coherent with the local context and to ensure they only include things they have an influence over.

Bad Nauheim is exploring how to provide continuation to this participation process by looking at possibilities to provide a platform for continuous exchange among interest groups. The extensive participation process in Bad Nauheim is also oriented towards the fact that achieving the transition of the city into the doughnut cannot be done by the city alone and requires the collaboration between multiple public, private and civil actors. The 'engaged cities' network can be involved in implementing the doughnut by creating partnerships among actors that can help to work on the measures established in the participation process.

The doughnut assessment is considered a challenging exercise; using one indicator for a given dimension means you need to select one that will properly reflect this dimension, however, it also needs to be feasible to measure and monitor a given indicator over time. Working with a larger set of indicators than just GDP to assess progress allows for a broader consideration, but it also makes the implementation of projects more complex. One of the challenges is defining what boundary of complexity can be justified when using the doughnut while also keeping it useful in everyday planning and decision-making.

Barcelona

The doughnut provides Barcelona with a shared definition of sustainability that is operational across departments, helping in achieving greater institutional synergies in working towards set objectives. The doughnut was adopted on the political level after declaring a climate change emergency in January 2020 (City of Barcelona, n.d.-b) and is being operationalised by the climate change and sustainability office. By announcing a climate emergency declaration, Barcelona has increased the urgency behind climate change adaptation and mitigation objectives and the doughnut is considered to be a response to this. The purpose for Barcelona to work with the doughnut is twofold; first, it serves the city's commitment to enhance ambitions to address the climate change emergency and they aimed to develop an economic strategy to reflect these ambitions. Secondly, it was useful as an inspiration for the "Citizens Commitment to Sustainability" (City of Barcelona, n.d.-a). The "Citizens Commitment to Sustainability" was first adopted in 2002 and serves as a guidance document for the cities' business and citizens' initiatives to work towards sustainability, being updated every ten years.

During the latest renewal period (2022) it was opted to use the doughnut in the renewal of the commitment as it offered a holistic framework for addressing local sustainability challenges.

The city has worked on developing a city portrait. This took a considerable amount of time because the resources provided by DEAL are place-based and hence, need to be adapted to the local context. The city did two workshops about the city portrait; one with experts to validate the selected indicators, and one on the 'four lenses' and how to operationalise these.

In parallel, the city worked with the network associated with the Citizen Commitment to Sustainability on using the doughnut for the renewal of the commitment, as well as on making a community portrait. In doing so, the city could compare the outcome of the community portrait with the city portrait.

Barcelona has also engaged in what they call a 'transition cycle', during which they organised three open conferences to spark the doughnut debate among its citizens. The three presentations were about the doughnut economy, the importance of planetary health, and a culture of limits. After these conferences, the speakers were invited for a discussion with the network of the citizens' commitment to sustainability to discuss how to downscale these topics to Barcelona's context.

The city has also discussed the outcomes of the city portrait with the network of the citizens' commitment to sustainability, to assess priority areas and how different business and citizen initiatives can get involved

The city aimed to use the doughnut in an updated economic strategy, but due to the start of an election phase, this process had to be halted. Looking towards the future, the city also foresees issues with including the traditional economic sector in the sustainability transition, as they have a vested interest in the current economic system and might not see how they will benefit from the doughnut.

Cornwall

Cornwall was motivated by the doughnut because it offered an opportunity to integrate its social and environmental sustainability assessment of decisions. This was in relation to their climate emergency declaration from 2019. Initially, they developed a climate change decision wheel, a decision-support tool, that asked decision-makers to consider the impacts of their plans on the environment. In efforts to further integrate both environmental and social sustainability impacts, Cornwall has established an updated version of the wheel that also considers the social dimension. Moreover, an assessment of the doughnut is part of the Cornwall Plan 2020-2050 (Cornwall and Isles of Scilly Leadership Board, 2020). The development of the initial climate change wheel happened after the political decision to declare

a climate change emergency and was established as a means to consider the climate impacts of the decisions made in the Cornwall council. The Carbon Neutral Cornwall Team was responsible for the initial climate change decision wheel. The updated wheel is managed by the team that is responsible for its adoption across the organisation.

The city has updated its initial climate change decision wheel in an agile way to make it a one-stop place for decision-makers to report on the impacts of their plans. With the help of a good in-house IT team, Cornwall has developed a decision-support tool, called the Cornwall Development and Decision Wheel, that can be used for ex-ante assessment of how projects/programmes/plans will impact multiple dimensions of sustainability. The decision-support tool includes both the socio-environmental wheel (the doughnut) and the equality and inclusion wheel. The socio-environmental wheel will show decision-makers the anticipated impacts of their plan on the different dimensions of the local doughnut, auto-generating impacts based on underlying models made for the local context. The equality and inclusion wheel considers the number of people impacted by decisions, how these impacts are different, and how they can be mitigated, though these impacts are not auto-generated. The aim is for the development and decision wheel to be used as an ex-ante impact assessment to inform decision-makers of potentially unexpected impacts before they occur.

In collaboration with the University of Exeter, the council has assessed their safe and just operating space based on a locally adapted version of the doughnut. The local doughnut is part of the Cornwall Plan 2020-2050, focussing on the future development of a "cleaner, greener" and "fairer, more inclusive" Cornwall. The council aimed to share their plans regarding the doughnut with local stakeholders such as business and civic groups from the start. The plan identifies key partners in achieving the outlined transition (Cornwall and Isles of Scilly Leadership Board, 2020). These include the local enterprise partnership, local nature partnership, the council itself, and the joint health and well-being board. The plan is annually reviewed to assess if the council is moving in the right direction regarding the targets it set itself and they are exploring opportunities to link the development and decision wheel to its annual doughnut review.

Aggregating the impacts of different decisions made in the council is considered challenging; different projects and programmes can have very different scales (financially, spatially etc.) raising questions about how to assess the overall impact. There is the additional challenge of trying to relate the total impacts of the councils' decisions to the overall Cornwall doughnut assessment and putting the impacts of local operations in a global context.

The wheel developed in Cornwall is meant to be used as ex-ante decision-support, but severe negative impacts of a decision do not mean they will definitively be stopped. Development is

considered necessary in the context of Cornwall and some current development trajectories are in strong conflict with environmental goals, such as the spaceport. The decision wheel will highlight these trade-offs and previous decisions have been paused to reassess how to mitigate negative impacts, but whether or not to proceed is ultimately a political decision. Finding appropriate offsetting techniques for development paths with high environmental impacts is considered challenging.

The wheel has been developed in an agile way, and though amendments are still being made, the team is happy with their current version. However, there is recognition that the wheel will require regular updates for it to remain relevant. Managing the wheel in an agile way requires collaboration and hence capacity and the team responsible for this is in the process of establishing how regular updates need to be for the wheel to remain relevant for decision-makers.

Dunedin

The Dunedin City Council was motivated to explore the doughnut because it offers a holistic definition of sustainability, including other frameworks such as the SDGs. The framework is considered appealing because you can adapt it to the local context, making it truly representative of your city. In particular, the city portrait also provides an opportunity to monitor and track changes over time. The doughnut was explored after the council committed to updating its strategic documents and explored different frameworks to renew the strategic commitment to sustainability. There were strong advocates for the doughnut within the city leadership, which likely motivated the choice to explore it. The political decision was made to explore the use of the city doughnut as a framework for renewing the strategic commitment to sustainability, but the strategy is yet to be officially adopted. The exploration of the doughnut has been done by the policy department, which has a strategic focus in the context of Dunedin.

The city has started exploring the city portrait as a means to renew its commitment to sustainability. Dunedin has not formally adopted the doughnut yet but has been in the process of exploring how it could be applied. In this process, there has been a lot of internal outreach to identify key departments that will impact the doughnut, aiming to create buy-in for the approach from the different departments that will have to adopt it. The city is collaborating with the Planetary Accounting Network to assess the ecological ceiling and what is still needed to improve its understanding of it. As a next step, the city is going into the community engagement phase to reach out to its citizens. They aim to organise several smaller workshops throughout the city, rather than one central conference, so that they can engage with diverse communities. The city is working on making a local adaptation of the doughnut for Dunedin, building on the resources provided by DEAL. Dunedin has engaged with other cities working with the doughnut. In their engagement phase, they consider the local

indigenous people, the two tertiary institutions, business groups, and place-based groups as key stakeholders to involve.

The city is experimenting with how to align the doughnut with other related requirements, such as the legislative requirement for local government to promote communities' social, economic, environmental, and cultural well-being (Department of Internal Affairs, 2002). This is a challenge because it might make the amount of information overwhelming when communicating about it.

The city is in an exploration phase but foresees some challenges in working with the doughnut. It is a visually appealing tool to communicate sustainability, but actually adopting it will require high levels of integration between departments and different scales of government. Moreover, there is no clear-cut way of how to adopt the doughnut and there's a range of considerations on how to best adopt it which might lead to both internal and external tensions.

Nanaimo

Nanaimo was motivated to adopt the doughnut because it offered a holistic approach to sustainability. The doughnut was considered appealing because it offered a chance to integrate several different plans. By applying the doughnut to the long-range plan the city aimed to include the social, environmental, economic and cultural aspects of sustainability in one big document. The use of the doughnut was initiated because it was an explicit request of the city council. There were strong champions for the doughnut in the city council and it was a political decision for it to be included in the development of the long-range plan. Nanaimo was already seeking to enhance the integration of goals across departments and the doughnut was a fitting way to support this aim in the update of their official community plan (City of Nanaimo, 2022). The application of the doughnut is managed by the department of community development, but the doughnut should ultimately be embedded across departments.

Nanaimo has integrated the doughnut into its official community plan (community plan). They started the process by exploring what areas of the doughnut they actually have an impact on, considering their mandate. This allowed Nanaimo to come up with a customised version of the doughnut which formed the basis for the goals in their community plan. Applying the doughnut in Nanaimo was done in collaboration between different departments within the government, as well as other stakeholders such as the business sector, civil groups, and representatives of the indigenous population. These groups have been involved in setting up the community plan. Collaboration between departments is perceived as essential in applying the doughnut in the context of Nanaimo. In the process of formulating the community plan, the city identified lead departments for different projects, but also what other departments ought

to be involved. integration between departments, in the form of close coordination and collaboration or urban planning projects, is perceived as crucial in achieving better outcomes.

Based on this plan the city is currently developing an action plan to further implementation, as well as a monitoring strategy in which they develop targets and indicators to measure and monitor progress. The process of selecting targets and indicators already started during the formulation of the community plan but was postponed when the city realised that the final version of the plan would require them to revise the selection. As part of this, the city did map out what measurements are currently in place and how relevant they are or if they need to be replaced/complemented. The same stakeholders that were involved in the community plan will be consulted again for the action plan and the revision of targets and indicators.

One challenge identified in Nanaimo is the level of institutional integration that the doughnut requires. This requires an organisational paradigm shift where collaboration and coordination become the norm, although it might increase the time taken to complete projects. Building the culture of working in integrated ways is considered challenging to build and maintain (the previous aim is for things to be efficient). The doughnut is considered to support the process of integrated working, but there is recognition that this can also be achieved with alternative frameworks.

Another challenge for the city is selecting targets and indicators for their monitoring tool, especially for the social dimension it is difficult to select indicators that accurately reflect the dimension. Selecting targets and indicators in the face of future uncertainty is a challenge. There is recognition of interactions between the planetary boundaries of the ecological ceiling and questions about how to select targets e.g. freshwater withdrawal in the face of climate change

Tomelilla
Tomelilla was motivated to work with the doughnut because it offered a more holistic definition of sustainability, also including the social dimension. The doughnut is applied as an evaluation framework for the quality of life programme (Municipality of Tomelilla, n.d.), which governs how the municipality deals with the goals of Agenda 2030. The doughnut has been adopted on the administrative level to provide different departments with a shared definition of sustainability when working on the quality of life programme. The application of the doughnut is managed by the department of growth and development.

Tomelilla started the process by assessing how the doughnut could be best of use to them in collaboration with a research institute. The key potential of the doughnut identified for Tomelilla was communicating the meaning of sustainability, both internally and externally. Since, they have been taking an experimental approach to applying the doughnut, trying different

pathways of applying it. They have started the process of developing a city portrait but this is still underway. The city is following the same approach as Amsterdam; mapping out targets and indicators that are already being used across the organisation and assessing whether or not these are effective for measuring the urban safe and just operating space. Another important focus area has been citizen engagement and participation in creating a shared vision for the future of the city. Ultimately, Tomelilla aims to use the doughnut to provide an overview of different sustainability areas the municipality is working on and to use it as a tool in their communication with citizens to show how they can get involved with these areas. The city also wants to use the doughnut for urban planning projects specifically, to reimagine the future of the built environment and use it as guidance in their comprehensive plans. The doughnut is considered useful in comprehensive planning because it supports ex-ante consideration of trade-offs and associated conflicts that might arise in proposed projects, for example, managing urban encroachment on agricultural land.

One challenge for the city is how to apply the doughnut to specific urban planning projects, as it does not provide direct decision-support in terms of what kinds of construction materials or building techniques should be used. Moreover, it is considered difficult to assess the impacts of projects at the building scale on the doughnut.

Another challenge is that working on the doughnut assessment is very labour-intensive and requires sufficient capacity and funding. Assessing the doughnut is further complicated by the mismatch between the scale of impact and the scale of the mandate of the municipality. For example, assessing consumption impacts in the municipality is a challenging task, while the city has little influence over the actual consumption behaviour of its citizens.

Integrating the doughnut in urban institutions
Holistic Thinking About Sustainability

Interviewees state that the doughnut offers a more holistic definition of sustainability, considering a diversity of both ecological and social considerations and how they are interrelated. This holistic definition is perceived to allow planners with thinking about trade-offs and synergies before implementing their plans and assist them in identifying what other municipal departments or external partners should be involved. Public perception regarding the urgency of sustainability is perceived as a factor that drives doughnut applications, reflected by one interviewee who states: *"I think public opinion is a big factor. I think the public are concerned about climate change and environmental degradation, and I mean you see this; the climate strikes and protests (…) So, I think that there's a lot more support for environmentalism, and also looking after each other".* Interviewees perceive the doughnut as useful for providing a shared definition of sustainability and for imagining what sustainable futures of a place might look like, as stated by one interviewee: *"(…)one issue is that sustainability is such a broad concept, and it can mean a lot of different things. So, we wanted to find a model and a more common framework of how to talk about sustainability here."* Staying within a safe and just operating space is considered an ambitious goal and interviewees consider that adopting this requires the organisation to change. One interviewee considers the doughnut to be the latest evolution in a line of sustainability models and multiple interviewees consider it a strength that it builds on the SDGs is considered a strength, though it can also be a challenge to combine the doughnut with other sustainability frameworks. Most interviewees state they consider the doughnut useful because it addresses the interrelated nature of socio-ecological sustainability challenges and helps them identify integrated ways of addressing these by working on coherent goals across the organisation. One interviewee stresses that finding integrated ways of addressing sustainability challenges is crucial and that this can be done with or without the doughnut, stating*: "The reason why we have the need for the doughnut is because we have systems and forces in place that result in power that destroys the environment and social structures, and where some people have a lot more and some people have a lot less".* Multiple interviewees consider that a holistic understanding of sustainability and integrated ways of working require a paradigmatic shift. They state this requires the continued willingness to collaborate and coordinate between departments and with external stakeholders in bringing about sustainability transformations, and this culture is considered challenging to establish and maintain. Other interviewees also consider that the interrelations between the different dimensions of the doughnut complicate the implementation of plans and projects. Interviewees state that the doughnut helps with thinking about the impacts of decisions in advance, which helps with identifying alternative pathways that

minimise negative impacts, and consider it crucial that the doughnut is used at the early stages of decision-making.

Governance Structures

Governance is perceived as an important theme in cities working with the doughnut. Interviewees state that working with the doughnut is useful for communicating a holistic definition of sustainability, both internally and externally, as seen in the statement of one interviewee: *"This is an opportunity to facilitate good conversations with your community and your colleagues".* Interviewees consider the importance of identifying key internal and external partners to collaborate with, both in assessing and implementing the doughnut and collaborations with non-government stakeholders are perceived as key to local sustainability. interviewees consider the doughnut to be beneficial for internal communication because it helps break through government silos by clearly articulating sustainability goals. One interviewee stresses that working with the doughnut requires high levels of integration between government departments and that organisational cultures need to change for this to be successful. Interviewees consider the doughnut relevant for external communication because the city can clearly show its citizens how they are engaging with sustainability and how communities can get involved. Interviewees express that the doughnut provides opportunities to identify important external partners and pool synergies in achieving local sustainability transitions. Participation is considered important for cities applying the doughnut and interviewees express the need to involve diverse people. Several interviewees state they collaborate with existing networks working on sustainability, and these networks, along with other civil and private groups, are perceived to be important partners in implementing plans and strategies. Several interviewees express the doughnut addresses a wide range of concerns and the model is considered easy to understand. Interviewees state that local doughnut applications might change the status quo of local governance and that it is important to minimise resistance by communicating transparently and highlighting the benefits. However, several interviewees state local governments have limited capacity to do outreach about their doughnut activities and experience a trade-off between creating internal and external buy-in for the use of the doughnut, reflected in the following statement: *"this is one of the things that a very small team does, and so we just haven't been able to kind of do that engagement with [the] communities as much as we would like, but that's something that we are seeking to do".* A few interviewees mention that because the different dimensions of the doughnut are interconnected, adopting it can make the communication of plans and strategies more complicated, reflected by an interviewee that states*: "for example, the energy is within the social sphere, but it's also (…) lots of what we do in the energy area is connected to climate change. So where do we put that?"*

Influence, Capacity, and Funding

Interviewees expressed capacity is an important constraint for local governments that are applying the doughnut, as the associated work is time-consuming and requires funding to be available, as stated by one interviewee: *"I mean, then most of it is about funding. It's about having enough people who can work with this".* One interviewee states that having secure funding addresses capacity issues because doughnut applications become standardised in the organisation, and the department working with the doughnut has a reliable budget to pursue their activities, reflected in the statement: *"Now it's kind of become business as usual, so we don't have that funding issue anymore".* Interviewees consider that mapping out what indicators and targets are in place is a demanding job. Interviewees also consider it important to assess how the doughnut ties in with existing goals because local governments only have limited capacity to address these. Interviewees consider it challenging to apply the doughnut in a way that aligns with existing strategies and plans because of the coordination required. Measuring and monitoring how cities perform in relation to their goals is perceived as a continuous challenge because of limited capacity at this scale. Because of capacity constraints and limited influence, interviewees consider it important to identify priority areas within your mandate and invest efforts in improving these, reflected in the statement: *"Where do you have control and influence and where is the biggest impact you could have on the different elements that the doughnut is trying to achieve?".* Several interviewees consider the global lenses of the doughnut to be challenging as they have very limited capacity to influence local consumption other than through their own procurement policies and educational programmes. Due to capacity issues, interviewees also perceive a trade-off between measuring and assessing performance versus practically implementing initiatives to improve their performance regarding sustainability. One interviewee states they have limited capacity to assess the doughnut considering the time invested in setting up participatory processes. There is some consideration that GDP is an easy figure to monitor and that measuring performance more broadly also increases the complexity of local government operations, this is reflected in*: "Where is your boundary of complexity that you can justify using, and where do you have to say OK, increasing the complexity will not help us get where we want to go".* Selecting indicators and coordinating between departments is considered an interesting exercise, but the time investment required is a limiting factor in doughnut applications. One interviewee states that the doughnut does not apply to everything they do in the local government because certain procedures are mandated by other government scales. Interviewees express that how the doughnut is applied also depends on how the local government is influenced by the mandates of other government scales, and that they may lack influence in key areas that would improve sustainable outcomes.

Conflict, Trade-offs and Synergies

Interviewees perceive the doughnut as helpful in thinking about conflicts and trade-offs associated with urban development in advance, helping with identifying alternative pathways or offsetting options. Interviewees perceive the application of the doughnut to be useful for identifying trade-offs and synergies between existing city goals*: "I mean we go towards the same objectives, but maybe we are not aware of what they are working on in other departments and maybe sometimes there could be some inconsistencies or contradictions. So, this holistic approach was very rich".* Two interviewees explicitly refer to the conflict between urban growth and encroachment on surrounding ecosystems, stating: *"So then, (…) that's a conflict; we need to provide housing for inhabitants, but at the same time we need to protect our agricultural land".* In this context, another interviewee mentions the need to coordinate regional growth strategies with surrounding local governments and with the region as a whole, demanding intergovernmental coordination. Several interviewees refer to the importance of housing, some in the context of severe shortages, and consider development crucial to meet the housing needs of residents, pointing to densification as a way to do this while minimising negative environmental impacts and urban-rural conflicts. Interviewees perceive trade-offs between the social and ecological domains and state these should be managed based on political priorities because the doughnut does not offer specific decision-support for managing trade-offs. Interviewees perceive a need for urban development, especially in some cases of housing shortages or deprivation, and it is considered difficult to balance this with ecological goals because offsetting large development projects is challenging. Working in more integrated ways between government departments is perceived to enhance synergies in the urban development process, though it can also cause conflicts between departments because of the compromises required to collaborate. This interviewee states: *"And so it requires a real culture shift of wanting to work across departments, and staff learning each of their roles and not sitting in one box".* Interviewees consider the pooling of knowledge, resources, and expertise in urban development leads to improved outcomes that can be achieved in more efficient ways. One interviewee states that the doughnut also reinforces the drive to look for integrated ways of addressing socio-ecological challenges, such as using green infrastructure in development. Interviewees point out that people still commonly perceive a conflict between environmental and economic sustainability, especially in more classical economic sectors. Several interviewees express there is a trade-off between gathering information and assessing the doughnut versus practically working on implementing projects related to it. in this context, interviewees are critical of the purpose of assessment, reflected in*: "but then it kind of feels like again, maybe not as narrow as the GDP question, but am I collecting data for the sake of collecting data, or am I collecting data for using it to actually get somewhere?".*

Champions and Political Uncertainty

All interviewees state it is important to have champions for the doughnut in top-level government positions who can advocate for its use, provide information on how to do that, allocate resources, and enforce its use across the organisation, reflected in the statement: *"I think that's very important because you need resources, you need the commitment to be able to have the impact on the decision-makers to actually make a change".* interviewees experience that relying on champions creates problems with political uncertainty due to election turnover and having to re-create internal buy-in when champions disappear, reflected by an interviewee stating: *"so the previous champions were no longer around, so we had to, you know, help the new administration kind of own it, and see, and understand it".* The political uncertainty created by elections is perceived to be a limiting factor in applying the doughnut as the doughnut does not reflect the progress you made during your political mandate, as reflected by an interviewee who states: *"the political difficulty for me is to see that the city portrait is something that is not your evaluation of the four-year electoral period, it's a longer one".* Some interviewees perceive the doughnut as something that can be used across the political spectrum, though others state there is potential for the doughnut to spark political opposition from those with neoliberal/growth or fringe ideologies. Interviewees state that cities working in coalition governments need to align their political vision on how the doughnut will be applied in that context.

Application

The cases in this study show that cities are applying the doughnut in diverse ways, though all cases use the DEAL methodology. All interviewees are motivated to work with the doughnut because it allows them to communicate a holistic and ambitious definition of sustainability. Commonalities are that it is considered important to identify priority areas within the mandate of the local government and map out what information is currently available on this. Few interviewees working with the doughnut communicate with each other and many consider learning from best practices to be important in improving the application. Interviewees perceive the doughnut as relevant for the strategic level of planning because it stimulates thinking about trade-offs and synergies in advance, helping to identify conflicts of interest and important partners for implementing plans. The doughnut is currently considered less relevant for applications at finer urban planning scales, with one interviewee stating: *"I think on a general level it could be very useful, in kind of setting the vision and intention for the city and the development path. And then, I found that when you go into more detail about how exactly are we going to do this, then it's not as helpful".* The doughnut can be modified to provide specific decision support, but this requires sufficient capacity. Interviewees consider that using the doughnut as an explicit decision-support tool or a monitoring and evaluation tool, as well as

how that information is used for local planning and decision-making, is a political decision. The renewal of strategies and plans is an important aspect of applying the doughnut in local governments as most interviewees stated they started working with the doughnut after they committed to updating their strategies or plans. The doughnut is used as an evaluation framework for sustainability strategies or as the basis to formulate goals for planning documents. Interviewees express that a challenge with applying the doughnut in strategies and plans is that it may also require the revision of previous strategies and plans to make them coherent with the doughnut. Interviewees working with the doughnut tend to follow an experimental approach and institutional learning from feedback is seen as an important part of improving the approach over time. Internal and external partnerships are seen as crucial in implementing goals related to the doughnut, reflected by an interviewee stating*: "So what I would say to any city is; are you ready to consider how you may need to change your system and way of working"*. Interviewees anticipate the uptake of doughnut economics to increase, especially because of public concern about environmental issues. In this context, one interviewee mentions the importance of best practices and the need to demonstrate that the urban doughnut approach works. Some interviewees consider that the data portrait of a place might consider different priorities than those held by residents and state that it is important to provide their citizens with information about how the doughnut is applied, reflected in the statement*: "we need to talk to people who have never heard of a doughnut economic theory before and just to get their input so that it is really for the city rather than done to the city"*.

Assessment and Data

In terms of assessment, interviewees consider it important to first adapt the doughnut to the local context and map out what is currently being measured and monitored, and what goals and targets are already in place. Interviewees consider assessing the doughnut is resource intensive and several refer to the social foundation and/or the global lenses as being specifically difficult to assess, with one interviewee stating: *"we are really, really strong on local-social and local-ecological, and we're... like there's some stuff on global ecological, but not a lot on global social".* Interviewees rely on databases from different scales and many express that local data availability and quality are poor, especially trying to assess impacts in advance requires using best estimates. Interviewees consider it difficult to select single indicators that accurately reflect a given dimension of the doughnut in the face of future uncertainty and interactions between dimensions, stating: *"So you can have a target for how much water you use per capita, but does that show you that over time, with climate change, you have less water every year in your reservoir?".* Interviewees also consider that the doughnut measures performance more broadly than GDP alone, but that a single indicator to reflect a whole doughnut dimension might still be narrow. One case tried to use multiple

indicators per dimension but realised this was not feasible. Interviewees rely on official targets when making their city portrait and one interviewee raises the question if official targets are enough, stating: *"I mean we have targets, but are these targets enough or can we, in an ideal city, do we have to think about a more ambitious target?"*. Interviewees experience difficulties with assessing how smaller projects impact indicators and express the impacts of different-sized projects need to be weighted depending on their local relevance. Measuring and monitoring performance is perceived as important and there is consideration that this can be made easier by automating certain processes with IT services. Interviewees consider that when using the doughnut as decision-support, an important part of the assessment is defining ways to classify impacts, which might require weighting or normalising outcomes depending on the local context. Interviewees experience an issue with assessing the aggregated impacts of urban planning projects taking place at different scales, creating challenges with linking local activities to global impacts, with one interviewee stating: *"And we want to consider that aggregation question, and what do we want to know and why? And then, what will we use that information for?"*

Scale

All cases in this study adapted the doughnut to fit their specific local context. Interviewees currently do not consider the doughnut as relevant to very fine scales. The doughnut considers the global impacts of local actions, but interviewees express this is difficult in practice: *"Since (…) it's also supposed to take into [account] the global perspective, and I mean it gets hard when it comes to measuring specific projects."*. Interviewees express they are influenced by other scales of government while having little to no influence over impacts that occur at larger scales via globalised consumption patterns. Interviewees state local scales of government are suitable for applying the doughnut because of their proximity to their communities and the potentially shorter decision-making paths. One interviewee points out that they currently have a lot of information on local decisions, but that aggregating these to understand global impacts is still a challenge, stating: *"how we want to bring all that information together, and then what does that mean for that safe and just operating space? What does that mean for us, you know, as a local authority (...)? And then what does that mean globally?"*. Several interviewees refer to an important scale mismatch between the mandate of local governments and the dimensions of the doughnut, especially the global-social dimension. Other interviewees also consider how perspectives on different challenges might differ depending on what scale is used to look at the city, stating: *"we have the city but we also have quite a few smaller towns that are considered part of the boundary (…) and they will have quite a different perspective to someone who lives in the city in an apartment"*. Some interviewees also refer to the time-scale of sustainability, stating the doughnut can help make an argument for long-term

investments: *"I think the doughnut is a good tool to kind of show that it is an investment that needs to be made to be sustainable in the long run"*. The time scale of the city portrait is also brought up by one interviewee stating they experienced difficulties with the temporal dimension of the targets the city set itself.

The Matter of Growth

The doughnut is growth agnostic, but what this means in urban practice is not yet clear. Interviewees stress that, although the doughnut highlights that economic growth should not be the goal in itself, economic growth is still required for urban development. Interviewees consider that if the doughnut is adopted at high political levels, the institution needs to clearly and transparently communicate where it stands regarding growth: *"But if the political government would decide that we're going to be a doughnut city, then I think they would also need to take a clearer stance of; are we going to grow or not? What's the reason for growing?"*. Several interviewees express their concern about the doughnut being used for greenwashing purposes, stating*: "and is it window dressing versus really attempting to look at the equity pieces that are supposed to be the foundations of the social component. Because you can use a doughnut to perpetuate systems, or you can use it to change systems"*. Interviewees consider that growth is still a contested issue and in most cases, it is not explicitly discussed, or only with people who have an in-depth understanding of the doughnut. One interviewee states*: "And I feel like most people are just still so brainwashed to this, that touching on this issue of growth is already (…) you can forget about having any sort of constructive conversation"*. Interviewees consider that balancing the need for growth to meet social needs versus the environmental impacts it creates is a continuous challenge.

Discussing the Doughnut in the Age of the Urban

The two questions addressed in this study are 1) How is the doughnut currently applied at the local scale, and 2) what is the perceived relevance of the doughnut for sustainable urban planning and decision-making? I have empirically answered these questions using qualitative results, including a literature review, case descriptions, and interviews. In the following section, I provide answers to the main research questions, discuss interpretations and implications in light of existing literature, and provide recommendations for theory and practice.

Answering Research Questions

To answer the first research question, how is the doughnut currently applied at the local scale, I have described academic literature and practical cases that are applying the doughnut locally. Literature on using the doughnut for urban planning and design is limited; there is some focus on trade-offs and synergies in the built environment (Benites & Osmond, 2021; Hassan, 2022) and how the doughnut could be used to enhance the sustainability of specific sectors in urban planning (Moghaddam et al., 2022; Paraskevopoulou et al., 2019). Studies explore how the doughnut can be used in urban institutions and consider collaborative governance to be important in achieving sustainability transitions (Fell & Mattsson, 2021; Moretti, 2022; Ssemugabo et al., 2021). The doughnut is perceived as useful in promoting holistic thinking and communication about sustainability (Eriksson, 2022), but its ability to challenge pervasive notions of growth and development might be limited (Eriksson, 2022; Olsson, 2020; Pasgaard & Dawson, 2019). Challenges for applying the doughnut in local governance are working with complex systems, goal coherence across scales, and managing trade-offs, inequalities and power dynamics (Turner & Wills, 2022). Successful doughnut applications require adaptive management practices, participation by diverse stakeholders, and transdisciplinary collaboration to enable local applications of complex, cross-scale, system science (Turner & Wills, 2022). Methods for locally assessing the doughnut are advancing and significant efforts are being made in developing absolute sustainability assessment methods for urban systems (Bjorn et al., 2020), using planetary boundaries as benchmarks (Goodwin et al., 2021). These studies reveal that many uncertainties remain, as outcomes vary depending on methodological choices (Froemelt et al., 2021; Hjalsted et al., 2021), and the relevance of planetary boundaries at this scale is scrutinised (Ferretto et al., 2022; Wang et al., 2022; Xue & Bakshi, 2022). Overall, methods for assessing the absolute sustainability of urban systems are actively being developed but should be treated with caution as the normative choices made in the process of assessment will have an impact on the outcomes, this is especially true for deciding on a sharing approach for the urban safe and just operating space (Dillman et al., 2021; Froemelt et al., 2021). Footprint and consumption-based approaches are

considered relevant for analysing the local-global interactions of urban sustainability, as they account for the embodied impacts of goods and services (Wiedmann & Allen, 2021). Assessment methods for specific boundaries are also being developed, these emphasise the importance of considering interactions in the planetary boundary framework (i.e., freshwater withdrawals and climate change) (Li et al., 2020). Studies are focussing on how the use of the doughnut across scales can strengthen regional sustainability by looking at how places along the rural-urban gradient may experience overshoot and shortfall in different dimensions which could be reduced through regional planning efforts (Chapman et al., 2021). Computer science approaches have the potential to assist urban planners and decision-makers with assessing the safe and just operating space but underscore the importance of good data availability and quality for accurate assessments (Dahl & Moreno-Navarro, 2022). Downscaling the doughnut poses challenges from both a technical and ethical perspective and there is a lack of consistent approaches for either downscaling or assessing interactions between the different domains of the urban safe and just operating space (Dillman et al., 2021; Ferretto et al., 2022).

Local governments are taking varying approaches to applying the doughnut and tend to use it for enhancing their sustainability ambitions. It is used as an evaluation framework in the context of broader sustainability strategies, to develop plans and programmes for achieving sustainable outcomes, and operationalised for specific decision-support. Participation and collaboration with civil and private groups are common features of places working with the doughnut, and these are perceived as key partners in achieving urban sustainability transitions. All cases in this study rely on the DEAL method, which is place-based and requires local adaptation. Places go about applying the doughnut in creative ways, using experimental approaches, and learning from feedback. The assessment of the doughnut at the local scale is considered challenging and relative. The DEAL methodology relies on identifying targets and categorising these according to the four lenses so that a snapshot of the city shows how it is currently operating in relation to its goals. The use of official policy targets and local adaptations of the doughnut means a relative, rather than an absolute assessment of the urban safe and just operating space.

To answer the second research question, what is the perceived relevance of the doughnut for sustainable urban planning and decision-making, I have looked for common trends and broken patterns of data to identify the overlap and divergence between cases applying the doughnut. The doughnut is considered most relevant as a tool for communicating about sustainability, thinking about it holistically, and considering both ecological and social dimensions. Defining sustainability based on the different socio-ecological dimensions of the doughnut is considered useful for goal coherence between different departments and when involving external stakeholders. Coordination between government departments regarding

sustainability goals, stimulating goal coherence, and breaking through government silos are benefits experienced by local governments working with the doughnut. Moreover, by clearly communicating how local governments engage with sustainability, the doughnut may assist in driving back participation by civil or private actors who want to get involved with local sustainability initiatives. Applying the doughnut helps with identifying and creating synergies between internal and external actors working on sustainability goals, making local sustainability governance an important theme. Local doughnut economics can potentially stimulate changes in governance structures; actors are stimulated to change ways of approaching internal and external collaboration, and external partners are perceived to be important in the implementation of sustainability strategies and plans. However, applying the doughnut alone will not change existing structures, this needs to be accompanied by a change in organisational culture; the doughnut is a model, and it depends on actors to use it in achieving changes.

Working with the doughnut provides local governments with a holistic definition of sustainability that can be used for updating local strategies and plans and potentially provide more specific decision support. When taking an experimental approach, the application process can stimulate adaptive management practices and institutional learning. Ex-ante consideration of trade-offs and synergies in urban planning and development can be enhanced by applying the doughnut, making it a relevant framework for strategic planning purposes. Moreover, considering impacts in advance helps with identifying important conflicts of interest, such as urban growth on agricultural land, and though the doughnut does not specifically assist in settling these conflicts, its application can be used to reinforce urban densification strategies. The doughnut is considered relevant for addressing increasing public concerns about the environment, imagining sustainable futures for a place, and securing long-term investments in sustainability, though it requires proof of concept to be picked up more.

Contingency on political advocacy is a barrier to the continuity of local doughnut applications; if there is no internal and/or external buy-in created in the process of application, progress can be undone when champions disappear. The relevance of the doughnut is limited by the lack of capacity and influence of local governments to apply the model; it is considered time and resource intensive and the model seeks to address areas that are beyond the mandate of local governments, i.e., the global lenses. Moreover, some local actions are mandated by other government scales and cannot be influenced by the limited mandates of local governments. Capacity constraints create a trade-off between measuring and assessing the doughnut versus implementing actions; interviewees consider it difficult to balance the need for accurate information with the need for information to be relevant in practical operations. Assessing the doughnut locally is challenging and slightly contested; measuring and

monitoring targets and indicators are considered crucial, however, the cost of this versus implementing actions to bring about change is high. There is a need for assessments to be accurate to inform planning and decision-making, however, accurate assessments are hard to achieve because of limited capacity and because they require consideration of lenses that local governments have limited to no influence over. Moreover, the cases follow a relative assessment method and face data quality and availability issues, further limiting insight into the global dimension of impacts. Interactions between doughnut dimensions, the use of single indicators to reflect a dimension, and the use of official targets and objectives means applying the doughnut will not necessarily ensure absolute safe and just outcomes in the long term. There are few direct debates about growth and what growth agnosticism means in practice is not yet clear. The doughnut is considered relevant for refarming the role of the economy without having to discuss growth and, in this regard, facilitates constructive conversations. However, growth is still considered contested, calling into question the ability of the doughnut to challenge the pervasive economic growth rationale.

Interpretations and Implications

First, I interpret the results from the two research questions by reflecting on differences and similarities in theoretical and practical approaches to local doughnut applications. Consequently, I will address the third objective of this study by discussing the implications of these results and evaluating them in relation to planetary urbanisation.

The absolute assessment that is being developed in theory is not (yet) practically applicable and it might not be in the near future because of the limited capacity of local governments to engage with multi-scale systems science. The use of planetary boundaries for local sustainability assessment is somewhat contested; uncertainty about interactions among planetary boundaries weakens their ability to inform policy, this is highlighted in theory and practice, both referring to the interactions between climate change and water use. The focus on absolute assessment is in contrast with the relative assessment that is used in practice, building on existing targets and objectives that are not necessarily informed by absolute measures of sustainability, but rather by politics and preferences. The lack of literature available on how to apply the doughnut for fine scales of the built environment is reflected by cases that face challenges applying the doughnut at this scale. The doughnut can reinforce regional sustainability planning, evident in both theory and practice. Accurately assessing the doughnut is contingent on good data availability, a condition often not met in practice, especially for data concerning the global impacts of local actions.

Theory and practice overlap in their focus on governance approaches to working with the doughnut locally and highlight the importance of widespread collaboration in effective urban

sustainability transitions, involving public, private, civil, and academic sectors. Collaboration is hindered by capacity issues, creating possible trade-offs between internal and external outreach, which is only marginally considered in the literature on downscaling. Both theory and practice showcase the relevance of the doughnut as a tool for communicating about sustainability, but in practice, this needs to be accompanied by a change in organisational culture and structure to lead to improved outcomes. Applying the doughnut in practice promotes ex-ante consideration of the impacts of urban development which can assist in improving outcomes, however, this may be limited to the city. The doughnut highlights how the urban has extended impacts and local actions have global consequences, but local governments have limited capacity to address the global lenses because they have no means to significantly influence these within their mandate, something often not considered in theory. When the doughnut is locally adopted in a top-down way, it appears to rely on a combination of champions who will promote its use and moments of opportunity for the doughnut to find its way into official plans and strategies. This implies advocacy coalition needs to be combined with policy opportunities to explain the local application of the model. Creating buy-in beyond political advocacy is crucial for providing continuation to doughnut applications and this is recognised in the literature. This challenge of continuity is exacerbated by that research concludes external civil actors involved need to possess some degree of power to act, which might be indirectly contingent on political champions in cases applying the doughnut top-down. Capacity issues challenge the local assessment of the doughnut and this is not sufficiently considered in current studies; it is considered relevant to have accurate information but local governments are highly limited in their capacity to gather this, exacerbated by assessment taking resources away from implementing actions.

Doughnut economics is limited in practice because the socio-ecological boundaries are defined in relative, rather than absolute terms; they do not necessarily lead to more safe and just outcomes from a global perspective. Relative limits do not account for complex interactions of urban systems with other systems (Solecki et al., 2013) and do not avoid leakage or rebound effects, meaning impacts can still be externalised (Elliot, Torres-Matallana, et al., 2022; Ottelin et al., 2019, 2020). Interactions between planetary boundaries (Häyhä et al., 2016) are problematic for their relevance in informing policy targets; Interviewees state it is difficult to select targets and indicators in the face of future uncertainty and interactions between doughnut dimensions. Despite the recognition of the significant socio-ecological impacts of the urban, rather than the city (Heynen, 2014; Kaika & Swyngedouw, 2014; Swyngedouw, 2006), in practice, these are difficult to assess. More importantly, the global lenses are nearly impossible to influence within the mandate of local governments.

The common approach for downscaling the doughnut uses official targets and objectives, however, these are not necessarily informed by absolute measures of sustainability, but rather by politics and preferences. Theory expresses the need for a critical science of urbanisation (Inostroza, 2014; Solecki et al., 2013), while the local doughnut method is not made to be comparable across cases (Fanning et al., 2022). Practically, it is relevant to locally adapt the doughnut, this is in line with communities selecting limited sets of meaningful indicators rather than aiming to harmonise measurements (Alberti, 1996). Local adaptations help with creating buy-in and measuring and monitoring under capacity constraints, but this limits cross-scale sustainability assessments of urban systems (Alberti, 1996; Solecki et al., 2013).

The doughnut methodology encourages local places to think about urban metabolic impacts, however, the global lenses of the doughnut are most difficult to assess in practice because efforts to enhance sustainability practices are added onto existing government processes (Bridges, 2016; Evenhuis, 2017). The method developed by DEAL is difficult to implement in practice; local governments face significant capacity constraints in trying to address the four lenses, confirming the need for developing decision support that can assist planners and decision-makers in assessing the impacts of their decisions across scales (Häyhä et al., 2016; Turner & Wills, 2022). The local lenses are easier to assess, specifically local ecological for cities that have a strong focus on sustainability, but the social and global dimensions are less well understood, which can be explained by scientific challenges to addressing matters of complexity, scale and uncertainty (Alberti, 2016).

Neither theory nor practice considers the stock of built environments already present in affluent cities and how this stock embodies historical impacts (Inostroza, 2014; Næss, 2001). Assessing the doughnut does not consider the embodied impacts of existing technomass (Inostroza, 2014) and how this affects where a place stands in relation to the safe and just operating space, though the DEAL method states it aims to include this in updates to the method. Nonetheless, cases in this study are still discussing adding additional building stock to meet the needs of urban dwellers, raising questions about the ability of efficient use of space and resources to address sustainability issues in affluent urban areas (Næss, 2001). It might be worthwhile to explore how the embodied impacts of existing building stock can be used to identify relevant measurements and reference conditions for urban systems (Alberti, 2016), especially considering the ambiguity regarding sharing approaches of the safe and just operating space (Dillman et al., 2021; Froemelt et al., 2021). Defining embodied impacts in technomass (Inostroza, 2014) might assist with defining urban shares of the safe and just operating space, as well as defining indicators that link patterns of urbanisation to the conditions of supporting hinterlands (Alberti, 1996).

Using the doughnut to change local institutions is complicated because of the level of transaction cost (Vatn, 2015); accurately assessing overshoot and shortfall locally is highly challenging in practice. Literature on absolute assessment and bottom-up approaches is advancing (Wiedmann & Allen, 2021) and could provide meaningful information on both the city and the urbanisation process (Solecki et al., 2013). However, as of yet, these approaches should be treated with scrutiny in practice, as normative and methodological choices influence outcomes. If these methods are used to inform urban management goals, special attention should be paid to how scientific uncertainty underpinning these goals might lead to undesirable outcomes for some in either the city (Heynen et al., 2006) and/or the urban (Arboleda, 2016; Hornborg, 2016; Swyngedouw, 2006)

The doughnut promotes holistic thinking about socio-ecological challenges and is perceived as a meaningful tool to communicate sustainability inclusively by its users (Eriksson, 2022). The tools provided by DEAL are considered useful and despite encountering issues with the assessment, the four lenses and other tools are perceived to stimulate good conversations. The use of universal basic needs in accounting for the social foundation might conflict with the perceptions, priorities, and preferences of local communities (Custodio et al., 2023; Pasgaard & Dawson, 2019), which is reflected by all cases adapting the doughnut to better fit the local context. The social dimensions are considered more difficult to assess because indicators are less well established, the ambiguity of a universal basic needs perspective in defining the social foundation for a given community, and aggregate quantitative indicators that might not accurately reflect the qualitative reality experienced by the residents of the city (Custodio et al., 2023; Drees et al., 2021; Pasgaard & Dawson, 2019). Applying the doughnut encourages participation and this might minimise the use of limits to marginalise vulnerable groups, as the method explicitly asks to consider who is not being heard in the process of application (Shorter, Grcheva, et al., 2022b, 2022a), allowing for consideration of the diversity of perspectives and concerns held by urban dwellers. Facilitating participation processes can be limited by capacity constraints and trade-offs with focusing on quantitative assessment. Participation in doughnut applications might improve safe and just outcomes for local communities but will not necessarily improve sustainable outcomes from a global perspective (Næss, 2001).

This study deals with formal institutions and the changes investigated are designed (Vatn, 2015), with all cases referring to the importance of advocacy for the doughnut as a driver of its applications. Urban institutions are made up of actors operating within, but also influencing structures (Evenhuis, 2017; Vatn, 2015). When applying the doughnut, actors are presented with the opportunity to influence existing structures, showing signs of path plasticity in local sustainability governance (Evenhuis, 2017). The interrelated nature of socio-ecological

challenges visualised by the doughnut motivates actors to improve internal and external collaboration, potentially changing interactions within the local governance system (Bridges, 2016; Evenhuis, 2017; Vatn, 2015). By improving interactions, especially by stimulating goal coherence between government departments, planning outcomes are perceived to be improved because local government processes can be better aligned (Yigitcanlar & Teriman, 2015). However, achieving and maintaining this paradigmatic shift within the organisation is a challenge. The doughnut is a useful tool for strategic planning and improving local interactions between actors in the governance systems. Local actors focus on working with the doughnut in experimental and participatory ways but face significant capacity constraints (Turner & Wills, 2022). The doughnut needs to be aligned with existing strategies and plans, showing signs of dynamic path dependence in local institutions (Bridges, 2016; Evenhuis, 2017).

Local scales of governance have emerged as key scales for addressing sustainability (Brugmann, 1996; Evans et al., 2006; Næss, 2001), however, this study highlights that local governments face issues with transaction costs when aiming to change governance structures (Vatn, 2015). Moreover, their limited mandates highlight the importance of intergovernmental coordination for achieving sustainability outcomes(Saha, 2009), especially by focusing on how regional sustainability planning can lead to better allocation of environmental benefits and burdens (Chapman et al., 2021). However, these approaches need to consider bottom-up perspectives so that the enhanced sustainability of one region is not at the expense of another (Feng et al., 2022). Local scales of governance have a limited mandate and capacity to address the global dimensions of the doughnut framework. This is problematic because it inhibits assessing the biophysical, socioeconomic, and ethical dimensions that should be considered when downscaling the doughnut (Häyhä et al., 2016). Local governments face problems because of uncertainty related to scales and interactions, limited capacity to assess patterns resulting from socioeconomic processes, and the combination of this leads to limited insight to meaningfully address the ethical dimension.

It is not clear if the doughnut stimulates a renewed urban planning and design paradigm; it provides a holistic definition of sustainability and stimulates thinking about circular resource use (Sodiq et al., 2019) it does not necessarily lead to an understanding of cities as complex, hybrid systems (Alberti, 2016). The use of single indicators to track progress in a given dimension reflects a traditional mechanistic planning paradigm (Heymans et al., 2019; Marshall, 2012) and the relationship between urban environments and natural cycles is unaddressed (Alberti, 2016; Sodiq et al., 2019). Doughnut applications, though facilitating improved local interactions, also perpetuate goal-oriented planning approaches (Næss, 2001) based on the predictability of urban systems. Hence, applying the doughnut does not

challenge the underlying modernist planning rationale nor advance a planning paradigm that enables dealing with complexity and uncertainty (Batty & Marshall, 2012; Portugali, 2012).

The doughnut model emphasises staying within the safe and just operating space rather than economic growth(Raworth, 2017b). The growth-agnostic nature of the model helps facilitate constructive conversations in practice, by avoiding a contested topic. However, it is not clear if the doughnut can challenge the core of the economic rationale (Eriksson, 2022; Olsson, 2020; Spash, 2021); economic and urban development continues to be perceived as important in meeting the social foundation, and whether this happens at the expense of the environment depends on the political priorities and preferences of a place. The doughnut as a visual influencing environmental discourse poses a contradiction in that it denotes boundaries to an ecologically safe and socially just operating space for humanity, and connotates values that fit a strong suitability paradigm because of interconnections between human well-being and the health of the surrounding ecosystem (Benjaminsen, 2021a). However, the doughnut also perpetuates the myth that continued growth and development of affluent urban centres can continue in safe and just ways, without appropriately considering how the urbanisation processes of those centres have and are contributing to current overshoot and shortfall across scales in the world system (Arboleda, 2016; Hornborg, 2016; Inostroza & Zepp, 2021; Swyngedouw, 2006). Despite being growth agnostic, the doughnut also perpetuates the idea that development is a requirement for meeting the social foundation, while the possibility of meeting the social foundation for all under current development trajectories might be a myth (O'Neill et al., 2018; Spash, 2021)

Recommendation for Future Theory and Practice

In this section, I will identify future research and practical recommendations based on the findings of the current study.

Future research can focus on empirically testing the effectiveness of applying the doughnut model to change the material basis of urban systems over time. Longitudinal studies can track changes in resource consumption, waste generation, and environmental impacts of cities that have adopted the doughnut model. Studies might also investigate the transaction costs of downscaling the doughnut model to the local context; this can involve analysing the costs of implementing the doughnut model in different urban contexts, to determine whether those costs are proportional to the benefits gained by its application. Studies focused on local assessment should explore the possibility of using technomass as a basis for defining sharing approaches of the urban safe and just operating space. This can potentially help set orientation values that consider the historic impacts of urban systems. Research should critically engage with the material sustainability of the urban system, both form and flow.

However, this engagement should consider the practical constraints of applying such approaches, such as economic and political factors, that affect their local operability.

For local governments working with the doughnut, it is recommended to focus on the strategic relevance of the doughnut. It is recommended to consider conflicts, trade-offs, and synergies between dimensions of the doughnut in advance; this assists with identifying and addressing potential challenges before they become significant problems. It is recommended to use the doughnut to enhance the way that sustainability is communicated both internally and externally, to help increase awareness and engagement around sustainability issues and build momentum for change in local governance structures. Local governments can map out available targets and indicators locally when capacity allows for this because it is an interesting exercise that potentially improves coordination between departments. However, local governments should be critical of the indicators and targets used, even if they are official, and should consider if current targets are sufficiently ambitious. Current assessments are demanding and do not provide insight into the absolute sustainability of the city, therefore, local governments should be creative when addressing challenges to urban sustainability and might explore alternative ways of assessing performance. The doughnut can be used to communicate values that are aligned with 'strong' sustainability paradigms, allowing for discussions about long-term sustainability without having to address the contested topic of growth.

Concluding Thoughts

In this study, I have aimed to explore the relevance of the doughnut for sustainable urban planning and decision-making in the context of planetary urbanisation. I used qualitative methods to describe recent advances in downscaling the doughnut to the local context, explored the doughnut's relevance for sustainable urban planning and decision-making, and evaluated these findings in light of ongoing planetary urbanisation. I have empirically shown how the doughnut is being locally applied, as well as the perceived relevance of the doughnut by its users.

Working with the doughnut can enhance strategic planning practices because the visualisation of the framework provides a meaningful definition of sustainability that can be communicated both internally and externally. This promotes goal coherence, ex-ante consideration of impacts, collaborative and experimental approaches, and renewed local governance paradigms. Applying the doughnut is mostly relevant for addressing local exchange processes between actors, but as of yet provides limited support for sustainable urban planning and decision-making in the context of planetary urbanisation. Despite methods being developed to assess the sustainability of urban systems across scales, significant theoretical and practical barriers to such approaches remain to be addressed. Working with the doughnut is stimulating cities to consider the cross-scale impacts of local actions because the doughnut includes the global dimensions in the four lenses. However, practically speaking, these are difficult for local governments to assess and, more importantly, influence. The transaction cost associated with broader sustainability considerations might not be proportional to the local scale of government, calling into question the narrative about the role of cities in saving the planet. Greater efforts need to be made to integrate intergovernmental and academic sectors in sustainability planning to address the local-global interactions of urban systems. Working with the doughnut does not appear to challenge the hegemony around local urban and economic growth, as these remain key in meeting the needs of urban dwellers and staying above the doughnut's social foundation. The doughnut might improve sustainability outcomes through changing interactions in the local governance structure, however, this improves sustainability outcomes in the city, rather than the urban space. Applying the doughnut provides cities with an opportunity to change the status quo of interactions between actors in the local governance system and redirect the operations of local institutions. The question remains whether incremental actions of local actors will suffice in halting the rate and pace of socio-ecological deterioration in the age of urbanisation.

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Appendices

Appendix A: format literature review

Title
Authors
Type of source
Published where
Objective/questions
Definition of key concepts
Method and theories used
Scale/case
Results and conclusion
How does this relate to knowledge about urban safe and just operating space
If and how does the paper assess the urban safe and just operating space
If and how does the paper relate to the use of safe and just operating space in institutions/planning/decision-making
What are barriers and opportunities towards operationalisation of urban safe and just operating space

	Other comments

Appendix B: Case Codebook

	City
Motivation	
Context	
Initiation	
Approach	
challenges	

Appendix C: Interview Guide

Talking points for semi-structured interviews

Welcome the interviewee, thank them for their participation, and allow them to ask questions before the interview begins. Confirm they have received the information letter and discuss the terms of consent. Also as for oral permission to record the interview before starting recording.

Role of interviewee within the city:

- In what capacity do you work for the city (position, department)?

The process of applying the doughnut

- What motivated the city to work with the doughnut?
- How is the city applying/operationalising the doughnut economics framework?
- If and how did the city assess their safe and just operating space?
- What stakeholders have been involved in the process?
- What is still needed for the city to better understand/operationalise/assess their safe and just operating space?

Doughnut experiences in the city:

- What are the barriers and opportunities for local/city governments to apply the doughnut economics framework/integrate it into urban institutions?
- What is the relevance of the doughnut economics framework for urban planning and decision-making for sustainability?
- Has working with the doughnut had an influence on debates regarding growth, and if so, how?

Future development:

- Do you anticipate an increase/decrease in the application of urban doughnut economies? And why
- What is important to consider for cities that want to start working with the doughnut?