Area Neutrality: safeguarding urban biodiversity with a new land management framework in Trondheim

Area Neutrality: safeguarding urban biodiversity with a new land management framework in Trondheim

AA McCormack[1,2], LM Foldnes Lunde[1,3], JL McDowell[1,2], A Iqbal[1,2], S Ojee[1,3] and A Nowokreschenow[1,2]

[1]Bærekraftssenteret - Centre for Sustainable Development
Bytorget, Erling Skakkes gate 14, 7013 Trondheim
[2]Department of Geography, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway
[3]Department of Biology, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

Email: amy.anne.mccormack@gmail.com, linn.m.f.lunde@gmail.com, jlmcdowell30@gmail.com, afridaiqbal@gmail.com, stephanieojee@gmail.com, aljona@posteo.de

Abstract. Area neutrality is a municipal land use management system that prioritizes the protection of nature in urban development. This framework calls for first avoiding nature destruction, then reducing nature loss, and finally "replacing" natural lands that are developed for human use by restoring other areas. In effect, it extends the net-zero philosophy to the loss of nature. In this exploratory study, we consider the effects of implementing area neutrality in the municipal planning of Trondheim, Norway. The potential benefits of the framework are considered in terms of the United Nations Sustainable Development Goals and Intergovernmental Panel on Biodiversity and Ecosystem Services. Principles of urban ecology are applied to the framework so that positive ecological impacts are maximized. We conclude with a SWOT analysis of area neutrality in general and consideration of challenges for Trondheim Municipality specifically. This study provides an overview of a system which could be highly beneficial to both the urban and natural ecosystems of Trondheim and other areas if implemented responsibly.

1. Introduction and Defining Area Neutrality

In 2021 an international, interdisciplinary team with experience of ecosystem management, sustainable development, grassland ecology, mires restoration, stakeholder engagement, urban resilience, hydrology, food security and area accounts were selected by the Center for Sustainable Development in Trondheim to conduct an exploratory study on the concept of area neutrality. This included creating a widely usable definition of area neutrality, theorizing the potential impacts to human and non-human life, and suggesting how area neutrality could be implemented in Municipal land management plans.

The imperative for the early stage research is the global need for restoration as highlighted by the UN decade of restoration. As the global population continues to grow and redistribute toward centers of commerce [1] and employment [2], [3] cities are under increasing pressure to expand to accommodate the influx of residents [4]. Small to medium sized cities of less than 1 million residents are growing at twice the rate of the world's megacities [3] challenging municipalities like Trondheim, Norway to allow city planners and land developers to meet this increasing demand without negatively impacting the urban and suburban landscape. The areas required for such urbanization are often carved out from undeveloped "natural" land types, setting the stage for a conflict between human needs and nature preservation.

Accordingly, international bodies such as the United Nations [5], Organization for Economic Cooperation and Development [OECD] [6], World Health Organization [WHO] [7], and World Wildlife Fund [WWF] [8] have raised concerns about the consequences of rapid development on human and non-human life. To avert the worst outcomes, Norway and other nations have elected to participate in international environmental initiatives such as the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change [9].

These initiatives highlight land development as a primary threat to both biodiversity and climate, resulting in species loss [10], habitat fragmentation [8, 10], soil loss [9, 11] decreased carbon storage [11, 12] and increased carbon emissions associated with longer transit distances [13]. Furthermore, it threatens human health and wellbeing, as the loss of natural spaces is associated with poorer quality of life. This is due to decreased time spent in nature [14], fewer opportunities for exercise [7], increased stress [15], overstimulation [16], increased crime [3], decreased access to traditional foods and medicines [17], and negative public health impacts [18]. Broadly, the conversion of natural land to developed land threatens the ability of the urban environment to provide ecosystem services to its population [10, 12].

The population of Trondheim municipality is expected to grow by 48,000 by 2050 [19], thus asking the question “Where will everyone live, work and recreate?” How will sites be selected for development, and how will the qualities of different sites be valued and compared to each other? Despite the clear need for a systemic approach to sustainable land use management in city settings, there is not yet an established policy framework that prioritizes the preservation of nature spaces within urban landscapes [20]. In response to this need, the concept of area neutrality is considered as a solution towards sustainable land-use planning and biodiversity protection.

Area neutrality is a novel land use management system whereby limits are placed upon the area of developed and degraded land. In this framework, developed areas are re-developed, natural areas are left undeveloped, and those natural areas that are developed must be “replaced” by the restoration of developed areas to a more natural state. The goal of this system is to balance the maintenance of biodiversity and nature’s contributions to people, while allowing development and urbanization to continue in stride with expected population growth. In essence, area neutrality applies the logic of “net zero” to land use change.

2. Why use Area Neutrality in Trondheim?

Area neutrality is a straightforward and easy-to-explain policy tool for net-zero land use management that can aid Trondheim in achieving sustainability goals relating to nature management, land use planning and sustainable urban development. It provides an opportunity for achieving several of the UN Sustainable Development Goals, notably those pertaining to education [SDG4], clean water [SDG6], sustainable city life [SDG11]; responsible consumption practices [SDG12]; climate change mitigation and adaptation [SDG13]; and protecting aquatic and terrestrial life [SDG14 and SDG15]. Similarly, area neutrality could be a tool to improve species diversity and ecosystem services at the municipal level, according to the IPBES framework. Avoiding, reducing and finally reversing land degradation is vital to reduce biodiversity loss [24], and the promotion of ecosystem services through the protection of nature spaces can improve quality of life in cities [21].

To do this, the key principles of urban ecology need to be applied - this includes that when natural processes are integrated into the urban landscape these areas are healthier and more resilient to change. It is important to consider which species and units of land are used to create green spaces, as certain interventions will have a stronger ecological impact than others. Finally, both community stakeholders and experts should

be consulted when weighing the value of different projects. Area neutrality creates a framework for negotiation which allows for the enhancement of ecosystem functions and networks by creating a system where areas of greater ecological significance can be exchanged for areas of less importance. In effect, it can be used as an index in achieving zero net loss of ecosystems and species [21]. For example, in this framework, municipal land managers could allow a housing project to proceed but require that the developer fund the restoration of a river or wildlife corridor. This could improve water filtration, flood control, and the connectedness of larger community nature preserves, which enhances their function.

3. SWOT

There are many potential ecological and social benefits to the implementation of area neutrality as well as drawbacks. To outline potential risks and rewards, a SWOT analysis of the concept has been conducted [Figures 1]. SWOT is a tool used to highlight and clarify the Strengths, Weaknesses, Threats and Opportunities of a business or organization, but is used here to visualize these factors for the implementation of area neutrality in Trondheim municipality. This was done considering Ghazinoory's [2011] remarks on SWOT methodology [22].

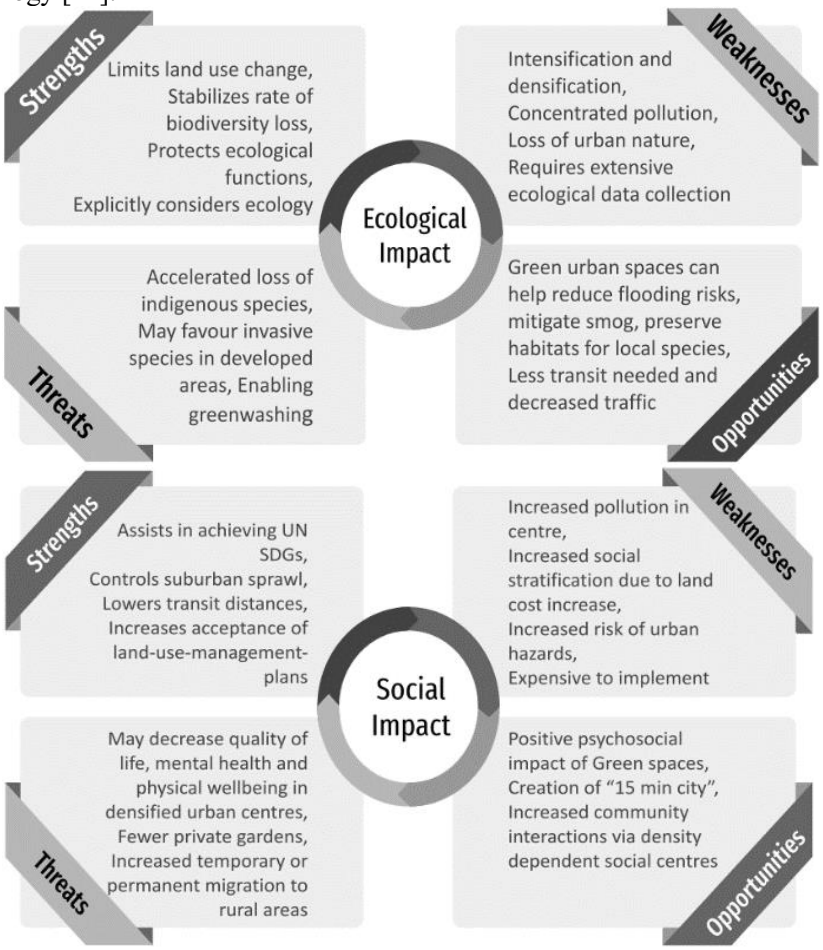

Figure 1. Results from SWOT analysis on Ecological impacts and Social Impacts of area neutrality in Trondheim Municipality. This was done considering all interviews carried out during this research and the expertise of those writing. For details of who was interviewed please consult the acknowledgements.

The major strength of area neutrality is that it mandates the protection of municipal nature spaces and the creation of new green spaces, while its major weakness is that it requires densification of the already-built areas of Trondheim. This system gives the municipality the opportunity to improve biodiversity and ecosystem services as well as the key performance indicators of the UNSDGs, but comes with the threat of reducing human wellbeing and favoring invasive species if implemented poorly.

4. Steps Needed to Achieve Area Neutrality

Based on the interview results, review of the literature referenced above and the teams' previous experience it was decided that the likely steps needed to achieve area neutrality are: setting a reference stage, defining an approach, creating area accounts, outlining a financing system, and managing cities growth.

4.1 Setting A Reference Stage

The goal behind the creation of area neutrality is to keep the loss of nature at net zero, this requires a reference point from which the net land use change should be measured. This opens the discussion of when this reference point should be. According to the United Nations, in addition to halting and preserving nature, there is also a need to reverse nature loss [23]. It is not enough to halt the loss of natural areas due to urban development; there is a need to restore previously degraded areas as well. In the future the municipality needs to restore more land to a natural state than is developed to compensate for the rapid land loss of the past. Hence, the authors recommend the zero point for area neutrality should not be the current state of degradation but should rather be set at an earlier stage of Trondheim's development.

4.2 Defining an Approach

Area neutrality creates a framework for negotiation between policy makers, developers and other key stakeholders to create space for nature protection within current political, market and social systems. By putting a nature-based valuation on all potential locations for development, this framework incorporates biodiversity and ecosystem protection into finance-based land markets, forcing land developers to consider ecosystem management based on monetary interests. Potential systems for translating ecosystem value into financial value will be further discussed in the sections below.

4.3 Creating Area Accounts

An area account is an overview of the nature in the areas. According to Sabima, this should include the environmental status of each type of nature within the area, the amount of nature present, and the degree of ecological quality [25]. The area account should also include an overview of areas with potential for restoration. Several municipalities in Norway already have an area account, but as there is no set way to execute an area account the practice differs between municipalities [26]. The purpose of an area account is to help the municipality map the areas that can be developed and make informed decisions on which areas should be avoided, such as sites with red listed nature types. This area account will be the basis of creating a financing system.

4.4 Outlining a Financing System

There are substantial limitations on the practice of financially assessing nature spaces [27] however the absence of a valuation system for biodiversity and ecosystems means land units are currently valued in purely economic terms. A major strength of the area neutrality framework is the ability to incorporate biodiversity and ecosystems management into previously finance-dominated land markets. However, we do not discount that nature spaces are impossible to objectively monetize within existing property markets [27],

and that a valuation framework will be highly place-based [27]. Hence it is recommended area neutrality should be adopted at municipal planning level to allow for adaptive management by local stakeholders.

Restoration is a long lasting and expensive process, so fully financing the costs in return for developers using natural land is essential for the implementation of area neutrality. [28]. To do this a system for financing restoration needs to be created. One potential system is to create a restoration fund supplied by taxes imposed on the purchase of natural land, while another is to obligate developers directly to restore comparable, but degraded, ecosystem areas. The first option enables top-down management of restoration funds by municipal land managers, while the latter allows developers to absorb the costs of a direct exchange of land. Practices of developer-sponsored restorations can be found in sectors such as construction, forestry and mining, while an example of the fund-based system can be found in the United States' Superfund Act [29]. We recommend future interdisciplinary teams apply legal and economic lenses to the framework in order to provide deeper analysis of workable systems.

4.5 Management of Cities Growth

To manage the growth of the city, redevelopment must occur [11]. Firstly, the redevelopment of properties including the renovation of buildings no longer in use, redeveloping brown sites, utilizing damaged environments, and the reshaping of built areas to better suit the city's changing needs. Secondly densification by moving the needed parts of the city closer together. This can be done by building new structures within already built-up areas or adding more structures to planned areas. It can also be achieved by constructing taller buildings or constructing more useful spaces underground. Densification requires multi use areas and more people living in a smaller area. One benefit of this effort is the opportunity to create a "15 minute city," where residents can access all their daily needs within a short walk from where they reside.

For effective management land use planning rules must be enforced. The system of area neutrality allows for key developments to occur without the net loss of natural lands, but this can only happen if all developments are held to these standards [21]. Collaboration with surrounding municipalities is needed. If land use rules change in Trondheim it could increase the demand for development on natural land in surrounding municipalities [32]. For this reason we recommend area neutrality should be a major policy and should be stipulated in the municipal plan.

5. Challenges

New management systems face several challenges: difficulty of scaling, lack of knowledge, resistance from key stakeholders, risk of unintended consequences, and forming collaboration. These challenges will also be faced in the implementation of area neutrality. Recommended solutions include the establishment of a long-term monitoring program, landowner consultation, and coordination with the surrounding municipalities.

5.1 Scaling and Knowledge

The major challenges of implementing area accounts are scaling and knowledge. Each municipal implementation of area neutrality must be tailored to the specific urban environment. This will require considerable work to be done by ecologists and GIS specialists which will need substantial financing. To solve these problems Trondheim municipality may decide to establish an office for the monitoring of issues arising from applying area neutrality locally, as well as to maintain up-to-date planning, nature and land use maps. Alternatively, partnerships with local institutes of higher learning may provide expert knowledge and student manpower. Funding from utilization of a carbon credit scheme may assist here.

5.2 Resistance from Stakeholders - Land Ownership

Another potential challenge could be finding suitable land for conservation, protection, and restoration. Some areas suitable for conservation may already be owned by the municipality. However, the area account could find areas most suitable for these purposes are owned by private landowners. If the landowners are unwilling to halt development in such areas this could create political or social resistance to the implementation of area neutrality. Navigating the challenge of landowner resistance will be made easier by involving them early in the process and incorporating their desires into land use planning. Although not all parties can be satisfied, the mutual respect and feelings of empowerment cultivated by stakeholder consultation can reduce the likelihood of political backlash.

5.3 Unintended Consequences - Outsourcing Urbanization

Another challenge in implementing area neutrality is the potential for developments that would no longer be allowed in Trondheim Municipality to simply relocate to the neighboring municipalities, especially Skaun, Malvik and Melhus. Much like Trondheim municipality, all three of these districts are projected to experience population increases of over 15% by 2050. However, compared to the 13.5% of land already used for construction in Trondheim Municipality, the neighboring municipalities have 5.5% or less of land developed [32].

The issue with this disparity in development is that if area neutrality is implemented only in one municipality, developers may find more affordable land with less restrictions in the suburbs, leading to a more dispersed but equally destructive effect on regional nature. Indeed, previous research has shown that as population density increases in an urban center, residents who can afford longer commutes and larger properties tend to move to peripheral communities [33]. This phenomenon not only results in a greater degree of income inequality between neighborhoods, but more land under construction per capita. If the surrounding municipalities have no system of area neutrality in place, then this suburban land will come with no obligation of replacing nature lost in the process. The result is therefore a larger area of natural habitat destroyed per person than if the same population had built housing in Trondheim itself. The solution to this problem is twofold: first, it is important for Trondheim to coordinate with the surrounding municipalities in developing a regional plan for area neutrality so that suburban development is not inadvertently favored over urban development. Second, using area neutrality as a framework to protect and restore nature that enhances the livability of the urban environment should be prioritized. By putting special focus on ecosystem services that improve the human experience of the urban environment, the municipality may avoid geographic income stratification and the proliferation of high-income developments in the suburbs.

5.4 Collaborating

Area neutrality in Trondheim will be closely linked to the planning and development of urban areas. Successful implementation of area neutrality must include collaboration with institutions, governance, and corporations to ensure social and ecological welfare. Human drivers of land use change including resource usage, pollution and the introduction of alien species can also be addressed by area neutrality.

6. Conclusion

The potential impacts to human and non-human life of implementing area neutrality as defined here include assisting in achieving many UN SDGs and other positives for a growing city. Hence, we recommend Trondheim municipality allocates funding for further research on area neutrality. As a UNECE-designated Smart City, Trondheim has not only the opportunity but also the obligation to sustainably manage urban nature and the impacts of the increasing population. Area neutrality offers policymakers a tool for land use

management that through negotiation protects nature in a growing city. By balancing land uses the continued prosperity of human and non-human life in Trondheim could be achieved. The municipality can create a healthier, more desirable, and more sustainable urban environment for those who live and work there in the coming decades. Further research on whether area neutrality is the best technique for achieving these goals should include legal, economic, ecology and GIS expertise.

Acknowledgements
Thanks go to Berit Therese Nilsen, NTNU; Lars Even Egner, NTNU; Tanja Kofod Petersen, NTNU; Fredrik Vikse, Sabima; Evelyne Marie T Gildemyn, Miljøenheten-Trondheim Kommune; Magnus Irgens, Miljøenheten-Trondheim Kommune; Esther Balvers, Trøndelag Fylkeskommune for their insight. Many thanks also go to Gine Roll Skjærvø, Thor Harald Ringsby, Kristian Mjøen and Kelly Riedesel.

References
[1] Ellingsen W and Nilsen B 2021 Emerging geographies in Norwegian mountain areas–Densification, place-making and centrality *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography* **75** 101-13.
[2] Tacoli C, McGranahan G, Satterthwaite D 2015 Urbanisation, rural–urban migration and urban poverty. *International Institute for Environment and Development* [Available from: https://www.iom.int/sites/g/files/tmzbdl486/files/our_work/ICP/MPR/WMR-2015-Background-Paper-CTacoli-GMcGranahan-DSatterthwaite.pdf].
[3] Gaub F 2019 Welcome to 2030: the mega-trends *European Union Institute for Security Studies* [Available from: https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/ESPAS_Report2019.pdf].
[4] Revision of the world urbanization prospects [press release]. 2018 [Available from: https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html].
[5] Kirabo-Kacyira A 2021 Addressing the sustainable urbanization challenge [Available from: https://www.un.org/en/chronicle/article/addressing-sustainable-urbanization-challenge].
[6] OECD 2018 Biodiversity, land use and ecosystems [blue], What's happening 2019-20 and recent work
[7] WHO 2010 Why urban health matters [Available from: https://www.who.int/world-health-day/2010/media/whd2010background.pdf].
[8] WWF 2013 Urban solutions for a living planet – learning cases. stockholm, sweden. [Available from: https://d2ouvy59p0dg6k.cloudfront.net/downloads/urban_solutions_for_a_living_planet_final_version_2012.pdf].
[9] Boer B and Hannam I 2020 Land degradation *Oxford Handbook on Comparative Environmental Law* 2019 **1** 1
[10] Brown L and Graham C 2015 Demography, traits and vulnerability to urbanization: can we make generalizations? *Journal of Applied Ecology*. **52** 1455-64.
[11] Imbrenda V, Quaranta G, Salvia R, Egidi G, Salvati L and Prokopovà M 2021 Land degradation and metropolitan expansion in a peri-urban environment *Geomatics, Natural Hazards and Risk* **12** 1797-818.
[12] Meineke E, Youngsteadt E, Dunn R and Frank S 2016 Urban warming reduces aboveground carbon storage *Proceedings: Biological Sciences* **283** 1-9.
[13] Patacchini E, Zenou Y, Henderson J and Epple D 2009 Urban Sprawl in Europe *Brookings-Wharton Papers on Urban Affairs* 125-49.
[14] White M, Alcock I, Grellier J, Wheeler B, Hartig T and Warber S 2009 Spending at least 120 minutes a week in nature is associated with good health and wellbeing *Scientific Reports **9*** 7730.
[15] Srivastava K 2009 Urbanization and mental health *Industrial psychiatry journal* **18** 75-6.

[16] Clayton S 2012 The Oxford Handbook of Environmental and Conservation Psychology *OUP USA*; 20-93.
[17] Poe M, McLain R, Emery M and Hurley P 2012 Urban forest justice and the rights to wild foods, medicines, and materials in the city *Human Ecology*. 2013 **41** 409-22.
[18] Kuddus M, Tynan E and McBryde E 2020 Urbanization: a problem for the rich and the poor? *Public Health Reviews* **41** 1
[19] Rådmannen 2019 Byutviklingsstrategi for Trondheim *Trondheim Kommune* [Available from: https://www.trondheim.kommune.no/globalassets/10-bilder-og-filer/10-byutvikling/byplankontoret/1b_off-ettersyn/2019/byutviklingsstrategi-trondheim--strategi--arealtrsp-2050/1.-horingsutkast.-byutviklingsstrategi-for-trondheim---strategi-for-areal--og-transportutvikling-fram-mot-2050.pdf].
[20] Gildemyn E and Irgens M 2021 Nature management in a city in growth- is area neutrality the solution? PowerPoint Presentation.
[21] Vikse F 2021 Arealnøytralitet Trondheim *Team TKI, editor*
[22] Ghazinoory S, Abdi M, Azadegan-Mehr M 2011 Swot methodology: a state-of-the-art review for the past, a framework for the future *J bus econ manag* **12** 24-48.
[23] UNEP 2021 Principles for ecosystem restoration to guide the united nations decade 2021-2030 [Available from: https://www.decadeonrestoration.org/publications/principles-ecosystem-restoration-guide-united-nations-decade-2021-2030].
[24] Cowie A, Orr B, Sanchez V, Chasek P, Crossman N and Erlewein 2018 Land in balance: the scientific conceptual framework for land degradation neutrality. *Environmental Science & Policy* **79** 25-35.
[25] Sabima 2021 Et arealnøytralt Norge. [Available from: https://www.sabima.no/et-arealnoytralt-norge/].
[26] Rambøll 2020 Kartlegging av praksis rundt bruk av arealregnskap i kommuneplan. https://www.regjeringen.no/no/dokumenter/kartlegging-av-praksis-rundt-bruk-av-arealregnskap-i-kommuneplan/id2722535/].
[27] Chan K, Balvanera P, Benessaiah K, Chapman M, Díaz S, Gómez-Baggethun E, Gould R, Hannahs N, Jax K, Klain S, Luck G, Martín-López B, Muraca B, Norton B, Ott K, Pascual U, Satterfield T, Tadaki M, Taggart J, Turner N 2016 Why protect nature? Rethinking values and the environment *PNAS* **113** 1462-1465
[28] Seea 2021 Ecosystem Accounting [Available from: https://seea.un.org/sites/seea.un.org/files/seea_ea_key_proposals_may2021.pdf].
[29] United States Environmental Protection Agency 2022 Superfund: CERCLA Overview [Available from: https://www.epa.gov/superfund/superfund-cercla-overview].
[30] Slätmo E, Ormstrup-Vestergård L, Lidmo J and Turunen E 2019 Urban–rural flows from seasonal tourism and second homes: planning challenges and strategies in the nordics *Nordregio report* **13** 1-58
[31] Sandberg T 2021 Her stanser de nedbyggingen av natur: – det mest effektive grepet vi kan ta *Dagsavisen* [Available from: https://www.dagsavisen.no/nyheter/innenriks/2021/07/05/her-stanser-de-nedbyggingen-av-natur-det-mest-effektive-grepet-vi-kan-ta/].
[32] Sliper J 2020 . Faktafredag - befolkningsvekst 2020-2050 trøndelag fylkeskommune *Trøndelag Fylkeskommune* [Available from: https://www.trondelagfylke.no/vare-tjenester/plan-og-areal/kart-statistikk-og-analyse/nyhetsarkiv-kart-og-statistikk/faktafredag---befolkningsvekst-2020-2050/].
[33] Mieszkowski P and Mills E 1993 The causes of metropolitan suburbanization *Journal of Economic perspectives* **7** 135-47.